VI MARINE PARK PROJECT

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VI Marine Park Project

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VI MARINE PARK PROJECT

The Government of the United States Virgin Islands (USVI) has embarked on a project to develop a Marine Park System Plan for the Territory. This project has five main components:

1. Preparation of a Marine Park System Plan for the USVI;
2. Preparation of a Resource Description Report for the marine environment in the USVI;
3. A Socio-economic Assessment of the uses and users of the marine resources in the USVI;
4. Preparation of a Management Plan for the proposed marine park for the east end of St. Croix; and
5. Preparation of an information brochure about the marine parks.

The University of the Virgin Islands (UVI) is coordinating this project on behalf of the Department of Planning and Natural Resources (DPNR). UVI will be working with other institutions, such as The Nature Conservancy (TNC), and Island Resources Foundation (IRF), to carry out this timely and important project.

During the period August to November 2001, personnel involved in the project will be contacting stakeholder groups, and the wider community in general, in an effort to solicit information and guidance concerning the marine environment.

Members of the public can use this web page to obtain general information on protected areas, as well as provide information and guidance to the project. Documents available for downloading from this site include:

a. A Community Information Document. This provides information on the project, its objectives, its outputs, and the long-term possibilities for protected areas in the USVI.
b. Information on the Categories of Protected Areas. This provides information on the different types of protected areas and the management objectives of each type.
c. Information on the Benefits of marine protected areas.
d. Information on Management Plans for protected areas. This includes the Tables of Content from a number of management plans for sites in the Caribbean.
e. Information on national System Plans for protected areas. This shows the difference between site planning and system planning, and provides information on the reason for system planning.
f. A list of publications that is provided as Recommended Reading for persons interested in marine protected areas.
g. The Questionnaire that is being used to gather information for the proposed marine protected areas system plan.
h. A Bibliography on marine fishery reserves.

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COMMUNITY INFORMATION DOCUMENT

BACKGROUND

The International Coral Reef Initiative (ICRI) is an internationally-agreed initiative that was launched in 1994 to address the rapid decline of coral reefs. ICRI is said to be a "blueprint for conservation of coral reefs", and is implemented through partnerships among governments, international organizations (such as the United Nations Environment Programme and the World Bank), and non-governmental organizations.

In response to both this global initiative, and the growing environmental crisis within the U.S., President William Clinton issued the Coral Reef Protection Executive Order 13089 on June 11, 1998. In addition to policies affecting coral reef conservation, the Executive Order established the United States Coral Reef Task Force. The Task Force, working with governmental and non-governmental organisations, prepared the National Action Plan to Conserve Coral Reefs.

The US National Action Plan to Conserve Coral Reefs was developed to guide the sustainable use of coral reef ecosystems within the jurisdiction of the U.S.A., including its Territories and Commonwealths. Sustainable use simply means that coral reef ecosystems should be used and managed in such a manner as to ensure the security of the economic, cultural, social, and environmental values and benefits of such ecosystems in perpetuity.

As part of the National Action Plan to Conserve Coral Reefs, the Government of the United States Virgin Islands (USVI) has embarked on a project to develop a Marine Park System Plan for the USVI.

THE USVI MARINE PARK PROJECT

This marine park project has five main components:

1. Preparation of a Marine Park System Plan. The System Plan will, among other things, provide the guidelines and processes for establishment of marine protected areas in the USVI, set out clearly the linkages between the management institutions, and identify sites that require management.

2. Preparation of a Resource Description Report for the marine environment in the USVI. This report will provide a statement of the status of the natural resources

within the marine environment, identifying important resources and habitats that require protection.

3. A Socio-economic Assessment of the uses and users of the marine resources in the USVI. This assessment will identify the patterns of resource uses, the value of those natural resources to the USVI economy, and the future demand for those resources.

4. Preparation of a Management Plan for the proposed marine park for the east end of St. Croix. The management plan will identify resources that require protection within the specific area, will propose boundaries for a marine park, propose management objectives for the park, and recommend the types of activities that may or may not be permitted within the park.

5. Preparation of an information brochure about the USVI marine parks, which can be used by residents and visitors.

The University of the Virgin Islands (UVI) is coordinating this project on behalf of the Department of Planning and Natural Resources (DPNR), and will be working with other institutions, such as The Nature Conservancy and Island Resources Foundation.

In addition to the technical work to be carried out, personnel involved in the project will be contacting stakeholder groups, and the wider community in general, in an effort solicit information and guidance concerning marine habitats and resources that require protection, or alternatively, possess special features that can support agreed levels of use by locals and visitors.

IF YOU ARE AMEMBER OF A GROUP THAT HAS AN INTEREST IN THIS PROJECT, CONTACT DPNR AT: Tel: 774-3320; Email: viczmp@viaccess.net.

THE NEED FOR ACTION

The lands, water, and other natural resources provide much of what the people of the USVI need for their well being. However, those resources are being degraded through the pressures of development activities. Most people agree that some effort must be made to take care of those resources on which we depend. We must develop a plan to manage critical resources in a coordinated and successful manner. Here are some of the reasons for taking immediate action.

Food Supply: The marine environment in the USVI provides a range of foods and drinks. Fishermen relate tales of times past when there were large numbers of fish, lobsters, and conch. Yet within the span of only two generations the amount of fish caught is so small that fishermen have serious concerns about their abilities to support their families.

Money and Jobs: The environment is the base of the VI economy. It attracts visitors in increasing numbers, which provides necessary jobs and income.

Rare Plants and Animals: Coral reefs and seagrass beds are some of the most productive ecosystems on the planet, providing resources that are found nowhere else. In addition to being necessary to fisheries and supporting tourism, the marine resources are important for medicine, and therefore human health.

Coastal Protection: Coral reefs protect our coastal areas by reducing the damage caused by wave action during storms.

Other Services: We use the marine environment for many other purposes that we take for granted. Swimming, picnics on the beach, teaching our children to fish, education, and a range of other activities contribute to our quality of life. That quality of life would be much diminished if those natural resources were absent. Therefore we must take measures to protect them.

THE ROLE OF MARINE PROTECTED AREAS

A marine protected area (MPA) can simply be defined as any area delineated by legislation to protect a given set of resources or values. Those values can be conservation, commercial, recreational, traditional/cultural, educational, scientific/research, or unique natural features. In many cases, a mixture of the above values is protected in each MPA. The many benefits provided by MPAs have been clearly demonstrated all over the world (see associated document on the benefits of MPAs).

Marine protected areas currently existing in the USVI are:

- Buck Island National Monument;
- Cas Cay/Mangrove Lagoon;
- Compass Point Pond;
- Inner Mangrove Lagoon;
- Sandy Point;
- St. James;
- The marine components of the Virgin Islands National Park (St. John) and Salt River Natural historical Park and Ecological Preserve (St. Croix).

This marine park project proposes to establish a marine protected area along the east end of St. Croix.

Do you know of other marine resources in the USVI that require improved management? Are marine protected areas necessary to protect those resources? If so, where should they be located?

BUILDING A PROGRAM OF ACTION

Building a system of protected areas in the USVI is a long-term process involving many steps and the active participation of the many interest groups and individuals in our community.

The system plan is a statement of intent, providing the policies and legislative and institutional framework within which an action plan for system development can be developed and implemented. While it is a statement of commitment by public sector agencies, it also provides a framework that allows all community interests to participate in the process of deciding on the priorities to be addressed, and then becoming engaged in implementing the agreed solutions.

As individuals and groups, you can participate in this project, as well as the long-term process of establishing a system of protected areas in the USVI by:

1. Staying informed. Watch for announcements on the project and get additional information on marine protected areas.

2. Participate in meetings.

3. Take the time to provide the project team and DPNR with specific information on the marine resources, as well as your ideas on marine protected areas.

4. Discuss the issue of marine protected areas with your friends or within your groups, and become actively involved in protecting environmental resources that support the VI economy.

Protected Area Categories and Management Objectives

A protected area is defined as: "**An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means**" (IUCN 1994[i]).

The above definition does not mean that no use will be permitted within protected areas. In fact, the most wide spread use of protected areas is for recreation.

The current IUCN WCPA categories (IUCN 1994) are as follows:

1. Strict protection
   a. Strict Nature Reserve
   b. Wilderness Area

11. Ecosystem conservation and recreation (National Park)

111. Conservation of natural features (Natural Monument)

IV. Conservation through active management (Habitat/Species Management Area)

V. Landscape/seascape conservation and recreation (Protected Landscape/ seascape)

V1. Sustainable use of natural ecosystems (Managed Resource Protected Area)

The mix of management objectives relevant to each of the categories is summarised in the following table (IUCN 1994, p.8):

Management Objective	**Ia**	**Ib**	**II**	**III**	**IV**	**V**	**VI**
Scientific research	1	3	2	2	2	2	3
Wilderness protection	2	1	2	3	3	-	2
Preservation of species and genetic diversity	1	2	1	1	1	2	1
Maintenance of environmental services	2	1	1	-	1	2	1
Protection of specific natural/cultural features	-	-	2	1	3	1	3
Tourism and recreation	-	2	1	1	3	1	3
Education	-	-	2	2	2	2	3
Sustainable use of resources from natural ecosystems	-	3	3	-	2	2	1
Maintenance of cultural/traditional attributes	-	-	-	-	-	1	2

Key: I: Primary objective; 2: Secondary objective; 3: Potentially applicable objective;
- Not applicable

The definitions, objectives, and selection criteria for the categories and sub-categories are summarised as follows (IUCN 1994, p.17):

Category I - Strict Nature Reserve/Wilderness Area: protected area managed mainly for science or wilderness protection

Category Ia - Strict Nature Reserve: protected area managed mainly for science

Definition: Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring

Objectives of management:

- To preserve habitats, ecosystems and species in as undisturbed a state as possible;
- To maintain genetic resources in a dynamic and evolutionary state;
- to maintain established ecological processes;
- To safeguard structural landscape features or rock exposures;
- To secure examples of the natural environment for scientific studies, environmental monitoring and education, including baseline areas from which all avoidable access is excluded;
- To minimise disturbance by careful planning and execution of research and other approved activities;
- To limit public access.

Guidance for selection:

- The area should be large enough to ensure the integrity of its ecosystems and to accomplish the management objectives for which it is protected.
- The area should be significantly free of direct human intervention and capable of remaining so.
- The conservation of the area's biodiversity should be achievable through protection and not require substantial active management or habitat manipulation (c.f. Category IV).

Equivalent category in IUCN (1978): Scientific Reserve/Strict Nature Reserve.

Category Ib - Wilderness Area: protected area managed mainly for wilderness protection

Definition: Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.

Objectives of management:

- To ensure that future generations have the opportunity to experience understanding and enjoyment of areas that have been largely undisturbed by human action over a long period of time;

- To maintain the essential natural attributes and qualities of the environment over the long term;

- To provide for public access at levels and of a type which will serve best the physical and spiritual well-being of visitors and maintain the wilderness qualities of the area for present and future generations;

- To enable indigenous human communities living at low density and in balance with the available resources to maintain their lifestyle.

Guidance for selection:

- The area should possess high natural quality, be governed primarily by the forces of nature, with human disturbance substantially absent, and be likely to continue to display those attributes if managed as proposed.

- The area should contain significant ecological, geological, physiogeographic, or other features of scientific, educational, scenic or historic value.

- The area should offer outstanding opportunities for solitude, enjoyed once the area has been reached, by simple, quiet, non-polluting and non-intrusive means of travel (i.e. non-motorised).

- The area should be of sufficient size to make practical such preservation and use.

Equivalent category in IUCN (1978): no direct equivalent.

Category 11 - National Park: protected area managed mainly for ecosystem protection and tourism

Definition: Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area, and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Objectives of management:

- To protect natural and scenic areas of national and international significance for spiritual, scientific, educational, recreational or tourist purposes;
- To perpetuate, in as natural a state as possible, representative examples of physiographic regions, biotic communities, genetic resources, and species, to provide ecological stability and diversity;
- To manage visitor use for inspirational, educational, cultural and recreational purposes at a level which will maintain the area in a natural or near natural state;
- To eliminate and thereafter prevent exploitation or occupation inimical to the purposes of designation;
- To maintain respect for the ecological, geomorphologic, sacred or aesthetic attributes which warranted designation;
- To take into account the needs of indigenous people, including subsistence resource use, in so far as these will not adversely affect the other objectives of management.

Guidance for selection:

- The area should contain a representative sample of major natural regions, features or scenery, where plant and animal species, habitats and geomorphological sites are of special spiritual, scientific, educational, recreational and tourist significance.
- The area should be large enough to contain one or more entire ecosystems not materially altered by current human occupation or exploitation.

Equivalent category in IUCN (1978): National Park

Category III - Natural Monument: protected area managed mainly for conservation of specific natural features

Definition: Area containing one, or more, specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.

Objectives of management:

- To protect or preserve in perpetuity specific outstanding natural features because of their natural significance, unique or representational quality, and/or spiritual connotations;

- To an extent consistent with the foregoing objective, to provide opportunities for research, education, interpretation and public appreciation;

- To eliminate and thereafter prevent exploitation or occupation inimical to the p purpose of designation;

- To deliver to any resident population such benefits as are consistent with the other objectives of management

Guidance for selection:

- The area should contain one or more features of outstanding significance (appropriate natural features include spectacular waterfalls, caves, craters, fossil beds, sand dunes and marine features, along with unique or representative fauna and flora; associated cultural features might include cave dwellings, cliff-top forts, archaeological sites, or natural sites which have heritage significance to indigenous peoples).

- The area should be large enough to protect the integrity of the feature and its immediately related surroundings.

Equivalent category in IUCN (1978): Natural Monument / Natural Landmark

Category IV - Habitat/Species Management Area: protected area managed mainly for conservation through management intervention

Definition: Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

Objectives of management:

- To secure and maintain the habitat conditions necessary to protect significant species, groups of species, biotic communities or physical features of the environment where these require specific human manipulation for optimum management;

- To facilitate scientific research and environmental monitoring as primary activities associated with sustainable resource management;

- To develop limited areas for public education and appreciation of the characteristics of the habitats concerned and of the work of wildlife management;

- To eliminate and thereafter prevent exploitation or occupation inimical to the purpose of designation;

- To deliver such benefits to people living within the designated area as are consistent with the other objectives of management.

Guidance for selection:

- The area should play an important role in the protection of nature and the survival of species ('incorporating, as appropriate, breeding areas, wetlands, coral reefs, estuaries, grasslands, forests or spawning areas, including marine feeding beds).

- The area should be one where the protection of the habitat is essential to the well-being of nationally or locally-important flora, or to resident or migratory fauna.

- Conservation of these habitats and species should depend upon active intervention by the management authority, if necessary through habitat manipulation (c.f. Category Ia).

- The size of the area should depend on the habitat requirements of the species to be protected and may range from relatively small to very extensive.

Equivalent category in IUCN (1978): Nature Conservation Reserve/Managed Nature Reserve/Wildlife Sanctuary.

Category V - Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation

Definition: Area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinctive character with significant aesthetic. ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

Objectives of management:

- To maintain the harmonious interaction of nature and culture through the protection of landscape and/or seascape and the continuation of traditional land uses, building practices and social and cultural manifestations;

- To support lifestyles and economic activities which are in harmony with nature and the preservation of the social and cultural fabric of the communities concerned;

- To maintain the diversity of landscape and habitat, and of associated species and ecosystems;

- To eliminate where necessary, and thereafter prevent, land uses and activities which are inappropriate in scale and/or character;

- To provide opportunities for public enjoyment through recreation and tourism appropriate in type and scale to the essential qualities of the areas;

- To encourage scientific and educational activities which will contribute to the long term well-being of resident populations and to the development of public support for the environmental protection of such areas;

- To bring benefits to, and to contribute to the welfare of, the local community through the provision of natural products (such as forest and fisheries products) and services (such as clean water or income derived from sustainable forms of tourism).

Guidance for selection:

- The area should possess a landscape and/or coastal and island seascape of high scenic quality, with diverse associated habitats, flora and fauna along with manifestations of unique or traditional land-use patterns and social organisations as evidenced in human settlements and local customs, livelihoods, and beliefs.

- The area should provide opportunities for public enjoyment through recreation and tourism within its normal lifestyle and economic activities.

Equivalent category in IUCN (1978): Protected Landscape.

Category VI - Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems

Definition: Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs. The area must also fit the overall definition of a protected area.

Objectives of management:

- To protect and maintain the biological diversity and other natural values of the area in the long term;
- To promote sound management practices for sustainable production purposes;
- To protect the natural resource base from being alienated for other land use purposes that would be detrimental to the area's biological diversity;
- To contribute to regional and national development.

Guidance for selection:

- At least two-thirds of the area should be in, and is planned to remain in, a natural condition, although it may also contain limited areas of modified ecosystems; large commercial plantations are not to be included.
- The area should be large enough to absorb sustainable resource uses without detriment to its overall long-term natural values.
- A management authority must be in place.

Equivalent category in IUCN (1978): no direct equivalent.

[i] IUCN: 1994. Guidelines for Protected Area Management Categories. IUCN- The World Conservation Union, Gland.

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Potential Benefits of Marine Reserves

Marine Reserves offer many potential benefits, which include; protecting ecosystem functions, improving recreational and educational opportunities, improving fishery yields, and increasing knowledge and understanding of marine systems.

I. Protects Ecosystem Structure, Function, and Integrity

- Protects physical structure of habitat;
- Protects ecological processes;
- Restores population structure of fisheries(size and age);
- Restores community composition (presence and abundance of plant and animal species);
- Protects biodiversity at all levels;
- Protects important species;
- Protects vulnerable species;
- Protects threshold effects;
- Protects food web and trophic structure;
- Reduces incidental damage; and
- Facilitates ecosystem recovery after major human or natural disturbances.

II. Improves Support to Human/Economic Systems

- Reduces fishing gear impacts;
- Maintains high quality feeding areas for fish and wildlife;
- Improves non-consumptive opportunities, especially recreation;
- Enhances and diversifies economic activities;
- Enhances and diversifies social activities;
- Enhances aesthetic and spiritual experiences;
- Improves wildlife opportunities;
- Provides opportunities for education;
- Increases sustainable employment opportunities;
- Creates public awareness about environment;
- Reduces the impacts from irresponsible development activities;
- Encourages holistic approach to natural resources management; and
- Stabilizes the local economy.

III. Improves Fishery Yields

- Protects spawning fish stocks;
- Increases spawning stock biomass;
- Provides undisturbed spawning conditions, habitats, sites;
- Increase egg and larval production;
- Enhances recruitment;
- Provides spill over of adults and juveniles to areas outside reserve;
- Reduces chances of recruitment overfishing;
- Reduces overfishing of vulnerable species;
- Protects diversity of fishing opportunities;
- Enhances recovery from stock collapses and management failures;
- Reduces bycatch fishing mortality
- Simplifies enforcement and compliance;
- Reduces conflicts among users;
- Maintains sport trophy fisheries;
- Reduces variance of yield;
- Allows increased fish outside reserves;
- Facilitates stakeholder involvement in management;
- Provides fishery management data to improve fisheries;
- Increases understanding and acceptance of fishery management;
- Reduces impacts of environmental variability; and
- Provides some protection with limited resources and without data or information.

IV. Increases Knowledge and Understanding of Marine Systems

- Provides long-term monitoring sites;
- Provides focus for study;
- Provides continuity of knowledge;
- Provides opportunity to restore or maintain natural behaviors;
- Reduces risks to long-term experiments;
- Provides experimental sites needing natural areas;
- Provides controlled natural areas for assessing anthropogenic impacts, including fishing and other impacts;
- Provides sites for enhanced primary and adult education; and
- Provides sites for high-level graduate education.

For more information on the benefits of marine reserves read Sobel 1996.

Sobel, J. 1996. “Marine Reserves: Necessary Tools for Biodiversity Conservation?”, in Global Biodiversity. 1996: 8-18.

Examples of Effects of Marine Reserves on Fisheries (Roberts & Hawkins, 2000)

Reserve Name and Location	Years of Protection	Habitat Type	Effects Reported
Leigh Marine Reserve, New Zealand	21	Warm-temperate rocky reef	The most common predatory fish, *Pagrus auratus*, was 6 times more common in the reserve than outside, while the spiny lobster, *Jasus edwardsii*, was 1.6 times more abundant, and had a bigger carapace (a part of their horny outer skeleton: average size=110mm in reserve, 94mm outside). In 18 years, sea urchin densities declined from $4.9m^2$ to $1.4m^2$ in the reserve, while urchin cover rose from 14% to 40% in unprotected areas (Babcock 1999).
Tawharanui Marine Park, New Zealand	14	Temperate rocky reef	The most common predatory fish, *Pagrus auratus*, was 9 times more common in the reserve than outside, while the spiny lobster, *Jasus edwardsii*, was 3.7 times more abundant, with a carapace about 16mm bigger (Babcock 1999).
Mayotte Island, Indian Ocean	3	Coral reef	Total numbers of species present did not differ between protected and unprotected areas. However, most large carnivores were more diverse and abundant in the reserve. The mean biomass of commercial species was $202g/m^2$ in the reserve, compared to $79g/m^2$ outside (Letourneur 1996).
Looe Key, Florida, USA	2	Coral reef	15 species that were targets of spear fishers increased in abundance after spearfishing was banned: snappers by 93%, grunts by 439% (Clark et al. 1989).
Cousin Island, Seychelles	15+	Coral reef	Groupers, emperors, and snappers were more abundant and diverse within the reserve than in fished sites (Jennings 1998).
Sainte Anne, Seychelles	11	Coral reef	Despite the fact that a few families retain fishing rights and poaching is fairly common in this reserve, the diversity of target species and total fish biomass was higher than in heavily fished areas. The biomass of prey did not increase when predators were removed by fishing (Jennings et al. 1995, Jennings et al. 1996).
Merritt Island Wildlife Refuge, Florida, USA	28	Sub-tropical estuary	Experimental catch per unit effort (the amount caught for every unit of fishing effort) was 2.6 times greater in the reserve for all game fish combined, 2.4 times for spotted sea trout (*Cynoscion nebulosus*), 6.3 times for red drum (*Sciaenops ocellata*), 12.8 for black drum (*Pogonius cromis*), 5.3 for snook (*Centropomus undecimalis*), and 2.6 for striped mullet (*Mugil cephalus*). Fish in the refuge were larger and more abundant, and anglers were preferentially targeting the reserve boundary (Johnson et al. 1999).

Reserve Name and Location	Years of Protection	Habitat Type	Effects Reported
Kisite Marine National Park, Kenya	5	Coral reef	Snappers, emperors, and groupers were more abundant in the park and appear to be spilling over into fishing grounds. Protection did not affect species number of diversity (Watson et al. 1996).
Punta El Lacho, Chile	2	Temperate rocky intertidal	The commercially important marine snail, the Loco (*Concholepas concholepas*), increased in density from 5 to 14 times, and doubled in body size following protection (Castilla & Duran 1985).
Barbados Marine Reserve	11	Coral reef	Large, trapable fish were approximately twice as abundant in the protected area, and 18 of 24 species were bigger (Rakitin & Kramer 1996, Chapman & Kramer 1999).
Exuma Cays Land and Sea Park, Bahamas	36	Tropical seagrass meadow	The average density of adult queen conch (*Strombus gigas*) was 15 times higher in the reserve, and late stage larval densities were 4-17 times higher (Stoner & Ray 1996).
Exuma Cays Land and Sea Park, Bahamas	10	Coral reef	The reproductive output of Nassau grouper (*Epinephelus striatus*) was 6 times greater in the reserve (Sluka et al. 1997).
Hawaii Marine Life Conservation Districts	Not reported	Coral reef	Fishes were 63% more abundant in areas protected from fishing (Grigg 1994).
De Hoop Marine Reserve, South Africa	2	Warm-temperate rocky reef	Experimental catch per unit effort increased by up to five-fold for 6 out of 10 of the most commercially important species (Bennett & Attwood 1991).
Saba Marine Park, Saba, Netherlands Antilles	4	Coral reef	In the no-take zone the biomass of target species was over twice that in fishing grounds (Polunin & Roberts 1993).
Hol Chan Marine Reserve, Belize	4	Coral reef	Biomass of target species in the reserve was on average almost double that in fishing grounds, while in certain parts of the reserve it was 10 times greater (Polunin & Roberts 1993, Roberts & Polunin 1994).
Anse Chastanet Reserve, St. Lucia	2	Coral reef	Total biomass of commercially important species was more than double that in fishing grounds, and the reserve contained 3 easily caught species found nowhere else (Roberts & Hawkins 1997).
Ras Mohammed Marine Park, Egypt	15	Coral reef	Mean biomass of fish was 1.2 times greater on protected reefs, while differences for 7 target species were much greater. Individuals of the lunartail grouper (*Variola louti*) were 3 times larger in the reserve (Roberts & Polunin 1993).
Kisite Marine	Kisite 20,	Coral reef	Abundances of key commercial species (groupers,

Reserve Name and Location	Years of Protection	Habitat Type	Effects Reported
National Park and Mpunguti Marine National Reserve, Kenya	Mpunguti 0 (open to fishing using traditional methods		snappers, and emperors) were up 10 times higher in the fully-protected Kisite Marine National Park compared to the fished Mpunguti reserve. Furthermore, keystone species such as triggerfish (a predator of urchins) were also more abundant in the Kisite Park, while their urchin prey were much more abundant in the fished Mpunguti reserve (Watson & Ormond 1994).
Three Kenyan Marine Parks: Malindi, Watamu, Kisite	Malindi 24 Watamu 20 Kisite 19	Coral reef	Reserves helped to support regional diversity by protecting species that were unable to persist in fished areas. Of the 110 species recorded on protected reefs, 52 were not found in fished areas (McClanahan 1994).
South Lagoon Marine Park, New Caledonia	5	Coral reef	Within protected areas the species richness of fish populations increased by 67%, density by 160%, and biomass by 246%, but the average size of most species did not increase (Wantiez et al. 1997).
Banyuls-Cerbere Marine Reserve, France	6	Warm-temperate rocky reef	18 target species were bigger in reserves (Bell 1983).
Shady Cove, San Juan Islands, Washington, USA	7	Temperate rocky reef	Lingcod (*Ophiodon elongatus*) were nearly 3 times more abundant in the reserve (Palsson & Pacunski 1995).
Edmonds Underwater Park, Washington, USA	27	Temperate rocky reef	The number of rockfish eggs and larvae originating from within the park is 55 times greater than outside. For lingcod (*Ophiodon elongatus*), the figure is 20 times as many (Palsson & Pacunski 1995).
Anacapa Island, Channel Islands, California, USA	20	Warm-temperate rocky reef	Densities of the commercially exploited red sea urchin (*Strongylocentrotus franciscanus*) were 9 times higher in the reserve than in nearby fished areas (Gary Davis, quoted in Fujita 1998).
Tsitsikamma National Park, South Africa	22	Rocky reef	Of the 3 species studied, 1 was 4 times more abundant in the reserve and another 13 times more. Bream (*Petrus rupestris*) were on average twice as large when protected. The biggest individuals for all species were found in the reserve, and maximum sizes in fished areas were depressed (Buxton & Smale 1989).
Sumilon Island Reserve, The Philippines	10	Coral reef	18 months after fishing was resumed in the reserve, catch per unit effort fell by a half, and the total yield of fish was 54% less, despite a greater area available for fishing (Alcala & Russ 1990).

Reserve Name and Location	Years of Protection	Habitat Type	Effects Reported
Apo Island Reserve, The Philippines	6	Coral reef	The biomass of large predators increased 8-fold in the reserve. In fishing grounds, mean density and species richness of large predators also increased (Russ & Alcala 1996).
Kyoto Preture Closure, Japan	4	Temperate sand and mud bottom	The proportion of large male snow crabs (*Chionoecetes opilio*) rose by 32% in the closed area (Yamasaki & Kuwahara 1990).
Maria Island Reserve, Tasmania	6	Termperate rocky reef	The densities of rock lobster (*Jasus rubra*) and bastard trumpeter fish (*latridopsis forsteri*) increased by 1 and 2 orders of magnitude respectively within the reserve. The numbers of species also increased for fish, invertebrates, and algae, as did the densities of fish larger than 33cm (Edgar & Barrett 1999).

For more on the design, size, location, and benefits of marine reserves, read:

Roberts, C.M. and J.P. Hawkins. 2000. Fully-protected Marine Reserves: A Guide. WWF Endangered Seas Campaign and University of York.

MARINE PROTECTED AREA OBJECTIVES

- To protect and manage substantial examples of marine and estuarine systems to ensure their long-term viability and to maintain genetic diversity.

- To protect depleted, threatened, rare or endangered species and populations and, in particular to preserve habitats considered critical to the survival of such species.

- To protect and manage areas of significance to the life cycles of economically important species.

- To prevent outside activities from detrimentally affecting the marine protected area.

- To provide for the continued welfare of people affected by the creation of marine protected areas.

- To preserve, protect and manage historical and cultural sites and natural aesthetic values of marine and estuarine areas, for the present and future generations.

- To facilitate the interpretation of marine and estuarine systems for the purpose of conservation, education and tourism.

- To accommodate within appropriate management regimes a broad spectrum of human activities compatible with the primary goal in marine and estuarine settings.

- To provide for research and training, and for monitoring the environmental effects of human activities, including the direct and indirect effects of development and adjacent land-use practices.

Source: IV World Congress on National Parks and Protected Areas. Workshop III.2.

CONSERVATION OBJECTIVES FOR PROTECTED AREAS

Sample ecosystems. To maintain large areas as representative samples of each major biological region of the nation in its natural unaltered state for ensuring the continuity of evolutionary and ecological processes, including animal migration and gene flow.

Ecological diversity. To maintain examples of the different characteristics of each type of natural community, landscape and land form for protecting the representative as well unique diversity of the nation, particularly for ensuring the role of natural diversity in the regulation of the environment.

Genetic resources. To maintain all genetic materials as elements of natural communities, and avoid the loss of plant and animal species.

Education and research. To provide facilities and opportunities in natural areas for purposes of formal and informal education and research., and the study and monitoring of the environment.

Water and soil conservation. To maintain and manage watersheds to ensure an adequate quality and flow of fresh water, and to control and avoid erosion and sedimentation, especially where these processes are directly related to downstream investments which depend on water for transport, irrigation, agriculture, fisheries, and recreation, and for the protection of natural areas.

Wildlife management. To maintain and manage fishery and wildlife resources for their vital role in environmental regulation, for the production of protein, and as the base for industrial, sport, and recreational resources.

Recreation and tourism. To provide opportunities for healthy and constructive outdoor recreation for local residents and foreign visitors, and to serve as poles for tourism development based on the outstanding natural and cultural characteristics of the nation.

Timber. To manage and improve timber resources for their role in environmental regulation and to provide a sustainable production of wood products for the construction of housing and other uses of high national priority.

Cultural heritage. To protect and make available all cultural, historic and archaeological objects, structures and sites for public visitation and research purposes as elements of the cultural heritage of the nation.

Scenic beauty. To protect and manage scenic resources which ensure the quality of the environment near towns and cities, highways and rivers, and surrounding recreation and tourism areas.

Options for the future. To maintain and manage large areas of land under flexible land-use methods which conserve natural processes and ensure open options for future changes in land use, incorporate new technologies, meet new human requirements, and initiate new conservation practices as research makes them available.

Integrated development. To focus and organize conservation activities to support the integrated development of rural lands, giving particular attention to the conservation and utilization of "marginal areas" and to the provision of stable rural employment opportunities.

Source: Miller 1980, McNeely et al. 1994

SELECTION CRITERIA cf. Salm and Clark

The following examples of criteria for protected areas in general have been compiled from IUCN (1981) and Salm (1982). The major headings represent programme goals, the numbered headings are the criteria.

Social Criteria. Social benefits are measured in the following terms:

1. *Social acceptance,* the degree to which the support of local people is ensured. When an area is already protected by local tradition or practice, it should be encouraged, and the area should receive a higher rating. An "official" protected area designation may not be necessary if local support is high.

2. *Public health,* the degree to which the creation of a protected area may serve to diminish pollution or other disease agents that contribute to public health problems. Granting protected status to contaminated areas, such as shellfish beds or bathing beaches, may result in reduced pollution as the polluting source is recognised and controlled.

3. *Recreation,* the degree to which the area is, or could be, used for recreation by country residents. Areas that provide the local community opportunity to use, enjoy, and learn about their local natural environment should receive a high rating for this criterion.

4. *Culture,* the religious, historic, artistic, or other cultural value of the site. Natural areas that also contain important cultural features should be given high ratings as their protection may help to maintain the integrity of the adjacent ecosystems.

5. *Aesthetics,* a seascape, landscape, or other area of exceptional scenic beauty. Natural areas that also contain features of natural beauty should be given higher ratings since such features depend on maintaining the integrity of the adjacent coastal and marine systems. However, when species diversity and the biological conservation value are low, and the site is picturesque, it retains a high value for recreation.

6. *Conflicts of interest,* the degree to which area protection would affect the activities of local residents. If the area is to be used for recreational purposes, for example, the site should not be a major fishing area and should have few dependent fishermen. In some instances, careful zoning can minimise such conflicts.

7. *Safety,* the degree of danger to people from strong currents, surf, submerged obstacles, waves, etc. The principal users will often be swimmers, snorkelers, divers, and boaters. It is important that they are able to pursue their activities safely.

8. *Accessibility,* the ease of access across both land and sea. Areas to be used by visitors, students, researchers, and fishermen must be accessible to them. The more accessible, the greater the value, but the greater the likelihood of conflicting interests (such as between coral mining and fisheries or fisheries and diving) and the greater the impact of users. Accessibility weighs high for goal one (social), fairly high for goal two economic), and low for goal three (ecological).

9. *Benchmark,* the degree to which the area may serve as a "control group" in the scientific sense, an un-manipulated area used to measure changes elsewhere. Benchmark areas are essential to an ecological monitoring programme and should receive a higher rating.

10. *Education,* the degree to which the area represents various ecological characteristics and can serve for research and demonstration of scientific methods. Areas that clearly demonstrate different habitat types and ecological relationships and are sufficiently large both to serve conservation and to accommodate teaching (i.e., field trips or on-site learning centres) should receive a higher rating.

Economic Criteria. Economic benefits are measured in the following terms:

1. *Importance to species,* the degree to which certain commercially important species depend on the area. Reefs or wetlands, for example, may be critical habitats for certain species that breed, rest, shelter, or feed there and that form the basis of local fisheries in adjacent areas. Such habitats need management to support these stocks.

2. *Importance to fisheries,* the number of de-pendent fishermen and the size of the fishery yield. The greater the dependence of fishermen on an area, and the greater its yield of fishes, the more important it becomes to manage the area correctly and to ensure sustainable harvest.

3. *Nature of threats,* the extent to which changes in *use patterns threaten the overall value to people. Habitats may be threatened directly by destructive practices, such as fishing with explosives and certain bottom trawls, or by overexploitation of resources. Areas traditionally harvested by local fishermen be-come important to manage. The numbers of fishermen on these grounds may increase, bringing extra pressure to bear on stocks and habitats. Even if the numbers do not change, the traditional capture methods may be re-placed by others that yield more per unit effort (an extreme example is the use of explosives). The stocks of some species may not be capable of withstanding such in-creased drains on their breeding populations. In this way whole species have disappeared from fishing grounds or have become exceedingly rare.

4. *Economic benefits,* the degree to which protection will affect the local economy in the long term. Initially, some protected areas may have a short-lived, disruptive economic effect. Those that have obvious positive effects should have higher ratings (for

example, for protecting feeding areas of commercial fishes or areas of recreational value).

5. *Tourism,* the existing or potential value of the area to tourism development. Areas that lend themselves to forms of tourism compatible with the aims of conservation should receive a higher rating.

Ecological Criteria. The values of ecosystems and their species are measured in the following terms:

1. *Diversity,* the variety or richness of ecosystems, habitats, communities, and species. Areas having the greatest variety should receive higher ratings. However, this criterion may not apply to simplified ecosystems, such as some pioneer or climax communities, or areas subject to disruptive forces, such as shores exposed to high energy wave action.

2. *Naturalness,* the lack of disturbance or degradation. Degraded systems will have little value to fisheries or tourism, and make little biological contribution. A high degree of naturalness scores highly. If restoring de-graded habitats is a priority, a high degree of degradation may score highly.

3. *Dependency,* the degree to which a species depends on an area, or the degree to which an ecosystem depends on ecological processes occurring in the area. If an area is critical to more than one species or process, or to a valuable species or ecosystem, it should have a higher rating.

4. *Representativeness,* the degree to which an area represents a habitat type, ecological process, biological community, physiographic feature or other natural characteristic. If a habitat of a particular type has not been protected, it should have a high rating. (A classification scheme for coastal and marine areas is desirable in applying this criterion).

5. *Uniqueness,* whether an area is "one of a kind. " Habitats of endangered species occurring only in one area are an example. The interest in uniqueness may extend beyond country boarders, assuming regional or international significance. To keep visitor impact low, tourism may be prohibited but limited research and education permitted. Unique sites should always have a high rating.

6. *Integrity,* the degree to which the area is a functional unit-an effective, self-sustaining ecological entity. The more ecologically self-contained the area is, the more likely its values can be effectively protected, and so a higher rating should be given to such areas.

7. *Productivity,* the degree to which productive processes within the area contribute benefits to species or to humans. Productive areas that contribute most to ecosystem sustainment should receive a high rating. Exceptions are eutrophic areas where high productivity may have a deleterious effect.

8. *Vulnerability,* the area's susceptibility to degradation by natural events or the activities of people. Biotic communities associated with coastal habitats may have a low tolerance to changes in environmental conditions, or they may exist close to the limits of their tolerance (defined by water temperature, salinity, turbidity, or depth). They may suffer such natural stresses as storms or prolonged immersion that determine the extent of their development. Additional stress (such as domestic or industrial pollution, excessive reductions in salinity, and increases in turbidity from watershed mismanagement) may determine whether there is total, partial, or no recovery from natural stress, or the area is totally destroyed.

Regional Criteria. The contribution of an area to a regional network of protected areas can be assessed in the following terms:

1. *Regional significance,* the degree to which the area represents a characteristic of the region, whether a natural feature, an ecological process, or a cultural site. The role the area plays in contributing nutrients, materials, or support for species (especially migratory ones) to the region as a whole should be evaluated. Both ecological processes and natural resources are often shared among nations, so areas contributing to the maintenance of species or ecosystems beyond national boundaries should have higher ratings.

2. *Subregional significance,* the degree to which an area fills a gap in the network of protected areas from the sub-regional perspective. This contribution may be assessed by comparing the distribution of protected areas with sub-regional characteristics. If a type of area is preserved in one sub-region, that type should also be protected in another sub-region.

3. *Awareness,* the degree to which monitoring, research, education, or training within the area can contribute knowledge and appreciation of regional values. Areas that can combine such activities as pollution monitoring and education should receive a higher rating.

4. *Conflict and compatibility,* the degree to which the area may help to resolve conflicts between natural resource values and human activities, or the degree to which compatibilities between them may be enhanced. If an area can be used to exemplify the resolution of conflicts in the region, it should receive a higher rating. Protected areas that demonstrate the benefits, values, or methods of protection or restoration should also have higher ratings.

Pragmatic criteria. The feasibility and appropriate timing of protection can be measured in terms of the following:

1. *Urgency,* the degree to which immediate action must be taken, lest values within the area be transformed or lost. Lack of urgency should not necessarily be given a lower rating since it is often best, and least costly, to protect well in advance of the threat.

2. Size, which and how much of various habitats need to be included in the protected area. Size is an important factor in designing protected areas. It has often been overlooked in the design process, resulting in severe degradation, even total destruction, of protected areas. The protected area must be large enough to function as an ecological unit to receive a high rating.

3. *Degree of threat,* present and potential threats from direct exploitation and development projects. The farther the protected area is from potential sources of accidental poisoning (such as large ports, petroleum deposits, or river mouths) the better are the survival prospects of species and communities. However, if an important habitat is severely threatened, it may be important to implement a management plan to reduce the threats to tolerable levels.

4. *Effectiveness*, the feasibility of implementing a management programme. A site that satisfies many criteria, but cannot be adequately managed (i.e., monitored, patrolled, and defended) is not of much use. Higher ratings should go to sites that are manageable.

5. *Opportunism,* the degree to which existing conditions or actions already under way may justify further action. An extension of an established protected area should have a higher rating.

6. *Availability,* the degree to which the area is available for acquisition or can be managed satisfactorily by agreement with the owners. The problem of tenure rarely applies to the sea. Beaches also often belong to the central or provincial government. Thus, acquisition of aquatic areas, wetlands, and seashores may not be necessary. However, adjacent lands and islands may be privately owned or leased. Generally, to secure long-term control over these areas, the title or lease will need to be bought from current owners. Higher ratings should go to areas owned by state or national governments.

7. *Restorability,* the degree to which the area may be returned to its former natural state. Areas that can increase in productivity or value to important species and processes should receive higher ratings.

SELECTION CRITERIA cf. Kelleher and Kenchington 1992

The following list identifies factors or criteria that can be used in deciding whether an area should be included in an MPA or in determining boundaries for an MPA.

Naturalness - the extent to which the area has been protected from, or has not been subject to human-induced change.

Biogeographic importance - either contains rare biogeographic qualities or is representative of a biogeographic "type" or types.
- contains unique or unusual geological features.

Ecological importance - contributes to maintenance of essential ecological processes or life-support systems .e.g. source for larvae for downstream areas
- integrity.
- the degree to which the area either by itself or in association with other protected areas, encompasses a complete ecosystem.
- contains a variety of habitats.
- contains habitat for rare or endangered species
- contains nursery or juvenile areas.
- contains feeding, breeding or rest areas.
- contains rare or unique habitat for any species.
- preserves genetic diversity i.e. is diverse or abundant in species terms.

Economic importance - existing or potential contribution to economic value by virtue of its protection e.g. protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others or as a refuge nursery area or source of supply for economically important species.

Social importance - existing or potential value to the local, national or international communities because of its heritage, historical, cultural, traditional aesthetic, educational or recreational qualities

Scientific importance - value for research and monitoring

International or National significance - is or has the potential to be listed on the World or a national Heritage List or declared as a Biosphere

		Re-serve or included on a list of areas of international or national importance or is the subject of an international or national conservation agreement.
Practicality/feasibility	-	Degree of insulation from external destructive influences.
	-	social and political acceptability, degree of community support.
	-	accessibility for education, tourism, recreation.
	-	compatibility with existing uses, particularly by locals.
	-	ease of management, compatibility with existing management regimes.

SELECTION CRITERIA cf. Kelleher et al 1995

Criteria for Selection of Priority Areas

Biogeographic criteria

- Presence of rare biogeographic qualities or representative of a biogeographic "type" or types; and
- Unique or unusual geological features.

Ecological criteria

- An essential part of ecological processes or life-support systems (for example, is a source for larvae for downstream areas);
- Area's integrity, or the degree to which the area either by itself or in association with other protected areas, encompasses a complete ecosystem;
- The variety of habitats;
- Presence of habitat for rare or endangered species;
- Nursery or juvenile areas;
- Feeding, breeding or rest areas;
- Rare or unique habitat for any species; and
- Genetic diversity (is diverse or abundant in species terms).

Naturalness

- Extent to which the area has been protected from, or has not been subject to, human-induced change.

Economic importance

- Existing or potential contribution to economic value by virtue of its protection (for example, protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others or as a refuge nursery area or source of economically important species).

Social importance

- Existing or potential value to the local, national or international communities because of its heritage, historical, cultural, traditional aesthetic, educational or recreational qualities.

Scientific importance

- Value for research and monitoring.

International or national significance

- Potential to be listed on the World (or national) Heritage List, declared a Biosphere Reserve, or included on a list of areas of international or national importance, or is the subject of an international or national conservation agreement.

Practicality/or feasibility

- Degree of insulation from external destructive influences;
- Social and political acceptability, degree of community support;
- Accessibility for education, tourism, recreation;
- Compatibility with existing uses, particularly by locals; and
- Ease of management or compatibility with existing management regimes.

MODEL OF MANAGEMENT PLAN cf. Kelleher and Kenchington

This example of the content of an MPA Management Plan is provided to assist those involved in the preparation of plans and submissions in government agencies and non-government organisations. It should be viewed as an ideal since it implies a planning situation where there is a high level of description and understanding of the area under investigation. The precise format adopted will depend upon the provisions of the legislation establishing the MPA and the government 'processes required for putting a management plan into effect.

The relationship between a management plan and a zoning plan is optional. In large, multiple use MPAs, the zoning plan may be the primary document that defines the strategic framework for management. In such cases it will be supplemented by various subordinate tactical documents such as guidelines arid day-to-day management plans.

The example that follows refers to the case where the management plan is the primary policy-setting document and the zoning plan is subordinate to it. In many cases, the items 1-4.1 may form a preliminary document which establishes the initial case for protection of the area in question.

All the information listed in the following example should be provided in one document or another.

TITLE PAGE

This includes:

- The name of the area subject to the plan and its status;
- The words - MANAGEMENT PLAN;
- The name of the agency/agencies responsible for implementing the plan; and
- The date when the plan was prepared and the expected date for review.

EXECUTIVE SUMMARY PAGE

On this page are summarised:

- The reason why the plan was prepared;
- The period of time for which it applies;
- Any special conditions which controlled its preparation, including the legislative basis and authority for plan development;
- The principal provisions of the plan;
- The estimated budget; and
- Acknowledgements.

CONTENTS PAGE

The headings of the body of the plan are listed here against the appropriate page numbers. It may be preferable to list only the main headings, but sub-headings are usually included.

BODY OF THE PLAN

1. Objectives for Management

The goal and objectives for management are stated in this section. They will reflect the purpose(s) for which the area is protected and the use(s) that will be permitted.

2. Resource Description

This section provides information on the following categories for the areas to be protected. Maps will be an important feature of this section.

2.1 Name of Area and Location
To include the geographic location (State district, etc.); latitudes and longitudes (preferably on a map); surface area (square kilometres, hectares or other units of area).

2.2 Geographic and Habitat Classification
The area should be categorised according to a habitat classification scheme to identify its geographic zone, substrate type(s) and major biological feature(s).

2.3 Conservation Status
This should indicate the area's degree of naturalness, aesthetic values, degree and nature of threats (if any), jurisdiction(s) and present ownership. The degree of habitat representativeness should also be indicated.

2.4 Access and Regional Context
The regional land and sea surroundings and access routes to the area are described, in addition to the character and use of contiguous areas, emphasising their effectiveness as buffer zones.

2.5 History and Development
This section contains a summary account of direct and peripheral human involvement in the area. This section may be divided into several sub-sections e.g.:

2.5.1 Archaeology

A summary description of the people who used the area before historical times, including any known areas of religious significance, species taken and if closed seasons or closed areas were ever used as management techniques. Archaeological information could also provide clues to species that were found in the area.

2.5.2 Historical relics

This sub-section should identify submerged wrecks and any submerged structures.

2.5.3 Written and oral history

2.5.4 Recent developments

Give a brief history of fishing and other human use of the area and developments on the land that may have had a major influence on the area.

2.5.5 Current human use and development

In this section the current use of the area by subsistence, artisanal, commercial and recreational fishermen, tourists and others is discussed. It is most important to establish who the users are, where they conduct their activities, at what times of the year, and for how long, and the social and economic importance of their use. A user survey may be helpful. This information is just as important as biophysical data.

2.6 Physical features

In this section the non-living features of the area are described. Maps in addition to descriptions should be included.

2.6.1 Coastal landforms

Nearby landforms should be described together with islands and underwater formations.

2.6.2 Bathymetry

A map showing isobaths is needed. The depth of water can provide an important insight into the dynamics of the system. Major trenches, canyons and shallows should be described in as much detail as is available.

2.6.3 Tides

A description of the tidal regime and resultant currents and water movements associated with phases of the tidal cycle.

2.6.4 Salinity and turbidity

Measurements of salinity and turbidity in all seasons are desirable.

2.6.5 Geology

A description in geological terms about how the area was formed and how that process is continuing with the deposition of present day substrates and by erosion processes observable in the area.

2.6.6 Dominant currents

A description of physical oceanographic features of the area, wind-driven, tidal and residual currents, on a seasonal basis.

2.6.7 Freshwater inputs

Major river and estuarine areas should be noted.

2.7 Climate

2.7.1 Precipitation

Annual precipitation figures and a chart to indicate average precipitation on s a monthly basis should be included.

2.7.2 Temperature

Monthly charts for both air and average sea temperatures (surface and at given depth). If possible include a monthly chart of solar radiation received.

2.7.3 Winds

Monthly charts of rose diagrams plus a description of any unusual feature of the local winds.

2.8 Plant life

This section should contain at least a description of dominant marine plant life, and wherever possible a comprehensive summary of the plant community and related environmental factors such as the depth of occurrence, together with any botanical features that may have special scientific, recreational or other interest. Phytoplankton could be included if information is available. Plant species identified in the area should be listed in an appendix.

2.9 Marine fauna

As a minimum, a description of the dominant marine or estuarine fauna is required, with an account of their ecological relationships if known. Include sections on Mammals, Reptiles, Amphibians, Fish, Birds, Invertebrates and Zooplankton as appropriate. A separate appendix should list the species.

Note: Sections 2.8 and 2.9 could be amalgamated to one section entitled "Marine Wildlife". Wildlife would be defined as animals and plants that are indigenous to the nation, to its coastal sea, to its continental shelf, or its overlying waters; migratory animals that periodically or occasionally visit its territory; and such other animals and plants, not being domesticated animals or cultivated plants, as are prescribed by legislation.

2.10 Miscellaneous

This can be a varied section that includes those matters which do not fit under any of the other descriptions of the plan. Each plan will be site specific and could therefore have features or problems which are not encountered in other plans.

3. Description of Management Issues

A summary of past, present and possible future threats and management conflicts should follow.

3.1 Historic and current conflicts

A brief statement of any historic or current conflicts between uses or user groups.

3.2 Pollution

Include point and non-point sources of external pollution within the area and in nearby areas, especially those up-current, e.g. runoff, sewage inputs, fish processing, industrial pollution and pollution from tourism and shipping.

3.3 Future demand

Estimate future demand for recreational and other uses, and if applicable, future pollution loading and proposed developments.

3.4 Potential conflicts

Potential conflicts specific to the area within and close to the boundary of the MPA should be described. Any potential conflicts due to more distant regional influences should also be identified. This should include review of sectoral development plans and propose projects for, or likely to influence, the area in question.

4. Management policies

In this section, the management plan comes to grips with the threats and conflicts and prescribes solutions.

4.1 Objectives

The goal of protecting the area is briefly reiterated. The objectives of management are stated clearly. If the area is to be subdivided, sub-objectives should be stated for each zone or subdivision of the managed area.

4.2 Resource units

It could be useful to divide the area into resource units.

4.2.1 Natural

Each MPA will have unique characteristics and the resource units will be site specific. An area could be divided into resource units such as beaches, islands, deep-water trenches, turtle or seal rookeries etc.

4.2.2 Development areas

Another category could be areas that are either developed or proposed to be developed.

4.2.3 Areas of impact

Areas showing marked impact from human activity could be identified.

4.3 Zoning

The resource units defined above may provide a basis for zoning, which should be kept as simple as practicable, consistent with avoiding unnecessary restriction on human activities. Zoning must be easy to understand both from the point of view of the manager and the managed. This section should explain why a particular area has been given a zone classification and what activities are permitted and prohibited within each zone.

Special habitats or wildlife areas such as a seagrass bed or a turtle rookery, may require additional management provisions such as seasonal closures or permanent restrictions to human access. Unusual prescriptions may be needed in the short term and these should be described in this section.

4.4 Management policies for resource units

In the draft management plan a list of management options can be presented in this section and a choice made between them in the final version of the plan.

5. Surveillance

This section should describe any programmes proposed to assess movement of people, vessels and aircraft within and through the area and the use made of the area.

6. Monitoring

This section should describe any biological, environmental and usage-monitoring programmes proposed for the area, when these programmes will be completed and how they are to be used in reviewing the management plan. It may also identify other monitoring programmes to be initiated during the first stage of the plan and who could carry them out. Some of the results from monitoring may eventually be included in the appendices.

7. Education and Interpretation

This section should describe programmes and co-operative arrangements with educational institutions, public associations and community groups to promote protection, wise use, public understanding and enjoyment of the MPA.

8. Enforcement

This section should outline the arrangements which will need to be made to detect apparent offences and to apprehend and prosecute offenders in order to achieve an acceptable level of adherence to.MPA regulations. No nation could afford to manage primarily on the basis of enforcement in the face of general public hostility or to apprehend every breach of regulation. Education is therefore the primary management tool.

9. Maintenance and Administration

A section will be required to address the subjects of budget, staffing, etc.

9.1 Budget

Anticipated costs should be identified so that adequate funding may be arranged.

9.2 Staffing

The management plan should indicate staffing needs and identify major functions. Volunteers, consultants and head office staff involved in the planning process should also be identified, as this will provide a more accurate indication of staffing levels. Staffing deficiencies can be predicted

and recommendations suggested. Section 9 should be updated and released as part of an annual report.

10. Information Sources

Information regarding the area will come from sources outside the manager's regular information base. These should be identified and listed wherever possible, and include those other government agencies, non-government organisations, individuals, consultants, overseas sources etc that were consulted. A bibliography should be appended.

11. Appendices

Appendix 1: Boundary and Area Description

This should provide the legal description of the area including any outstanding legal tenure or matters of existing interest that might have become clear during the development of the management plan. In most federal systems of government, there are complex and sometimes unresolved questions of jurisdiction between levels of government especially in the intertidal environment. These problems should be highlighted and, if appropriate, solutions suggested. One solution is to have complementary legislative, planning and management provisions on each side of that jurisdictional boundary. Examples of this include adjacent Federal and State Marine Protected Areas at Florida Keys and the Californian Channel Islands in the United States of America and the Great Barrier Reef Marine Park and adjacent Queensland Marine Parks in Australia.

Appendix 2: Legislation

All legislation and regulations relating to the area and their interactions, should be noted and explained. Where feasible, the legislation that prevails in the event of conflict between the provisions of different enactments should be identified. Implications for the protective status of the area should be identified.

Appendix 3: Plant Species

A comprehensive list of plant species should be attempted for the first management plan. As the process continues over the years, it is very likely that new plant species will be discovered in the area. Plant names should be listed in broad taxonomic groups, with botanical and common names where possible.

Appendix 4: Animal Species

Animal species should be listed in broad taxonomic groups: e.g. Mammals, Reptiles, Amphibians, Fish, Birds and Invertebrates and common names provided where possible.

Appendix 5: Special Features

This section could describe unusual or outstanding features of the area and could range from whale strandings, waterspouts, oil slicks to spiritual revelations and cultural beliefs.

Appendix 6: Past, Present and Proposed use

This section should attempt to provide 'more detail on uses, identify key user groups and assess the social and economic significance of areas.

Maps

The following are suggested as a minimum number of maps required.

Map 1	-	Location
Map 2	-	Land/water tenure and jurisdiction
Map 3	-	Land topography and seabed bathymetry
Map 4	-	Geology
Map 5/6	-	Dominant plant and animal communities
Map 7/8	-	Major uses
Map 9	-	Major use conflicts and threatened resources
Map 10	-	Zoning

Where practicable the use of overlay presentation is recommended in order to illustrate the associations between such factors as topography, biological communities, and uses.

MODEL OF MANAGEMENT PLAN cf. Salm and Clark

I. Executive Summary

II. Introduction

- A. Purpose and scope of plan
- B. Legislative authority for the action

III. Management Content

- A. Regional setting: location and access
- B. Resources (only facts pertinent to management, with other data in an appendix or separate document)
  1. Physical
  2. Biological
  3. Cultural
- C. Existing uses (economics, description, facilities, etc.)
  1. Recreational
  2. Commercial
  3. Research and education
  4. Traditional
- D. Existing legal and management framework
- E. Existing and potential threats and implications for management (i.e., analysis of compatible or incompatible uses, solutions)
- F. The plan
  1. Goals and objectives
  2. Management tactics
     - a. Advisory committees
     - b. interagency agreements (or agreements with private organizations,
     - c. institutions or individuals)
     - d. Boundary and zoning
     - e. New regulations
     - f. Resource studies plan
     - g. Resource management plan
     - h. Interpretive plan
  3. Administration (phased over 3- to 5-year plan)
     - a. Staffing
     - b. Training
     - c. Facilities and equipment
     - d. Budget
  4. Surveillance and enforcement
  5. Evaluation of plan effectiveness (monitoring uses, impacts, etc.) and revision
- G. References
- H. Appendices.

Indonesia Model
(Bali Barat National Park)

This is a rather old management plan (1980) prepared under the WWF Indonesia Programme and the UNDP/FAO National Parks Development Project. Follow-up and implementation of the plan is unknown. The original park did not have a marine component and the management plan was prepared in response to the Government's decision to extend the park with 6,220 ha of marine area in the early eighties.

Organization of the plan:

INTRODUCTION
- The status of planning
- Management objectives
- Marine tourism potential in Bali Barat

MARINE RESOURCES AND PROBLEMS
- Marine resources
- Human impacts on the marine habitats
- Conclusions

MANAGEMENT AND DEVELOPMENT PROPOSALS
- Conservation values and options
- Regulations, boundaries and zoning (also including permits and enforcement)
- Staffing, administration, resource management and guarding.
- Visitor use and facilities
- Summary of facilities, equipment, costs and scheduling

APPENDIX
Description of the major marine ecosystems of proposed marine extension.

Comments: This is a fairly traditional model of a management plan. The management and development section is quite detailed, although the management plan would gain in clarity by a more elaborate division into sections and subsections of the different chapters.

Netherlands Antilles Model
(Curacao Underwater Park)

This plan is called a management guide, perhaps to reflect its primary purpose to serve as a guide for management of an already established park. The park was *de facto* established in 983, but was never formally enacted by government. This has hampered the implementation of management, which has been solely based on an existing but inadequate reef management ordinance. For these reasons the plan has had little, if any, effect on actual management practice.

Organization of the plan:

PART I: DESCRIPTION

GENERAL INFORMATION
Includes location, tenure and map coverage

SITE INFORMATION
- Physical
- Biological
- Cultural
- Ecological relationships

PART II: PRESENT SITUATION

REASONS FOR ESTABLISHMENT

EVALUATION OF FEATURES AND SITE POTENTIAL

OBJECTIVES

RESOURCE USERS AND AVAILABLE FACILITIES

IMPACT OF RESOURCE USERS

PAST MANAGEMENT

PART III: MANAGEMENT ISSUES/MANAGEMENT ACTIONS

LEGAL AND MANAGERIAL CONSTRAINTS

FINANCIAL REQUIREMENTS

ADMINISTRATIVE ARRANGEMENTS

MAN INDUCED TRENDS
Includes impacts of uses, artificial beaches and mariculture

NATURAL TRENDS
Includes impact of coral diseases, bleaching, sea urchin die off, and storms

IMPACT ASSESSMENT

MANAGEMENT ACTIONS
Includes both on-site and off-site management programs

PART IV: BIBLIOGRAPHY AND RESEARCH REGISTER

Comments: The plan is well organized and very detailed, but is heavy on the descriptive/background information and light on management actions. As such it will not constitute a good model for a management planning exercise. The management plan has since been replaced by a management plan for the entire nearshore marine environment.

Turks and Caicos Marine Parks Model

The management plan relates to two almost adjacent MPAs, which were to be managed from a single operational base. The parks have been in existence for quite some time, but were not under active management. The management plan was intended to change this. The management activities for both areas are very similar in nature.

Organization of the plan:

SECTION I: BACKGROUND

- Introduction
- Objectives of the plan
- Review of existing legislation
- Resource description
- Uses and impacts

SECTION II: MANAGEMENT

- Objectives for management
- Legal framework for management
- Zoning
- Institutional framework for management
- Park equipment, infrastructure and facilities
- Public outreach, education and interpretation
- Research and monitoring
- Carrying capacity and visitor management
- Licensing procedures
- Enforcement
- Staffing and training
- Revenue generation and budget
- Timetable for implementation

SECTION III: ANNEXES

I. Information sources/bibliography
II. Legal texts
III. Job descriptions park staff
IV Visitor survey

CONCLUSIONS OF EVALUATION OF EXISTING MANAGEMENT PLANS

(Tom van't Hof, 1999)

- Management plans are being prepared by scientists, managers, consultants, or teams of experts from several agencies.

- Each author or team appears to have its own preferred model for a management plan.

- All management plans follow a general pattern, including a descriptive part and a management issues/activities part.

- Some management plans follow a strict pattern of policy, goals and objectives, strategy and actions.

- Management plans that have been prepared on the basis of extensive public consultation and review seem to be the most valuable and may have the best chances of implementation.

- Some management plans were prepared prior to implementation of management, others after IUCN has prepared a generic management plan outline which constitutes a useful basis for any organization involved in management planning.

- There is no single model that MPAs can adopt for its management planning without modifications.

- MPAs should develop its own model, based on the comprehensive outline proposed by IUCN, and using formulas and approaches of existing management plans as appropriate.

VI MARINE PARK PROJECT

SYSTEM PLANNING FOR PROTECTED AREAS

Individual protected areas, by themselves, cannot address the range and scope of environmental management issues in a country or territory. In many instances, protected areas stand out as gems in an otherwise degraded environment. As such, unless the links between protected areas, national conservation strategies, and national development strategies are identified and addressed, it becomes difficult to resolve basic conservation issues. In many cases, economic pressures and threats external to the protected area result in areas being taken out of protected area status, and used for development. In other words, system planning is one form of approach to integrated planning, linking environment and development.

A national protected area system helps to address conservation issues at a macro level. Davey (1998) explains protected areas system planning as:

- Defining the priority of protected areas as a worthwhile national concern; defining the relationships between (a) different units and categories of protected areas; and (b) protected areas and other relevant categories of land;

- Taking a more strategic view of protected areas;

- Defining roles of key players in relation to protected areas and the relationships between these players; this may include building support and a constituency for protected areas (i.e. as a means to that end, not as an end in itself);

- Identifying gaps in protected area coverage (including opportunities and needs for connectivity) and deficiencies in management; and

- Identifying current and potential impacts – both those affecting protected areas from surrounding lands and those emanating from the protected areas which affect surrounding lands.

Reasons for Adopting a System Approach to Protected Area Planning

Adrian Davey, 1998

- To relate protected areas to national priorities, and to prioritise different aspects of protected area development;

- To facilitate access to international and national funding, by defining priorities for investment in protected areas and increasing the level of confidence in the efficient use of funds and resources.

- To get away from a case by case, ad hoc, approach to resource management decision making;

- To target proposed additions to the protected area estate in a more rational and persuasive manner than ad hoc planning;

- To facilitate integration with other relevant planning strategies, such as those for national tourism, national biodiversity conservation, or sustainable development;

- To help resolve conflicts, assist in making decisions relating to trade-offs, clarify roles and responsibilities of different stakeholders, and facilitate diverse stakeholder involvement;

- To provide a broader perspective for addressing site-specific issues, such as tourism management;

- To enhance the effectiveness and efficiency of the way in which budgets are developed and spent;

- To assist in meeting obligations under international treaties;

- To assist countries to be more proactive in conservation management, and in developing effective protected area systems;

- To encourage consideration of a "system" which incorporates formal protected areas and areas outside of protected areas;

- To provide a structured framework for a system of protected areas, ranging from areas managed for strict conservation to areas managed for a range of conservation and appropriate ecologically-sound activities;

- To assist protected area agencies to build political support for protected areas as a worthwhile concern;

- To define a better process of decentralisation and regionalisation of protected area activities, resources and responsibilities, including the involvement of NGOs and the private sector; and

- To foster transboundary collaboration.

SYSTEM PLAN FOR THE BRITISH VIRGIN ISLANDS

The BVI system plan is in its third iteration, building on a system plan that was first developed in 1980. The BVI has a number of marine and terrestrial sites currently under management.

TABLE OF CONTENTS (modified)

VI MARINE PARK PROJECT

RECOMMENDED READING

Protected Areas Policy, Planning, and Management

Bunce, L., P. Townsley, R. Pomeroy, & R. Pollnac. 2000. *Socioeconomic Manual for Coral Reef Managemen*t. Global Coral Reef Monitoring Network and Australian Institute of Marine Science.

> This publication is intended to provide guidance to persons working with coral reef management in conducting socioeconomic assessments in the adjacent communities.

Ceballos-Lascuráin, H. 1996. *Tourism, Ecotourism and Protected Areas: The State of Nature-based Tourism Around the World and Guidelines for its Development*. IUCN, Gland.

> As its name suggests, this publication deals with the topic of tourism and the protected areas, reviewing issues such as: the economic value of ecotourism, tourism impacts, and ecotourism policy and planning. It's appendices contain case studies of ecotourism in protected areas, one on a coral reef ecosystem.

Davey, A.G. 1998. *National System Planning for Protected Areas*. IUCN, Gland.

> This publication deals with the issues of national level planning for protected areas. It provides a rationale for system planning, linking protected areas to wider conservation strategies and economic development. Additionally, it provides information on the essential elements of a national system plan.

Kelleher, G. 1999. *Guidelines for Marine Protected Areas*. IUCN, Gland.

> This publication is one in the "Best Practices" series published by IUCN. This book places marine protected areas in a wider social and legal context, dealing with issues such as stakeholders and communities. It provides detailed guidelines on the preparation of Management Plans and Zoning Plans for marine protected areas.

National Research Council. 2001. *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*. National Academy Press, Washington.

> This book is the result of a two-year examination of marine resources management in the USA. In addition to dealing with issues of fisheries management and marine protected areas, the book includes a chapter on the "Historical background and evaluation of marine protected areas in the United States".

Roberts, C.M. and J.P. Hawkins. 2000. *Fully-protected Marine Reserves: A Guide*. WWF Endangered Seas Campaign and University of York.

This book focuses primarily with marine reserves and fisheries. In addition to the general fisheries issues, it deals with relevant issues related to the design of marine reserves, including; size, location, degree of permanence, etc. It also includes thirteen case studies from around the world, including four from the Caribbean and two from the USA.

Salm, R.V., John Clark, and Erkki Siirila. 2000. Marine and Coastal Protected Areas: A Guide for Planners and Managers. 3rd Edition. IUCN, Washington.

This book covers a wide range of topics on marine protected areas, some in great detail. Main topics include; the role of marine protected areas, site planning and management, community involvement, selection criteria, support tools and strategies, and institutional and legal frameworks. The book also deals with marine protected areas in the context of specific ecosystems, such as coral reefs and lagoons. Additionally, it provides highlights of twenty-five case studies, six from the Caribbean and one from the USA.

Sobel, J. 1996. "Marine Reserves: Necessary Tools for Biodiversity Conservation?", in *Global Biodiversity*.1996: 8-18.

This article provides a listing of the benefits of marine reserves.

Bibliography on Marine Fishery Reserves

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February 1998

The Nature Conservancv
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Coral Gables, FL 33124, USA

1. Adams, P.B. 1979. Life history patterns in marine fishes and their consequences for fisheries management. Fishery Bulletin 78: 1-12.

Natural selection operates at the life history level to maximize the number of surviving offspring. Life history characteristics will vary in consistent patterns to meet this constraint. When theoretical patterns in life histories are investigated in terms of r and K selection and compared with actual trends in life history characteristics of fishes, the agreement between observed and predicted trends was significant. The effects of harvesting on stocks with these life history trends were investigated and it was found the K selected type species would be highly sensitive to over-fishing and, once depleted, recovery would require a long time.

2. Alcala, A. C. 1988. Effects of marine reserves on coral fish abundances and yields of Philippine coral reefs. Ambio 17:194-199.

This paper reviews the effects of long-term protective management on fish abundances at coral-reef reserves and non-reserves and on fish yields at non-reserves at four small islands in the central Philippines. One of the studied reefs lost its protection status after ten years, becoming a natural experiment on the effects of protection. Factors influencing fish yields and management problems affecting Philippine marine reserves are briefly discussed. Fish abundances were censused visually; data showed that fish abundances and standing stock of highly fished species were significantly higher in reserves than in non-reserves and control sites. Annual fish yields were estimated with daily records of fish catches from various types of gear, and with monthly samples of catches. The data revealed that protection at the ten-year site was responsible for maintaining high fish yields; it was also shown that the reserve exported biomass to the fished area. The effects of less than five years of protection at two other reek were not evident, although some species increased in abundance. A fish-monitoring program at the protected reek is intended to test the generality of the conclusions drawn from data on one reef.

3. Alder, J. 1992. Have six years of marine public education changed community attitudes and awareness? Proceedings of the 7th International Coral Reef Symposium 2: l043-105l.

The day-to-day management of the Cairns Section of the Great Barrier Reef Marine Park commenced in May of 1985. A survey to determine community attitudes towards and awareness of the marine park was conducted in August of that year. Over the next six years various public and user education programs were implemented. To gauge the effectiveness of these programs, the marine parks awareness survey was repeated in October of 1991. Preliminary results indicate changes in community awareness and attitudes.

4. Andersson, J. 1995. Marine resource use in the proposed Mafia Island Marine Park. Studies in Environmental Economics and Development, Unit for Environmental Economics, Department of Economics, Gothenburg University. 34pp.

The marine resource users in the proposed Mafia Island Marine Park include the local men, women, and children and an increasing number of outsiders, mainly from Dar es Salaam, Mtwara, Lindi, and Zanzibar. Finfish were the main marine resource, but the individual income earnings were larger for the coI1ection of corals. Octopus fishing was the activity that involved the largest number of people; this is mainly because it can be performed by women and children. Octopus is the product that had the largest difference in buying price on Mafia and selling price in Dar es Salaam. Other identified marine resource activities of significance to the locals were shell and sea cucumber collection. These had very small or no relevance for local consumption and were sold to external markets. Identified environmentally harmful activities were coral collection, dynamite fishing, the use of destructive fishing gears, and the illegal cutting of coastal and mangrove forests. The economic incentives to burn corals for the production of lime were large. Dynamite fishing was generally considered as '~ad [1]9, but there was a discrepancy in the perception of the activity between the smaller islands included in the proposed park area. The perception among the locals towards the implementation of the park was very positive. The largest expectations among the local resource users were for the park to secure and eventually improve the productivity of their fishing grounds.

5. Attwood, C.G. and Bennett, B.A. 1994. Variation in dispersal of galjoen *(Coracinus capensis)* (Feleostei:

Coracinidae) from a marine reserve. Canadian Journal of Fisheries and Aquatic sciences 51:12474257.

The dispersal of the surf-zone galjoen *(Coracinus capensis)* from the De Hoop Marine Reserve, South Africa, was investigated. Over a period of 5.5 years, 11,022 galjoen were tagged in the center of the reserve. Most of the 1,008 recoveries were at the site of release, while the remainder covered a distance of up to 1,040 km. There was no difference with respect to age, sex, or season between those that dispersed and those that did not. Six models were developed to test the hypotheses that 1) galjoen are polymorphic with respect to dispersal behavior, 2) nonreporting of tags masks a random dispersal process, and 3) the recovery distribution is the result of unequal movement rates in different areas. It is inferred from the likelihood of the various models that the tagged population was polymorphic, with fish displaying either resident or nomadic behavior. This conclusion is unaffected by a large uncertainty in the extent of nonreporting of recoveries, or by spatial variability of movement rates. The estimate of emigration from the reserve implies that the unharvested reserve population is restocking adjacent exploited areas with adult fish.

6. Ballantine, WJ. and Gordon, D.P. 1979. New Zealand's first marine reserve, Cape Rodney to Okakari Point, Leigh. Biological Conservation 15:273-280.

New Zealand's first marine reserve, Cape Rodney to Okakari Point, with an area of 500 hectares, occupies a portion of the northeastern coastline centered on a small island. The physical and biological characteristics of the reserve are outlined. The park was opened in 1977, twelve years after it was first proposed. The problems encountered and lessons learned from trying to establish the nation's first marine

2

reserve are discussed.

7. Bayle-Sempere, J.T. and Ramos-Espla, A.A. 1993. Some population parameters as bioindicators to assess the "reserve effect" on the fish assemblage. Pages 189-214 In: Qualite du Milieu Marin-Indicateurs Biologiques et Physico-Chimiques. C.F. Boudouresque, M. Avon and C. Pergent-Martmi (Eds.), GIS Posidonie, Marseille, France.

Marine fisheries reserves have been proposed as a useful tool to manage littoral fisheries. In this study, four population parameters were evaluated as to their utility as bioindicators to assess the effect of the protection on the fish assemblage. Abundance and diversity were poorly correlated with protection. Richness and size were more correlated with protection, thus were considered more suitable to assess the "reserve effect" on the fish assemblage.

8. Beets, J. and Friedlander, A. 1992. Stock analysis and management strategies for red hind, *Epinephelus* guttatus, in the U.S. Virgin Islands. Proceedings of the Gulf and Caribbean Fisheries Institute 42: 66~79.

Analysis of landings data from 1984 to 1988 demonstrated significant decline in average size and the apparent loss of large size classes of red hind, *Epinephelus* guttatus in St. Thomas, U.S. Virgin Islands. The two large islands in the U.S. Virgin Islands, St. Thomas and St. Croix, are on separate geological platforms with different species abundances; therefore. Data were analyzed separately. Fisheries parameters analyzed differed between - the two platforms. Information obtained from fisherman suggested a classic case of over-fishing spawning aggregations. The decline of red hind mirrors the demise of Nassau grouper, E: *striatus* off St. Thomas during the mid4970's. Landings information from a known spawning aggregation during 1988 and 1989 demonstrated a trend for smaller average size for red hind and a skewed sex ratio toward an abundance of gravid females. This suggests a shortage of males in the population and an increased potential for spawning failure. Strict management strategies have been recommended to reverse the present trend. Protection of spawning sites has been proposed as the first critical action for maintaining adequate spawning success. Additional management strategies, such as gear restrictions and establishment of permanent refuges, are also needed to insure adequate stock recovery.

9. Bennett, B.A. and Attwood, C.G. 1991. Evidence for recovery of a surf-zone fish assemblage following the establishment of a marine reserve on the southern coast of South Africa. Marine Ecology Progress Series 75: 17~181.

This study was designed to establish whether populations of fish species important in the catches of rock and surf anglers increased following the proclamation of the De Hoop Marine Reserve on the southern coast of South Africa. Catch per unit effort (CPUE) and size frequency distributions of angling species were

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monitored approximately monthly by angling from the shore at 2 sites in the reserve. At one site sampling commenced 2 years before the reserve was established and continued 4.5 years thereafter, allowing comparisons of periods of exploitation and protection. The other site had a long history of minimal exploitation and data collected there Z54.5 years after complete protection was considered to represent an unexploited condition. Ten species accounted for 99 percent of the catch. Following establishment of the reserve, CPUE increased for 6 of these species. The catch rates of 2 species improved ~5 fold within 2 years of protection and remained at these high levels. Recoveries were slower amongst the other 4 species, their catch rates reaching 3060 percent of the unexploited level after 2.54.5 years of protection. This study provides evidence of general stock recoveries of exploited fish species in a shallow marine habitat following protection within a marine reserve.

10.

Indonesia: components for effective marine conservation. Proceedings of the 7th International Coral Reef

Symposium 2:10014006.

The Indonesian Archipelago has a coastline of about 80,000 km, which includes some of the most productive and diverse coastal ecosystems on earth. The Indonesian coastal ecosystems are also among the most heavily exploited, especially where human population densities are high. Three main steps need to be taken in order to execute effective management programs: 1) research the ecological aspects of the reef systems; 2) produce an inventory of adverse human influences; and 3) raise public awareness through participation of communities and politicians. The most effective way to take these steps is by bilateral or multilateral cooperation and a multidisciplinary approach. The components are considered here, using examples from current and proposed activities representing some of the most long4erm on-going marine conservation programs in Indonesia.

ii.

This study evaluated a method used by the Republic of France to protect discrete marine areas of shoreline and adjacent coastal waters through designation of sites as marine nature reserves. Although much smaller in size than many national marine sanctuaries in the United States, the reserves in France represent successful efforts to protect and manage coastal marine areas. This is due in part to a high amount of local involvement during the designation process; the use of advisory committees at the reserves, as well as scientific committees that develop and conduct research projects within the sites; and the use of core areas, in which almost all human activities are prohibited or restricted, to promote re-populating of fish communities and to increase species diversity. The initiative for creating the reserves begins at the local level and is coordinated among local officials, user groups, environmental organizations, and the national government. This study describes the legal framework in which the reserves are created and examines aspects of management, scientific research, and law enforcement of a marine reserve.

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12.

277-288.

It has been hypothesized that nature reserves should be as circular as possible to maximize the total number of species conserved. Using multiple regression, this study examined the relationship between species richness on oceanic islands and island shape for 33 data sets. After accounting for the effect of island area, island shape does not explain a significant amount of the residual variation in species number in more data sets than expected due to chance alone. It is concluded that if the mechanisms controlling species richness on oceanic islands and isolated patches of terrestrial habitat are the same, then shape is not of major concern in the design of nature reserves.

13.

Increased human activities in the coastal zone has brought about an increase in user conflicts and marine resource exploitation. This article discusses the advantages of marine reserves, specifically for the enhancement of fisheries populations. The author discusses life history strategies of coral reef organisms and the susceptibility of fishery target species to over-fishing. An overview of problems associated with creating marine reserves is discussed.

14.

Reef species are vulnerable to over-fishing because of their life history characteristics. Various fisheries for reef species have declined worldwide, including the Caribbean, Gulf of Mexico, and U.S. South Atlantic. Traditional

fishery management techniques may not be practical or effectively deal with certain problems, such as by-catch and release mortality. Marine fishery reserves, areas with no consumptive usage, provide an alternative management approach with attractive attributes from a fishery prospective. Marine fishery reserves ~ ~n improve reef fish fisheries by protecting species composition, population age structure, spawning potential, and genetic variability within species. Reproductive output from reserves would help re-supply fished areas by natural egg and larval dispersal. Properly located reserves of adequate size could protect the quantity and quality of reproductive output, reduce recruitment uncertainty due to environmental variation, and ensure against management failure. Substantial empirical evidence shows that protection from fishing has increased fish abundance and availability inside and outside protected areas. A model of the red snapper fishery in the Gulf of Mexico with 20 percent of the habitat protected by reserves, show that total egg production was potentially 1,200 percent greater than under the status quo. Uncertainties remain concerning the ideal number, location, and size of reserves necessary to achieve management objectives.

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15.

Marine Sanctuary, U.S.A. Protected Areas in Resource-Based Economies: Sustaining Biodiversity & Ecological Integrity. Canadian Council on Ecological Areas National Conference and 14th Annual General Meeting. Calgary , Alberta, Canada.

The US. Congress created the Florida Keys National Marine Sanctuary in recognition of the area's unique and rich natural resources, its economic importance, and its increased anthropogenic stress. A management plan was developed based on principles of integrated coastal management as a cooperative effort by local, state, and federal agencies using a bottom-up, consensus- building approach with extensive public involvement. Unique accomplishments of the plan were the use of no-take zones in approximately 6 percent of the sanctuary, increased public involvement resulting in action concerning important problems, and the establishment of ongoing management that provides a balance between managers, government, and users. Success of the effort was based on shared common goals, dear legislative mandates, continued commitment by stakeholder and agency participants, intensive public involvement, and consensus and compromise by various users. Major drawbacks of this approach are the time and costs needed to develop a plan and the need for professional support to guide the process. Future success will require sufficient program funding, continued cooperation between participants, and the failure of those opposed to the Sanctuary to preempt the process through legislative action.

16.

73-82.

Marine biodiversity is increasingly threatened by habitat destruction, environmental changes, and overexploitation. Preventing reductions in biodiversity and promoting sustainable resource use requires new management strategies, more effective education, and strong research. There is a need to switch to less destructive and wasteful fishing methods to protect critical and sensitive habitats from development and overexploitation. Marine reserves, areas permanently protected from all extractive uses, are gaining widespread

attention as an innovative tool for conserving biodiversity while maintaining healthy sustainable fisheries. This article provides a summary of the issues surrounding the use of marine reserves as a management tool Specific details of the proposal for marine fisheries reserves in the Florida Keys National Marine Sanctuary is presented. The Sanctuary presents a unique opportunity to elucidate the relative impacts of fisheries exploitation and oceanographic processes in determining the biodiversity and abundance of reef organisms. Cooperative academic and governmental research will test critical hypotheses in order to improve marine resource management.

17.

6

This article provides a comprehensive summary of commercial, recreational, and marine life fisheries in Monroe County. Results are presented for commercial landings, recreational headboat fishery, and other recreational fishery landings. Landings for some species varied greatly over time. The most conspicuous declines were for pink shrimp, combined grouper, and king mackerel while the most conspicuous increases were for amberjack, stony crab, blue crab, and yellowtail snapper. Landings of spiny lobster have generally remained constant. The article provides a summary of management efforts in the region and problems in data interpretation and information gaps.

18. Bolsssack, J.A., Kumpf, H., Hobson, E., Huntsman, C., Able, K.W. and Ralston, S.V. 1989. Report on the concept of marine wilderness. Fisheries 14:22-24.

The Marine Wilderness Committee of the AFS Marine Fisheries Section recommends that the American Fisheries Society endorse the concept and work toward the establishment of marine wilderness areas. A suggested definition of a marine wilderness is the following: A unique or representative ecosystem or subset with geographically defined boundaries that is set aside, or protected for nonconsumptive usage. The major distinction between marine wilderness areas and other managed areas is that significant consumptive usage would not be permitted. The primary use for marine wilderness will be for research, education, and fisheries management. Marine wilderness areas offer several practical benefits for marine resource management that are not being realized under present conditions. Marine wilderness areas could 1) complement traditional fisheries management by allowing undisturbed population reservoirs to act as sources of recruitment and re-population for exploited areas; 2) help maintain natural age structure of populations, ecosystem balance, and the genetic diversity of exploited populations; and 3) act as environmental insurance in case of resource management failures by providing unexploited populations.

19. Bradstock, M. and Gordon, D.P. 1983. Coral-like bryozoans growths in Tasman Bay, and their protection to conserve commercial fish stocks. New Zealand Journal of Marine and Freshwater Research 17:159-163.

Mounds of coral off Separation Point, Tasman Bay, which have recently been protected to conserve ecologically associated commercial fish species, are predominantly growths of bryozoans. Two species make up the bulk of these structures. Trawling through the coral grounds has affected the fish populations to the extent that an area has been closed to trawling to conserve stocks.

2(). Buechner, M. 1987. Conservation in insular parks: simulation models of factors affecting the movement of animals across park boundaries. Biological Conservation 41:57-76.

Many parks represent insular areas of habitat and the movement of animals across park boundaries can be critical to park wildlife populations. This study used computer simulation models to analyze factors

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affecting the movement and density of animals in patches of habitat. The results suggested that the perimeter to area ratios and edge permeability of parks, the appearance and stopping patterns and habitat preferences of moving animals, and the relative size of dispersal sinks and source pools can all potentially influence the direction and magnitude of the movement of animals across the park boundaries. The results suggest that scientists interested in park and reserve design need to consider other factors than just the size of potential sites, particularly park perimeter to area ratios. The simulations also suggest a strategy for solving some types of conservation and control problems by manipulating sinks or pools: 1) identity which factors can be practically altered in a given situation, 2) evaluate those factors to estimate their current levels, and 3) focus on the factor that is nearest to the lower end of its range of values.

21. Buxton, C.D. 1992. The application of yield-per-recruit models to two South African sparid reef species, with special consideration to sex change. Fisheries Research 15:146.

Yield-per-recruit models were applied to *Chiysoblephus laticeps* and C. *cristiceps* both of which are important to the line-fishery industry in South Africa. Sex change and slow growth were investigated, particularly with respect to the ratio of males to the total number of mature fish in the population. Predictions based on the yield-per-recruit and spawner-biomass-per-recruit models were viewed with caution owing to the rapid decline in the number of survivors past the age of recruitment, and their failure to take into account the effects of sex change on the reproductive potential of the population. Model predictions correlated well with observations that indicated a relationship between population structure and the level of exploitation. Considering the options for the management of these and similar reef fishes, the tactic of protection through marine reserves is supported.

22. Buxton, C.D. 1993. Life-history changes in exploited reef fishes on the east coast of South Africa. Environmental Biology of Fishes 36: 47~3.

The impact of exploitation on various life-history characteristics of two sex changing, reef-dwelling sparid species was examined by comparing populations protected in a large marine reserve with those adjacent to the reserve in South Africa. Like other sparids, *Chrysoblephus laticeps* and C *cristiceps* grow slowly and are long lived, reaching ages of 17 and 21 years, respectively. No significant differences in the growth rate of C *laticeps* were measured, but growth in C *cristiceps* was significantly slower in the exploited population. Observed data showed that sex ratios outside the marine reserve were skewed towards females, a result of size selective exploitation. Size at sex change was also significantly smaller for C *cristiceps* in the exploited area, but not for *C laticeps.* This differences between the species was explained as a function of the size at recruitment into the fishery and the degree of protection afforded both large females and male fish. Considering the possibility that reproduction could be impaired as a result of changes in population structure, the tactic of protection through marine reserves is supported as a hedge against recruitment failure.

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23. Buxton, C.D. and Smale, MJ. 1989. Abundance and distribution patterns of three temperate marine reef fish (Teleostei: Sparidae) in exploited and unexploited areas off the southern Cape coast. Journal of Applied Ecology 26:441451.

Visual underwater census was used to determine the abundance and size structure of three conspicuous marine reef fish species on the southeast Cape coast, South Africa, during 1984-86. Sites inside the Tsitsikamma Coastal National Park and outside the reserve at Cape Recife were compared to evaluate the effectiveness of the reserve as a management option for the fish. Three sparids were studied: *ChrysobIephus laticeps, C cristiceps,* and *Petrus* rupestris Transect techniques suggested that point counts were best suited for mobile species, while line counts were best suited for more sedentary species. Distribution of the target species within an area was correlated with depth and substratum relief, both factors reflecting feeding and habitat preferences. Fewer fish were found in shallow water and on flat reefs. During cold upwelling, fish moved away from the study area, presumably following warmer water. Seasonal differences were observed in the abundance of *C laticeps* abundance was greatest in summer. Sampling showed that the abundance and size of fishes was greater within the reserve. The data suggested that the reserve is providing effective protection for species vulnerable to line-fishing.

24. Cabanban, A.S. and White, A.T. 1981. Marine conservation program using non-formal education at Apo Island, Negros Oriental, Philippines. Proceedings of the 4th International Coral Reef Symposium 1:317-321.

The Apo Island Marine Conservation Program was conducted from July 1979 to March 1980. The objectives of the program were to develop environmental awareness among the residents and to begin the establishment of a marine park in the island. Operational generalizations of non4ormal education, relevant to this program, were applied. These include the 1) help of local leaders, 2) the winning of villager support and commitment, and 3) the adoption of effective communication systems and methods. In particular, techniques such as lecture-slide presentations; forums, or group distribution of printed materials were used. Non-formal education was a useful tool to these objectives as shown by the considerable success achieved in cultivating environmental awareness, understanding, and approval of the establishment of a marine park by some. The trade-off between the relative difficulty of instituting non-formal educational methods and the relative effectiveness of these methods are discussed. This paper attempts to thresh out the problems encountered in the program and propose recommendations from which biologist and others who conduct efforts along this line may glean some insights.

25. Caribbean Fisheries Management Council. 1993. Amendment 2 to the fishery management plan for the shallow-water reef fish fishery of Puerto Rico and the US. Virgin Islands. U.S. Department of Commerce, Washington, D.C. 29pp.

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Amendment 2 would 1) expand the management unit to incorporate the most important species of the deepwater reef fish fishery and fin fish species taken in the marine aquarium trade; 2) add measures to reverse the decline of certain reef fish species; 3) restrict harvest and gear for various species in need of protection; 4) close spawning aggregation areas to conserve red hind and mutton8snapper.

26. Castaneda, P. and Miclat, R.I. 1981. The municipal coral reef park in the Philippines. Proceedings of the 4th International Coral Reef Symposium 1:287-291.

The importance of coral reefs to an archipelagic country like the Philippines cannot be overemphasized. Coral reefs provide shelter, spawning, nursery and feeding grounds for various edible and commercially important marine organisms, thus providing an important source of protein. Presently, Philippine coral reefs are subjected to various stresses and perturbation and over-exploitation. Marine parks are now being established to give protection to significant portions of our coral reef areas. Because of the geographical and socioeconomic situation of the country, management of marine parks on conventional modes is rendered difficult if not impossible. It is in this context that a municipal coral reef park was conceptualized. The system calls for the establishment of small protected areas managed and protected by the local government which will complement the national marine park system being envisioned for the country.

27. Castilla, J.C. and Bustamente, R.H. 1989. Human exclusion from rocky intertidal of Las Cruces, central Chile: Effects on D *urvillaea antartica* (Phaeophyta, Durvilleales). Marine Ecology Progress Series 50: 2()3~214.

On the exposed rocky shores of central Chile there exists a continuous small-scale harvesting of bull-kelp, *Durvillaea antarctica,* by mariscadores (shellfish and algae gatherers). These harvest both fronds and stipes for human consumption. To assess the effects of human activity on D. *antartica,* the density, standing crop, and size structure of the kelp were compared in non- harvested and regularly harvested areas. Both coastal mainland and small islands were included in the fenced and unfenced areas. Unfenced areas were expected to receive less human disturbance than unfenced mainland areas, because the islands were less accessible to harvesters. Populations of kelp underwent great fluctuations in abundance throughout the study period. Comparisons between harvested and unharvested areas revealed significant differences in density, biomass, and size structure. In contrast, no significant differences were found between nearshore islands inside and outside the fenced area. Sources of variation in abundance of populations corresponded to recruitment, natural mortality, and harvesting. Interaction between time and extent of exploitation is significant when biomass is considered. The existence of protected areas and of areas of difficult access to mariscadores allows the preservation of populations and facilitates re-population of harvested zones.

28. Clark, J.R., Causey, B. and Bohnsack, J.A. 1989. Benefits from coral reef protection: Looe Key Reef, Florida. Coastal Zone '89: Proceedings of the 6th Symposium of Coastal and Ocean Management 4: 307~3086.

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By 1988, there were approximately 135 protected coral reef areas in the Caribbean and 123 in Southeast Asia. Major reasons for reef protection are enhancement of tourism, conservation of fish stocks, and prevention of shore erosion. This paper addresses conservation of fish stock in the United States (Florida Keys) and the Philippines (Central Visayas). Changes in fish abundance on study reef in both regions were determined by quantitative$_1$ before-and-after, studies of fish abundance at protected coral reef areas. Four Philippine projects to increase fish yields by creating inviolate replenishment zones, or reserves, are compared with one project in the United States to protect an intensively used coral reef for ecological, tourist, and fishery purposes. In all cases, a marked increase in desirable species was observed after strict protection was applied. For example, snappers (Lutjanidae) increased by an average of 47, 213, and 2850 percent in the Apo, Pamilacan, and Balicasag island projects in the Philippines, respectively. Snappers increased by 93 percent and grunts by 439 percent in the Looe Key National Marine Sanctuary. The success of these management experiments is most welcome now when the world's coral reefs are suffering increasing exploitation and diminishing faunal resources.

29. Cocks, K.K. .984. A systematic method of public use zoning of the Great Barrier Reef Marine Park, Australia. Coastal Zone Management Journal 12:359-383.

This paper is an abridged version of a report on the application of a land-use planing method developed by the Commonwealth Scientific and Industrial Research Organization to the task of providing a zoning scheme for a portion of the Great Barrier Reef Marine Park. The approach involves the development of guidelines for making zoning decisions, the development of methods for measuring whether a scheme satisfies these guidelines, and the use of a computer-aided technique to create successive schemes for evolution against these guidelines.

3(). Cole, R.G. 1994. Abundance, size structure, and diver-orientated behavior of three large benthic. carnivorous fishes in a marine reserve in northeastern New Zealand. Biological Conservation 70: ~99.

Spatial patterns in densities and population size structures of three large benthic carnivorous fishes, and behavior of one of these species, were compared in different parts of the Cape Rodney to Okakari Point Marine Reserve, northeastern New Zealand. As human activity is focussed in the central area of the marine reserve, perceptions of the effects of marine reserve protection may be biased if this area is not representative of the entire marine reserve. Abundances of cheilodactylus spectabilis and Pagrus auratus showed great variation among sites, while those of *Parapercis colias* were lower and less variable. During summer and winter, large *P auratus* were more abundant in the mid section of the marine reserve. *P auratus* of all sizes were attracted to divers and allowed them to approach more closely in the mid section of the marine reserve. Consequences or protection from harvesting are confounded with human-orientated behavior of P. auratus. Feeding of fish by divers may have altered the behavior of this species.

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31. Cole, R.G., Ayling, A.M. and Creese, R.G. 1990. Effects of marine reserve protection at Goat Island, northern New Zealand. New Zealand Journal of Marine and Freshwater Research 24:197-210.

The possible effects that marine reserve protection has had on densities of some reef fish and large invertebrates were investigated near Leigh, New Zealand, by a series of sampling programs from 197~88. Fish counts at intervals during the 6 years after the initial establishment of the Cape Rodney to Okakari Point Marine Reserve in 1975 suggested that red moki *(Cheilodactylus spectabilis)* had increased in abundance, whereas five others had remained at approximately constant densities. A comparison of data between 1978 and 1988 also revealed few consistent differences in fish abundances. A detailed survey in 1988 between sites inside and outside the marine reserve showed no dear patterns for sea urchins and several fishes. Most of the trends, however, were not statistically significant, owing largely to the low power of the tests used. Although it is now generally accepted that the creation of marine reserves such as the one at Leigh result in increased abundances of certain organisms, this study highlights the difficulty of rigorously demonstrating this, especially for patchily distributed and mobile fish species.

32. Colin, P.L. 1992. Reproduction of the Nassau grouper, *Epinephelus striatus* (Pisces: Serranidac), and its relationship to environmental conditions. Environmental Biology of Fishes 34:357-377.

Spawning aggregations of the Nassau grouper, *Epinephelus striatus,* occurring at the southern end of Long Island were investigated during the winters of 19874988 and 19884989. Fish aggregate at two specific sites around the time of the fill' moon in December and January, possibly not during November and almost certainly not during February. At one site the fish aggregate well inside the shelf edge while at the other they are on the drop-off into deep water. Fish migrate, probably as distinct groups of about 500 individuals, to the sites on or before the fill' moon and remain for several days. There was no significant difference in the size of males and females caught from the aggregations between years or months. The female/male sex ratio was between 5:1 and 3:1. Courtship occurred in late afternoon with spawning commencing shortly before sunset. Most spawning occurred with 10 minutes of sunset. Water temperatures were 25.025.5 degrees Celsius during a period of gradual decrease towards the annual minimum in February and March. Two color patterns were important in courtship and spawning. The Bicolor' pattern is a submissive coloration indicating a non-aggressive state acquired by both males and females near the time of spawning. The 'dark' phase is acquired by females who are followed by numerous bicolor fish during courtship and they lead spawning events in this pattern. Spawning occurred among subgroups of the aggregation numbering ~25 fish; gamete release was well above the bottom. Drogues deployed with the gametes either moved inshore or did not move far away from the shelf edge over the course of several days. Nassau groupers may not strictly be protogynous hermaphrodites and other groupers that form spawning aggregations may not be so either. Latitudinal shifts in spawning time may be related to water temperatures. Currents at aggregation sites do not appear to favor offshore transport of eggs. Questions of whether spawning aggregations should be protected

need to be answered.

33. DeMarini, E.L'. 1993. Modeling the potential of fishery reserves for managing Pacific coral reef fishes. Fishery Bulletin 91:414427.

The potential use of marine fishery reserves (MFRs) for managing fisheries on tropical Pacific coral reefs was assessed using the Beverton-Holt model The effects of year-round fishery closures on harvests in adjacent[1]

exploited areas were evaluated. Potential changes in spawning stock biomass per recruit (SSB/R) and yield per recruit ~/R) were estimated from published data, approximated natural and fishery mortality rates, size- and maturity-at-age distributions, and transfer (emigration and immigration) rates. For select cases, fundamental transfer rates were adjusted for possible density dependent emigration from closed areas as relative densities decreased in surrounding nonclosed areas because of continued fishing. Three hypothetical "fish types" Were constructed, bracketing the likely extremes in fundamental transfer rates - and related life-history parameters of Pacific coral reef fishes: a small-bodied, fast-growing and short-lived, strongly philopatric species of damselfish was contrasted with a large-bodied, relatively slow-growing, long-lived, vagile species of jack. A **"surgeonfish" type** was used to represent intermediate parameter values. Simulations corroborate previous observations that MFRs contribute little, if anything, towards increasing Y/R. Results for highly vagile jack confirm that rapid transfer rates will negate potential gains in SSB/R resulting from closures. At the opposite extreme, small reef philopatriots like damselfishes would almost never be harvested, because of negligible transfer rates, unless the MFR was periodically opened to fishing. The simulations suggest that the SSB/R of surgeonfish type is the most likely to benefit from MFRs, because moderate vagility allows biomass to accumulate within the closure despite harvesting in the nonclosed area. Results further suggest that growth rate, fishing effort in the nonclosed (open) area, natural mortality, maturity, and harvesting schedules influence the potential of MFRs to augment SSB when transfer rates are low to moderate.

34. Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biological Conservation *7:129446*.

A system of natural reserves, each surrounded by altered habitat, resembles a system of islands from the point of view of species restricted to natural habitats. Recent advances in island biogeography may provide a detailed basis for understanding what to expect of such a system of reserves. The main conclusions are as follows: The number of species that a reserve can hold at equilibrium is a function of its area and its isolation. Larger reserves, and reserves located close to other reserves, can hold more species. if most of the area of habitat is destroyed, and a fraction of the area is saved as a reserve, the reserve will initially contain more species than it can hold at equilibrium. The excess will gradually go extinct. The smaller the reserve, the higher will be the extinction rates. Estimates of these extinction rates for bird and mammal species have recently become available in a few cases. Different species require different minimum areas to have a reasonable' chance of survival. Some geometric design principles are suggested in order to optimize the function of reserves in saving species.

35. Dugan, J.E. and Davis, G.E. 1993. Applications of marine refugia to coastal fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 50:2029-2042.

Marine fisheries refugia, unaltered areas that serve as sources of replenishment, can potentially compensate for recruitment and ecosystem over-fishing and enhance fishery yields for some coastal stocks. The efficacy of refugia in fisheries management is virtually untested, despite the existence of many marine parks and reserves. Evidence from existing marine reserves indicates that increased abundance, individual size, reproductive output, and species diversity occurred in a variety of marine species in refuges of various sizes, shapes, and histories in communities ranging from coral reefs to temperate kelp forests. Fishery yield enhancement in areas surrounding refuges occurred in the few studies where yields were examined. The export of propagules required to enhance fisheries in areas surrounding refugia adds a level of complexity to the design of fishery refugia beyond that of terrestrial reserves. Fishery refugia design should consider species life histories, oceanographic regimes, habitat quality, and socioeconomic factors. Further evaluation of existing marine refuges and the investigation of experimental refugia over appropriate time spans will help resolve questions of optimal sizes, shapes, and distribution of fishery refugia.

36. Eldridge, M. 1994. The last wild place: Marine reserves and reef fish. Center for Marine Conservation, Washington, D.C. 19 pp.

This summary article presents information on the status of fishery resources and the importance of marine fishery reserves in protecting the long- term viability of commercial species in the Florida Keys. The article provides an overview of the decline in many commercial stocks, such as grouper, and the possible benefits to areas in the Florida Keys closed to fishing.

37. Francour, P.1994. Pluriannual analysis of the reserve effect on ichthyofauna in the Scandola natural reserve (Corsica, Northwestern Mediterranean). Oceanologica Acta 17:309-317.

From July 1988 to September 1992, SCUBA divers used a non-destructive sampling method to study the fish communities of rocks and seagrass beds in Scandola Marine Reserve. Sites were established in the integral reserve (protection of the marine environment), in the non-integral reserve (partial protection), and outside the reserve. Average density and biomass of the sampled population in seagrass beds showed no significant difference between the sties in the integral reserve and the others. Only the integrally -protected shallow- and deep-water zones shoed considerably reduced seasonal variations. For rocky substrata, the integral reserve site demonstrated higher density and biomass than the other sites. The impact of seasonal variations on the sampled population was not reduced in this biotope, as in the seagrass beds. Whatever the biotope, the demographic structures of the fish population sampled in the integral reserve and in the other sites were different. Species diversity was slightly greater in the seagrass bed sites of the integral reserve, but

site variations were not significant This was also true for rock substrata; in contrast, lesser seasonal differences were recorded in the integral reserve than outside. Three conclusions can be drawn from these pluriannual observations: 1) the reserve effect is real, not just theoretical, and affects the fish population in both rocks and seagrass beds; 2) the two habitats studied react very differently to protection which reduces anthropogenic disturbances; and 3) the reserve effect comprises both a refuge and a buffer effect. The refuge effect is the most traditionally highlighted and is characterized by larger fishes and a greater variety of species and noble fishes. The buffer effect, never shown in previous studies, is characterized by the fact that the impact of seasonal variations on parameters such as density, biomass, and diversity is considerably lessened.

38. Game, M. 1980. Best shape for nature reserves. Nat ure 287: 63(~32.

The idea of classical island biogeography have been used to derive rules for the optimal design strategy for nature reserves. For example, some scientists have stated that, given limited financial resources, it is better to purchase a few large reserves rather than many small ones of equal total areas; and that reserves should be as dose to one another as possible. The validity of some of these rules has, however, been questioned. For example, it has recently been shown that several small reserves may contain more species than a single one of equivalent area. These rules have nevertheless been accepted uncritically by others, including the IUCN. This study examined the hypothesis that reserves should be as round as possible and conclude that in certain circumstances the optimal shape may be other than circular. There is no a priori reason for believing that these circumstances are unrealistic. The author reasoned that the rule that reserves should be as close to each other as possible is inconsistent with the statement that they should be circular.

39. Goeden, G.B. 1982. Intensive fishing and a 'keystone' predator species: ingredients for community instability. Biological Conservation 22:273281.

A series of surveys of demersal fish stocks were carried out along the Great Barrier Reef in order to assess their condition and to investigate the effects of fishing on the large-predator community. Results from the surveys indicate that a significant relationship exists between the abundance of a keystone predator species and the distance from major human population centers. Removal of this predator through fishing has the effect of bringing about changes in the relative abundance of other large predatory species including several that do not comprise part of the usual catch. Although the changes in community structure are apparently unpredictable, it is possible to calculate a measure of community flux which reflects the rate of this change relative t variations in the abundance of the keystone species.

4(). Greene, LE. and Shenker, J.M. 1993. The effects of human activity on the temporal variability of coral reef fish assemblages in the Key Largo National Marine Sanctuary. Aquatic Conservation: Marine and Freshwater Ecosystems 3: 18~2()5.

A visual assessment method, called Discrete Group Censusing, was used to assess and monitor five coral reef fish assemblages in the Key Largo National Marine Sanctuary, Florida. Samples were obtained quarterly from Winter 1988 to Autumn 1990 to investigate a possible relation between the variability of reef fish assemblages and human disturbance. Two types of disturbance were studied: a ship grounding that occurred 4 years previous to the study, and intensive, recreational snorkel and SCUBA diving. These disturbances appeared to have no short term effect on the temporal variability of the reef fish assemblages during the study period. Furthermore, the assemblages at all five study sites appeared to be extremely stable over the 2 year period of the study. These results support the theory that coral reef fish assemblages are highly ordered and stable over relatively large spatial scales. The Discrete Group Censusing visual assessment method was found to be a valuable and easily applied tool for the nondestructive in *situ* monitoring of reef fish assemblages on coral reefs.

41. Grigg, R.W. 1994. Effects of sewage discharge, fishing pressure and habitat complexity on coral ecosystems and reef fishes in Hawaii. Marine Ecology Progress Series 103:25-34.

The major factor controlling the abundance of reef fishes in Hawaii appears to be habitat complexity. Fishes aggregate in areas of high habitat complexity at biomass levels which, in areas protected from fishing, may significantly exceed levels supported by primary production within the ecosystem. High relief natural areas act like artificial reefs in terms of aggregating fishes. Reef fish abundance is also affected by fishing pressure in the main Hawaiian Islands. Areas protected from fishing support standing crops of reef fishes that average about 43 grams per square meter higher than areas open to fishing. in areas unprotected from fishing, reef fish abundance has significantly declined in recent years. Conservation and management of reef fishes would be improved **f** more high relief areas were protected from fishing. Thus far, 11 no-fishing zones have ~ established in such areas as Hawaii. The discharge of primary or secondary sewage effluent into the ocean m Hawaii through deep ocean outfalls causes no apparent negative environmental impact to coral reef ecosystems. Increases in abundance around the outfalls appears to result from increased habitat complexity brought about by the construction of the pipelines and surrounding caprock and concrete. A small amount of the variability in reef fish abundance around the outfalls may also be due to food subsidies. No species of fish, coral, invertebrate, or algae at the outfalls exhibited any pathological symptoms. Hence, statewide declines in reef fish abundance in areas unprotected from fishing are not related to the discharge of sewage effluent via deep ocean outfalls. Rather, these declines appear to have been caused by over-fishing.

42. Harmelin, J.~., Bachet, F. and Garcia, F. 1995. Mediterranean marine Reserves: Fish indices as tests of protection efficiency. Marine Ecology 16:233-250.

The fish assemblages of a strictly protected area and of a neighboring fished area, located off a Mediterranean urbanized coast (Carty-le-Rouet, France), were compared in order to select the most evident, constant, and easily recorded indices of the reserve effect. Visual censusing was repeated simultaneously at

both sites eight times a year during 3 years along four permanent transects laid on shallow rocky bottoms (9-14 m). Overall species richness was 16 percent higher in the reserve, but differences in average instantaneous richness were only marginally significant. The most contrasting results were shown by the occurrence frequency, abundance, and demographic structure of two types of target species. The type A target species group comprised 16 large meso- and macro -carnivores particularly threatened by spear-fishing. Type B target species were represented by two small territorial fishes particularly impacted by angling. Fishing pressure is assumed to modify the social conditions of the local populations of certain target species and to induce earlier sex change.

43. Holland, K.N., Lowe, C.G. and Wetherbee, B.M. 1996. Movements and dispersal patterns of blue trevally *(Caranx melampygus)* in a fisheries conservation zone. Fisheries Research 25:279-292.

The short- and long-term movement patterns of blue trevally *(Caranx melampygus)* were monitored using a combination of sonic tracking and tag-and-release techniques. All fish were captured and released on the patch reef surrounding Coconut Island in Kaneohe Bay, Oahu, Hawaii, which has been a no-fishing conservation zone for over 30 years. Sonic tracking produced fine-scale movement data from five fish for periods spanning up to 18 days. All fish displayed diel movement patterns within consistent home ranges, which encompassed different parts of the reef during the night than during the day. Movements were predominantly along the walls of the patch reef, with occasional foray s to nearby sections of adjacent reef Four-hundred and ten fish were tagged and released on the Coconut Island reef, and the recapture of 85 fish indicated that most did not move far from their point of release; 75.5 percent were recaptured within 0.5 km of their release point. Time at liberty ranged from 4 to 454 days, and distance between release and recapture sites was not related to time at liberty. Some fish were observed many times in the same areas over periods of several months. Both the tracking and recapture data indicate strong site fidelity in this species and low occurrence of long distance emigration. These behavioral traits suggest that successful husbandry of this species may be accomplished through the use of management practices such as establishing no-fishing zones.

44. Holland, K.N., Peteson, J.D., Lowe, C.G. and Wetherbee, B.M. 1993. Movements, distribution and growth rates of the white goatfish *Mulloides flavolineatus* in a fisheries conservation zone. Bulletin of Marine science 32:982-992.

The movements, growth rates, and distribution of a population of white goatfish, *Mulloides fiavolineatus,* were investigated using a combination of tag-and-release and sonic tracking techniques. The study site was a 137 square *km* patch reef that has been a no-fishing conservation zone for over *30* years. The population showed

high site fidelity; 93 percent of recaptures occurred at the release site, with times at liberty of up to 531 days. Tracking revealed crepuscular movements away from daytime schooling sites to consistent nighttime foraging grounds up to 600 m away. The route taken between daytime and nighttime habitats was the same each night. Surround-net quadrats were used to measure goatfish densities on the nighttime feeding

grounds. The high site fidelity and limited range of diel movements of these fish indicates that quite small harvest refugia can serve to effectively protect populations of mature adults, and that for most of the year, emigration of adults into adjacent fisheries was minimal.

45. Jennings, S., Grandcourt, E.M. and Polunin, N.V.C. 1995. The effects of fishing on the diversity, biomass, and trophic structure of Seychelles' reef fish communities. Coral Reefs 14:225-235.

A fishery independent underwater visual census technique was used to assess the effects of fishing on the diversity, biomass, and trophic structure of the diurnally active non-cryptic reef-associated fish communities of the Seychelles. One-hundred and thirty4our species associated with three significantly different types of reef habitat were censused at one protected ground and in six fishing grounds subject to different fishing intensities. There was an inverse relationship between fishing intensity and the biomass of several species targeted by the fishery. The diversity of families containing target species (Lutjanidae, Lethrinidae) was significantly higher at protected and lightly fished sites as was the total biomass of the fish community and the biomass of piscivorous, piscivorous/invertebrate feeding, and herbivorous trophic groups. However, there was no indication that the biomass of non-target species increased in response to the removal of their predators by fishing. The findings of this study are significant for fishery managers because they suggest that intensive differential cropping of top predators will not necessarily lead to increases in the biomass and productivity of prey.

46. Jennings, S., Marshall, 5.5. and Polunin, N.V.C. 1996. Seychelles' marine protected areas: Comparative structure and status of reef fish communities. Biological Conservation 75: 2()1-209.

Effective management of Seychelles' reef resources is essential because the conflicting demands of fishing, tourism ~ conservation must be reconciled if sustainable development and the protection of natural resources is to be assured. Marine protected areas play a key role in the existing management strategy and yet there is little quantitative understanding of the benefits they may provide. This study compared the biomass and species richness of fish assemblages on coral and granitic reef habitats in four areas which receive different levels of protection from fishing and other human activities. Species richness and biomass were higher on both coralline and granitic reefs in two marine protected areas where protective regulations were effectively enforced. However, the biomass of the three principal families of fishes targeted by the fishery was significantly lower in one of these areas. This was attributed to illegal fishing and the fishing concessions offered to local people. The

authors conclude that poaching and minor fishing concessions did not affect the aspects of the fish community which are important to most tourist visitors, but that they have a statistically significant effect on the structure of the fish community. Furthermore, whilst a small well-patrolled area will provide an effective refuge from fishing, it will often be stocked by larval fishes which are the progeny of adults living many kilometers away. As such, the protected area cannot operate in isolation to maintain biomass and diversity. A valid long4erm aim of reserve management may be to assure the protection of a greater proportion of Seychelles' fishes throughout their life history. This may be achieved if current plans for

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the management of marine protected areas can be instituted.

47. Johannes, R.E. 1981. Working with fishermen to improve coastal tropical fisheries and resource management. Bulletin of Marine Science. 31: 673~80.

Marine resource development and management schemes in developing countries have often been designed without significant consultation with, or understanding of the users of these resources. They often fail in consequence. Tackling resource management problems at the village level is thus increasingly encouraged. Collaborating with villagers provides opportunities and difficulties quite unlike those encountered in more conventional environmental studies. Specific examples are given of how working with artisanal fishermen can y ield otherwise inaccessible insights into such matters as: unappreciated resource areas and their vulnerability to damage through coastal development$_1$ important aspects of the biology of target species, relevant local oceanographic phenomena, the local cultural palatability of proposed management schemes, and local traditional conservation practices of continuing value. Appropriate research methods are also briefly discussed.

48. Kelly, G.C. 1992. Public participation and perceived relevance as critical factors in marine park management. Proceedings of the 7th International Coral Reef Symposium 2:1033-1037.

The success of management for the conservation of marine resources in a democratic country is directly related to public understanding, sympathy and support. Support for attempted management may d('.rive from a perception of its' relevance to supporting individuals and organizations. he perceived relevance of management arrangements to certain users of marine reserves in five countries was examined. Public communication programs conducted to encourage public support were examined, and common successful components identified. Compliance with regulations as an indicator of public support for management constraints, was compared. Cultural differences in acceptance of the need for a particular style of management should be incorporated into public communication programs.

49. Lomolino, M.V. 1994. An evaluation of alternative strategies for building networks of nature reserves. Biological Conservation 69: 24~249.

The challenge to maintaining bio-diversity with limited funding and personnel puts a premium on building reserve networks that maximize species number per area. This study compared two alternative strategies suggested by the SLOSS debate (accumulating nature reserves from small-to-large (STL) or large4o-small (LTS) to the best possible network of reserves. The best network was determined by a computer program that considered all possible combinations of reserves and then selected the subset that satisfied a specified selection criterion. Here, the selection criterion was that the subset included all target species in the smallest total area. In addition, the author compared alternative strategies to a null model of randomly

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accumulated reserves. For ten data sets including a diversity of biotas (non-volant mammals, bats, birds, reptiles, amphibians, ants, isopods, and plants), the author found the STL and LTS strategies to be equivalent in maximizing species number per area. To include all target species, however, both strategies required much more area than the best possible network and, in most cases, more area than random accumulation of reserves. These results argue strongly against generic prescriptions for conserving bio-diversity. Given empirical studies on the biota in question, analytical solutions such as presented here will serves as valuable tools for preserving bio-diversity.

50. Man, A., Law, R. and Polunin, N.V.C. 1995. Role of marine reserves in recruitment to reef fisheries: a metapopulation model Biological Conservation 71: 197-2()4.

While marine reserves can replenish local populations of reef fishes through enhanced survivorship of post-recruitment fishes, the manner in which reserves enhance larger-scale recruitment is poorlyunderstood. This study investigated a metapopulation model to evaluate how marine reserves might conserve such populations and benefit fisheries. The model defines two kinds of patches: 1) those open to fishing and 2) those maintained as reserves free from exploitation. Each patch may occur in one of two states according to whether or not it contains fishes recruited to the fishery. It is shown that reserves become highly beneficial as the local extinction rate caused by fishing becomes large because the reserves provide a source of recruitment. In such circumstances, the introduction of reserves meets the needs both of conservation and of sustainable exploitation of the fishery. The abundance of the exploitable population is maximized when half of all patches are occupied by the stock. The sustainable yield is also maximized when half of all patches are occupied, assuming that yield is proportional to the local extinction rate. This result could provide a rule of thumb for fishery managers addressing the specific question of enhancing recruitment ill heavily depleted stocks of certain reef fisheries. However, like other metapopulation models, the one here makes some important simplifying assumptions which would need to be addressed in the application of these results to specific fisheries.

51. MClanahan, T.R. and Muthiga, N.A. 1988. Changes in Kenyan coral reef community structure and function due to exploitation. Hydrobiologia 166:269-276.

A comparison of Kenyan reefs of different historical and observed levels of fishing exploitation showed that more exploited reef lagoons had greater sea urchin densities and sizes, fewer and smaller fish, and less coral cover. In the most exploited lagoon the biomass of the burrowing sea urchin, *Echinometra mathaei* increased five-fold during the previous 15 years. An ecological study of the three most common omnivorous sea urchin species inhabiting hard substrate within these reef lagoons suggests that they are ecologically separated by predation and avoid predators and co mpetitors by occupying different size burrows or crevices within the lagoon. Predator removal through fishing activities may result in ecological release of the sea urchins and result in competitive exclusion of weaker competitors. The most exploited reef had a

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nearly mono-specific barren of F. *mathaei living* outside burrows; this result suggests that this species may be the top competitor. Its ecological release appears to lead to a decrease in live coral cover, increased substrate bioerosion, and ev entually a loss of topographic complexity, species diversity, fish biomass and utilizable fisheries productivity.

52. McClanahan, T.R. and Shafir, S.H. 1990. Causes and consequences of sea urchin abundance and diversity in Kenyan coral reef lagoons. Oecologia 83:362-370.

Large differences in community structure of sea urchins and finfish have been observed in Kenyan reef lagoons. Differences have been attributed to removal of finfish predators through human fishing activities. This study attempted to determine 1) the major sea urchin finfish predators, 2) the effect of predation on sea urchin community structure, and 3) the possible effect of sea urchin increases and finfish decreases on the lagoonal substrate. Six reefs, two protected and four unprotected, were compared for differences in finfish abundance, sea urchin abundance and diversity, and substrate cover, diversity, and complexity. Comparisons between protected and unprotected reef indicated that finfish populations were approximately 4 times more abundant in protected reef. Sea urchin populations were more than 100 times more abundant in the unprotected reef while predation on urchins was 4 times lower. Triggerfish (Balistidae) were the single sea urchin finfish predator family which had a higher population density at protected reef. Balistid density was positively correlated with predation rates and negatively correlated with total sea urchin density. The sea urchin assemblage had its greatest diversity and species richness at intermediate predation rates and low to intermediate sea urchin densities. Protected reef had greater cover of hard coral, calcareous algae, and greater substrate diversity and topographic complexity than unprotected reefs. Coral cover and topographic complexity were negatively correlated with total sea urchin density. Although experimentation is lacking, these substrate changes may be due to the switch from finfish to sea urchin consumers which results from over-fishing of finfish. Removal of top invertebrate-eating carnivores appears to have cascading effects on the entire coral reef ecosystem.

53. McNeill, S.E. and Fairweather, P.G. 1993. Single large or several small marine reserves? An experimental approach with seagrass fauna. Journal of Biogeography 20:429440.

One of the most frequently debated theories in conservation biology is whether a single' large area will preserve more species than several small areas of the same total area. This study tested this theory in the marine environment by comparing the diversity and abundance of fish and macro-invertebrates associated with small and large seagrass beds. In natural beds, several small beds had significantly more species than a single large bed; this occurred because a large proportion of species were not shared among beds. However, results of experiments using artificial seagrass beds to manipulate size of beds were equivocal. More species and more individuals were found in several small beds on only a few occasions in experimental treatments. These results contradicted the patterns found in comparisons among natural beds. The results of this study stress the need to experimentally validate theories for reserve design and also indicate the danger of directly

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applying land-based principles to marine communities without critically examining them for each habitat

54. Moran, D. 1994. Contingent valuation and biodiversity: measuring the user surplus of Kenyan protected areas. Biodiversity and Conservation 3:663-684.

The financial returns to Kenyan tourism demonstrates the importance of the country's tourist potential to its economic development Protected areas and their inhabitants are the principal focus of the tourist industry, the nation's main foreign exchange earner, and a source of wonder and value for a global population of non-users. It might be expected that such assets would be accorded some degree of security with sufficient funding to safeguard current and potential economic benefits. Yet park use is haphazard, and there is frequently little coincidence between those that benefit and those that pay for the continued existence of such areas. Growing economic and demographic pressures that threaten to swamp protected areas only emphasize the implicit subsidy currently paid by Kenyans to support conservation for the benefit of the world at large. In this climate the case for conservation depends on the measurement and capture of economic benefits. Using a contingent valuation survey of expressed preference, this study estimated the consumer surplus attached to current non-consumptive use of protected areas by foreign visitors at some ~50 million per annum. This sum alone is more than double the best available estimate of opportunity cost and appears to justify current resource use. The estimate is additional to current financial returns from tourism and makes no allowance for other direct and indirect benefits and potential returns from consumptive uses. Measured consumer surplus contains some margin of willingness to pay that could be captured through the current fee structure. Moreover, park fees represent the most accessible market mechanism to finance revenue sharing and additional park investment before potential recourse to emerging global market institutions.

55. Moreno, C.A., Sutherland, J.P. and Jara, HJ. 1984. Man as a predator in the intertidal zone of southern Chile. Oikos 42:155-160.

From 1978 to 1982, man was excluded from a 0.6 hectare reserve near Mehuin, Chile. During this time there was an increase in the abundance of species of Fissurella, coupled with a dramatic decline in the abundance of mid-intertidal macroalgae. Macroalgal abundance increased to near 100 percent cover from 1978-79 on a rock in the reserve where herbivores were removed. Outside the reserve, areas closest to large fishing villages had a higher cover of algae and a lower abundance of F. picta. Mid-intertidal macroalgae are abundant only where human predation on herbivores is severe.

56. Moreno, C.A., Lunecke, K.M. and Lepe4 M.I. 1986. The response of an intertidal *Concholepas concholepas* (Gastropoda) population to protection from man in southern Chile and the effects on benthic sessile assemblages. Oikos 46:359-365.

This study documented the changes experienced by the population of the carnivorous snail

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Concholepas concholepas after the establishment of a marine reserve in southern Chile in May 1978. The data indicate that the release from human predation resulted in a striking change of *the* population structure, due to the increment of individuals larger *than 4O-50 mm* peristomal length. *This* evidence strongly indicates that the usual absen~2e of larger size classes from the intertidal *is* not a consequence of physiological limitations, as was previously thought. Significant density differences were detected only in 1984, but they were due to substantial reduction of the snail in the harvested control area. The reduction experienced by prey species, such as barnacles, in the marine reserve area during the same period, indicated that the carnivore has an important role in the organization of the intertidal benthic sessile assemblage. Altogether, the results support the idea that in the absence of human intervention the intertidal community structure differs from the usual, previously considered "natural" structure.

57. Oakley, S.G. 1984. The effects of spearfishing pressure on grouper (Serranidac) populations in the eastern

Red Sea. Pages 341-359 In: Proceedings of the Symposium on Coral Reef Environment of the Red Sea. M.A.H.

Saad (Ed.), January 1-18, Jeddah, Saudi Arabia.

Grouper populations were observed using SCUBA on the fringing reefs in the Jeddah area of the Red Sea. A series of transects at sites with different human usage showed dearly the effects of sport fishing on grouper

populations. Large and medium sized fish were much less frequent in areas where spear and line fishing were common. Small fish, however, showed an increase in frequency at sites with high human usage. Small fish were also more frequent in shallow transects, while medium and large were found predominantly on the deeper transects. Attempts were made to quantify the timidity of the groupers and to assess the relative effects of spearfishing or hook and line fishing.

58. Ogden, J.C. 1997. Marine managers look upstream for connections. Science 278: 1414~1415.

The Florida Keys are a focus of a major national effort to manage a large land-sea area. In response to drastic declines in coral reefs and fisheries resources and to create a buffer zone from shipping, the U.S. Congress created a 9,500 square km National Marine Sanctuary in 1990, the second largest in the nation. Over the 6 years of management plan development, by far the most controversial was the no-take marine reserves, in which all fishing and collecting is banned. The initial drafts proposed 3 sites encompassing roughly 10 percent of the sanctuary area; however, the final version, due to commercial fishing interests, resulted in only one reserve comprising less than 0.5 percent of the area. The remaining reserve (Sambos Ecological Reserve) can clearly not be self-sustaining, thus the geographic scale for management and research must be expanded to include physical processing. The Florida Keys are dependent upon upstream sources of larvae, however, seasonal gyres may retain locally produced larvae.

59. Pauly, D., F. Arreguin-Sanchez, J.L Munro and M.C. Balgos. 1996. Biology, fisheries and culture of snappers and groupers: Workshop conclusions and updates to 1996. Pages 1-10 In: Biology, fisheries and

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culture of tropical groupers and snappers. F. Arreguin-Sanche4 J.L. Munro, M.C. Balgos and D. Pauly (Eds.), ICLARM Conference Proceedings 48, Manila, Philippines.

A summary of the findings of the three working groups (population dynamics and ecology, fisheries management, biology and aquaculture) of the International Workshop on Tropical Snappers and Groupers organized by EPOMEX and ICLARM, and held 2~29 October 1993 in Campeche, Mexico, is presented. Recent references are included to update coverage to 19%, particularly concerning issues of growth and integration of groupers and snappers in ecosystems and models thereof.

60. Plan Development Team. 1990. The potential of marine fishery reserves for reef fish management in the U.S. Southern AL antic. NOAA Technical Memorandum NMF~SEFC261, National Marine Fisheries Service, Southeast Fisheries Science Center. 40pp.

Marine fishery reserves (MFRs), areas with no consumptive usage, are recommended as a viable option for management of reef fisheries in the U.S. southern Atlantic region. MFRs are designed to protect reef fish stocks and habitat from all consumptive exploitation within the specified geographical areas for the primary purpose of ensuring the persistence of reef fish stocks and fisheries. This technical document reviews the life histories of reef fishes, patterns of exploitation, and the advantages and disadvantages of reserves corn pared to traditional fisheries management techniques.

61. Polacheck, T. 1990. Year around dosed areas as a management tool. Natural Resource Modeling 4:327-353.

Year-round closed areas or refuges as management mechanisms for controlling fishing mortality are explored using a two-component, spatial model with movement between areas. The model assesses the fate of a cohort when only a portion of it is vulnerable to fishing. The yield per recruit and spawning stock biomass per recruit are compared for equivalent amounts of fishing effort with and without a refuge. The results indicate that the institution of a dosed area can lead to substantial increases in spawning stock biomass realized from a cohort and, as such, could be a viable short-term management option to reduce overall fishing mortality rates on an overexploited stock. Yield per recruit with a refuge is a complex function of the size of the refuge, fishing mortality rates and movement rates. The results suggest that the proportional loss in yield per recruit will be less than the initial proportion of the cohort contained within the refuge. In some instances, the yield per recruit with a refuge can exceed the yield per recruit without one, but the net increases are usually small. The size of the refuge needed to achieve a specified gain in spawning biomass depends upon the mobility of the fish. Higher movement rates require a larger refuge to achieve the same increase, but any loss in yield per recruit will be less even though the refuge is larger.

62. Polunin, N.V.C. 1990. Marine regulated areas: an expanded approach for the tropics. Resource Management and Optimization 7: 28~299.

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Protected areas such as national parks and nature reserves combat environmental problems only in so far as they preserve designated sites from further damage. They scarcely solve such underlying problems as mangrove destruction, the dynamiting of coral reef or over-fishing. In a broader view regulations related to areas should

nevertheless be a major mode of conservation. Various types of regulation other than strict protection may in any case be more appropriate to the coastal zones of many tropical countries. A realistically designed regulated area should be planned with particular objectives in mind, and deal most of all with problems such as those of over-fishing, population replenishment, and conflicts between fisheries and various users of single ecosystems. However, there exist limitations to implementing this approach. Poor knowledge of larval recruitment patterns as yet precludes satisfactory design of replenishment areas. The multi species complexity of tropical fisheries makes simple management measures inadequate in many ways. There is limited knowledge of how certain beneficial ecosystem functions are maintained naturally. Such knowledge gaps will not be filled quickly, however, interim measures may nevertheless be feasible. Existing regulated areas may offer a focus for exploring the design of potential replenishment zones. There is little evidence yet that traditional marine reserves can contribute to modern management to any great extent.

63. Polunin, N.V.C. and Roberts, C.M. 1993,. Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Marine Ecology Progress Series 100:167476.

This article discusses a study of coral-reef fish communities of Saba Marine Park Netherlands Antilles) and Hol Chan Marine Reserve (Ambergris Cay, Belize) in the Caribbean to assess differences between them and adjacent ecologically similar sites after four years of protection from fishing. Forty- five percent of target species commonly recorded in visual censuses in Belize (23% of all recorded target species), and 59 percent at Saba (22%), showed greater abundance, size, or biomass in shallow protected sites. These differences are considered primarily to reflect increased survivorship with the cessation of fishing mortality. The greatest estimated biomass were observed in locally protected snapper (Lutjanidae) in Belize and Saba. In both protected areas the local stock of visible demersal target fishes was 1.9 to 2.0 times greater in biomass and 2.2 to 3.5 times greater in commercial value than fished sites. Larger local stock of many target species is likely to support higher egg output from the protected areas, while larger predators biomass will mean more intense predation at the protected sites.

64. Polunin, N.V.C., ~ M.K. and Kvalvagnaes, K. 1983. Bali Barat: an Indonesian marine protected area and its resources. Biological Conservation 25:171491.

Since the early 1970's the Indonesian Government has tried to establish marine nature reserves. The initial marine protected areas, however, have not been successful, due to lack of enforcement, and the present account is of a sits on the western tip of Bali, where it is hoped that the idea will come to fruition. The marine resources of this reserve, Bali Barat, are described, together with the various ways in which they are at present being exploited. The plan developed for the reserve aims to prohibit destructive uses, while allowing those

which are not as yet considered damaging to the area. The needs for strict protection of certain sites for tourism and for subsistence uses have been reconciled through a system of zones. The experience gained from Bali Barat should enable effective marine reserve conservation to be extended to other parts of the country, and the reserve could also contribute ~ to education of the public, and to research and management expertise.

65. Pressey, R.L, Humphries, C.J., Margules, C.R., Vane-Wright, R.I. and Williams, P.H. 1993. Beyond opportunism: Key principles for systematic reserve sel ection. Trends in Ecology and Evolution 8: 124~128.

The intention and practice of conservation reserve selection are different. A major reason for systems of reserves is to sustain biological diversity. This involves protecting examples of as many natural features, such as species, communities or environments, as possible. In reality, however, new reserves have rarely been dedicated for their representation of features. Furthermore, the opportunism that has characterized the development of reserve systems can actually jeopardize the representation of all features in reserves through the inefficient allocation of limited resources. More systematic approaches are essential if reserves are to play their role in protecting bio-diversity. Some basic principles for conservation planning are emerging from recent systematic procedures for reserve selection. These principles will help link intention and practice.

66. Rakitin, A. and Kramer, D.L 1996. Effect of a marine reserve on the distribution of coral reef fishes in Barbados. Marine Ecology Progress Series 131:97413.

High population densities of larger fishes within reserves could result in emigration of fish to surrounding non-reserve areas, producing a gradient of abundance and mean size across the reserve boundaries. The difference in fish abundance and size between reserves and non-reserves should be higher for sedentary than for mobile species and for highly catchable than for less catchable species. To test these hypotheses this study estimated the abundance and size of fishes by trapping and visual census on fringing reefs in Barbados: 5 reef within the 22 km of the Barbados Marine Reserve (BMR) and 8 reefs in the non-reserve (NR) area within 4 km of the reserve boundaries. The abundance of large, trap pable ~ fish of all species combined was higher in the BMR than NR. Trap catches decreased gradually with distance from the BMR center, but this gradient of abundance was less evident in visual census counts of trappable size fishes of all species combined, and not apparent in trap or visual census estimates of abundance for individual species. Mean size was larger in the BMR than NR for 18 out of 24 species. The relative difference in both abundance and size between BMR and NR did not differ between mobile and sedentary fishes. However, for sedentary taxa, the relative differences in abundance and size increased with trappability. These patterns suggest that the BMR does protect the fish community from fishing mortality and that emigration rates are generally low. Trappability and mobility depend on complex behavioral characteristics of fishes and are potentially important for the functioning of marine reserves.

67. Ray, M., Stoner, A.W. and Jones, ~ 1994. Adult queen conch distribution in the Exuma Cays Land and Sea Park near Warderick Wells. Technical Report to the Bahamas National Trust, Caribbean Marine Research Center, Vero Beach, Florida. 15 pp.

This report summarizes efforts by the Caribbean Marine Research Center to understand the factors affecting the distribution and abundance of queen conch, *5tmmbus~ga~* in the central Bahamas. The present report focuses on the distribution and abundance of adult conch near Warderick Wells, Exuma Cays Land and Sea Park. Transects were surveyed for the number and size of conch in bank and shelf edge Exuma Sound) habitats. Comparisons were made between these data and similarly collected information at Lee Stocking Island, southern Exumas. In the park, densities peaked a~ 250 conch/ha in water 1~l5 m deep. Adult densities were relatively low shallower than 5 m depth. All offshore conch measured were greater than 15 cm in total shell length. Relative to Lee Stocking Island, conch densities were four times greater in the park in both bank and shelf habitats.

68. Roberts, C., WJ. Ballantine, C.D. Buxton, P. Dayton, LB. Crowder, W. Milon, M.K. Orbach, D. Pauly, J. Trexler and CJ. Walters. 1995. Review of the use of marine fishery reserves in the U.S. southeastern Atlantic. NOAA Technical Memorandum NMF~SEFSC-376, National Marine Fisheries Service, Southeast Fisheries Science Center. 31 pp.

At the request of the South Atlantic Fishery Management Council (SAFMC), a panel of scientists was assembled at a special symposium at the 1995 annual American Fisheries Society meeting in Tampa, Florida. The specific objectives of the symposium were to provide the SAFMC and the National Marine Fisheries Service with recommendations and guidance on the possible use of permanently protected areas for fisheries management in the southeastern US. This report summaries the historical background of marine reserves in the southeastern U.S. It is concluded that marine reserves can be an effective management tool used in conjunction with other fishery management measures subject to the following constraints: 1) biological, ecological, social and economic objectives of the reserves are clearly specified, 2) the relative biological, ecological, social and economic impacts of reserves in the context of other fishery management measure have been estimated for various constituents, and 3) the development of marine reserve proposals proceed with the involvement of all constituencies and stakeholders.

69. Roberts, C.M. 1994. Marine reserves: A brief guide for decision makers and users. Presented at Workshop on Coastal and Ocean Resource Management, April 25-May 6. NGO Islands Forum, UN Global Conference on the Sustainable Development of Small Island Developing States, Barbados.

Marine reserves are becoming widely used in efforts to protect and manage coastal resources. In recent years they have attracted much interest for their possible role in sustaining reef fisheries. Protection of fish stocks within marine replenishment reserves should lead to increased abundance and size of target

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species, thereby translating into increased egg production, which should benefit fisheries by planktonic dispersal and subsequent recruitment to fishing grounds. Ongoing studies of fish stocks around the island of Saba, Netherlands Antilles, where a section of the marine park has been closed to fishing since 1987, have shown a rapid response to protection. There is now a significantly higher standing stock of commercially important species in the protected area compared to the fished area. Moreover, between 1991 and 1993 there has been a rapid increase in standing stock of fish within the reserve, with some families tripling over a two-year period, and an overall increase of 63 percent. These findings show that even very small reserves can protect significant fishery stocks. Benefits from protected stocks are likely to be felt locally through emigration of fishery species to fishing grounds, and by export of planktonic larvae. Although some of these larvae may drift away from the place where the reserve is located, recent studies of current patterns around small islands suggest that a substantial proportion of larvae will be retained, thus benefiting the host nation. Marine reserves also seem to be a promising means of protecting and enhancing biodiversity, and in doing so may yield further economic benefits. In Belize for example, the large and abundant fishes within the Hol Chan Marine Reserve provides a powerful attraction to tourists and so comprises a key to economic development of Ambergris Cay.

70. Roberts, C.M. 1995. Rapid build-up of fish biomass in a Caribbean Marine Reserve. Conservation Biology 9: 813~26.

Marine reserves have been argued to be an effective means of managing complex reef fisheries and of protecting populations of species vulnerable to over-fishing. The argument rests on predictions of increases in abundance and size of fishes after the elimination of fishing mortality, which in turn leads to greater eggs production per unit of reef and greater export via pelagic dispersal to fishing grounds. This study reports responses of fish populations to area closure in a small Caribbean marine reserve surrounding the island of Saba in the Netherlands Antilles. Part of the reserve has been closed to fishing since 1987, and the remainder is subject only to light fishing. Fish populations were visually censused and sizes of individuals present estimated from counts in fished and protected areas of the marine park in 1991 and 1993. For four of five commercially fished families, biomass was greater in the protected area. Predictions of greater abundance and size in the protected area were upheld for many of the species observed. Between 1991 and 1993 overall biomass of commercially important families increased 60 percent based largely on increases in abundances between years. The predatory snappers increased 220 percent. Fishing pressure in Saba was reduced between censuses due to changing employment opportunities. It was notable that populations increased in both fished and protected areas of the park, and the latter is probably an effect of this reduced fishing intensity. Despite protection from fishing, the Saba Marine Park has low population densities of groupers, perhaps due to a lack of supply of larvae from unprotected source areas. Protection of vulnerable species is only likely to be successful if networks of reserves are established throughout species ranges to link larval supply and settlement areas.

71. Roberts, C.M. 1997. Connectivity and management of Caribbean coral reefs. Science 278:1454-1457.

Surface current patterns were used to map dispersal routes of pelagic larvae from 18 coral reef sites in the Caribbean. The sites varied, both as sources and recipients of larvae, by an order of magnitude. It is likely that sites supplied copiously from upstream reef areas will be more resilient to recruitment over-fishing, less susceptible to species loss, and less reliant on local management than places with little upstream reef. The mapping of connectivity patterns will enable the identification of beneficial management partnerships among nations and the design of networks of interdependent reserves.

72. Roberts, C.M. and Polunin, N.V.C. 1991. Are marine reserves effective in management of reef fisheries? Reviews in Fish Biology and Fisheries 1: 65~91.

Fisheries for demersal reef fishes in tropical and warm4emperahire regions are typically multi-specific and the fish are harvested using a wide variety of methods. They are of particular importance to many developing countries, where large numbers of coastal people are dependent on them both for income and as their main protein source. However, owing to their complexity they pose particularly serious management problems. Classical fishery management can take two forms: management of catch or of effect. Management of catch is usually achieved through the imposition of quotas or gear restrictions, whereas management of effort can include limitation of numbers of fisherman or vessels, closed seasons, or temporary area closure. These approaches have been successful in many cases but have not always prevented overexploitation of stocks, or sometimes even collapse of the fishery. Marine fishery reserves represent a promising approach to fisheries management but, at present, many of their perceived benefits remain untested. Further study should concentrate on production and export of recruits, and patterns of movement by post-settlement fishes, 4~ refine their use to achieve the intended aims.

73. Roberts, C.M. and Polunin, N.V.C. 1992. Effects of marine reserve protection on northern Red Sea fish populations. Proceedings of the 7th International Coral Reef Symposium 2: %~977.

This study investigated the effects of establishment of the Ras Mohammed Marine Park on fish population structure. The park has been protected from most forms of fishing for 15 years. Cessation of fishing is expected to result in increases in abundance and average size of target species and may also lead to shifts in species composition. To determine if such effects were evident, populations of nine commercially fished families and pelagic piscivores were censused using point counts at 15 m depth. Effects of protection were determined by comparison of similar sites from three fishing levels: 1) none (Ras Mohammed), 2) little-fished, and 3) fished. Abundance of ~ of 45 species differed significantly among fishing levels. At the family level, surgeonfishes were more common on fished reef. Seven species increased in size with decreasing fishing intensity. Biomass of

14 species differed significantly among fishing levels, with higher biomass at protected sites for five species. At the family level, there were significant differences for parrotfishes and surgeonfishes, with the former greatest on little-fished reef and the latter on fished. Total biomass of all species combined

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did not differ significantly among fishing levels, although mean biomass was 1.2 times greater on protected reefs. These results provide some support for the view that marine reserve establishment has been effective in protecting stocks. However, fishing levels in the northern Red Sea are low and use of marine reserves to manage fisheries may prove most effective in regions where fishing intensities are high or use of damaging fishing methods widespread.

74. Roberts, C.M. and Polunin, NN.C. 1993. Hol Chan: demonstrating that marine reserves can be remarkably effective. Coral Reefs 13:90.

The Hol Chan Marine Reserve lies off Ambergris Cay, Belize. Covering 2.6 square km, the reserve has been protected from all forms of fishing since 1987. Although small, Hol Chan contains a higher biomass of fishes per unit area of reef than we have seen anywhere else in the world. Enormous schools of grunts and snappers, so dense they almost obscure the reef, mingle with huge roving black groupers and gray snappers. The standing stock of commercially important species reaches 340 grams per square meter in the center of the reserve, while at the periphery it averages 77 grams per square meter, about double that in adjacent fished areas. The reserve also contains seven more species of commercial fishes than areas subject to fishing. The presence of large fishes in the reserve is particularly important to replenishment because of their disproportionately large reproductive output, the reserve may also play an important role in protection of species which are vulnerable to fishing.

75. Roberts, C.M. and Polunin, N.V.C. 1993. Marine reserves: Simple solutions to managing complex fisheries? Ambio 22:363-368

Fisheries on coral reefs are highly complex, can be very productive, but typically have little or no management. Widespread over-fishing and declining yields reveal an acute need for proper management. Unfortunately, conventional management methods are inappropriate for two mean reasons: 1) they require much information on the biology of stocks and 2) are expensive to enforce. Use of marine reserves, or areas closed to consumptive use, have been proposed as an alternative. Although there are a number of advantages to this approach, the effectiveness of existing marine reserves in the Caribbean and Indo-Pacific has not been adequately addressed. This article provides a summary of information on the existing marine reserves and the status of reef fish stocks relative to unprotected areas.

76. Rowley, RJ. 1994. Marine reserves in fisheries management. Aquatic Conservation: Marine and Freshwater Ecosystems 4:233-254.

This paper summarizes research on the uses of marine reserves for fisheries management. Examples emphasize temperate marine reserves. Marine reserves commonly support higher densities and larger sizes of heavily fished species than are found outside reserves. Spillover of individuals across reserve borders is likely

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to augment local catches. There are good reasons to expect such spillover, and there is limited direct evidence for it. However, the magnitude of any resulting increase in local catches will be difficult to predict. Larval export from reserves has potential to augment recruitment over large regions, but its success will depend upon many factors that are difficult to predict. No studies have clearly tested the effects of larval transport. To design more effective marine reserves, studies are needed of the movement patterns and habitat requirements of all life stages of targeted species. To determine clearly the effects of marine reserves on fisheries requires replicated before/after studies.

77. Russ, G. 1985. Effects of protective management on coral reef fishes in the central Philippines. Proceedings of the 5th International Coral Reef Congress 4: 21~224.

This study collected information on the species richness and abundance of coral reef fishes at three study sites in the central Visayas, Philippines. The locations were Sumilon Island near Cebu, Apo Island near Negros, and Balicasag Island near Bohol. A modified combination of two techniques of visual census were used to make assessments of both the overall community structure of the assemblage of fishes and the abundance of fishes considered as favored targets of fishermen. Only one of the study sites had effective, long4erm protective management in the form of a total absence of fishing. This site, the steep slope reserve on the western side of Sumilon Island, had a significantly greater abundance of fishes, higher species richness, and the highest abundance of many species considered to be highly favored targets of fishermen, particularly groupers, than fished sites. It cannot be claimed that protective management is the cause of the high abundance and species richness of fishes at this site. In fact, the area was chosen as the site for a marine reserve because it possessed such characteristics. However, considering the very high fishing pressure on most Philippine coral reefs it could be argued that protective management has been very important in maintaining the high abundance of many of the species of fishes.

78. Russ, G.R. and Alcala, A.C. 1989. Effects of intense fishing pressure on an assemblage of coral reef fishes. Marine Ecology Progress Series 56:13-27.

This study documented a natural experiment in the central Philippines: a dramatic increase in fishing pressure within a 750 m long marine reserve, previously protected from fishing for 10 years (1974-1984). In 1983, the site had a significantly greater abundance of fishes, particularly those considered to be favored targets of fishermen, such as groupers and snappers, than similar sites which were fished. Abundances were estimated by visual counts within the reserve and at 3 control sites. In early 1984, protective management broke down and fishing by up to 100 municipal fishermen began, using traps, hand-lines, gill-nets, spears and occasionally more

destructive, non-selective fishing methods, such as explosives and drive nets. The reserve and control sites were recensused after 18 months of fishing in the Sumilon Island Reserve. There were decreases in abundance of favored targets of fishermen and a significant change in community structure of the coral ref fish assemblage inside the reserve, but not at the 3 control sites. Species which contributed most to the change in community structure were not favored targets and had not constituted a large proportion of

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yield in previous years. Significant decreases in the abundances of small, schooling planktivores and benthic feeding chaetodontids, and significant increases in the abundances of small labrids and large scarids, were related largely to the effectiveness of explosives and drive nets against planktivores and herbivores and degradation of shallow benthic habitats. Thus, the intense fishing pressure had both direct and indirect effects and a far wider impact on the fish assemblage thin predicted.

79. Russ, G.R., Alcala, A.C. and Cabanban, A.S. 1992. Marine reserves and fisheries management on coral reefs with preliminary modeling of the effects on yield per recruit. Proceedings of the 7th International Coral Reef Symposium 2: 978~985.

The potential advantages and disadvantages of the use of long-term spatial closures to fishing in the management of coral reef fisheries are reviewed briefly. The effects of marine reserves on fisheries yield will depend upon the nature and extent of interchange of fish between fished and protected areas. Preliminary modeling of the effects of fluxes of post-settlement fishes across the boundaries of a reserve at Sumilon Island, central Philippines, on yield per recruit of the caesonid Pterocaesio pisang suggests that reserves may enhance yield per recruit by this mechanism only at high levels of fishing mortality. Under high fishing mortality reserves act as growth refuges. Detailed research on patterns of reef fish growth, mortality, and adult movement will have to be carried out before any marine reserve can be designed which will allow an explicit prediction of its effect on local reef fishery yield. The more substantial and longer term benefits of marine reserves are likely to be their potential for maintenance or enhancement of fisheries yield to broad regional areas by larval dispersal. Given the critical levels of over exploitation of many coral reefs, marine reserves may be the only viable option available to maintain levels of spawning stock biomass necessary to sustain reef fisheries.

80. Sadovy, Y. and Figuerola, M. 1989. The status of the red hind fishery in Puerto Rico and St. Thomas as determined by yield-per-recruit analysis. Proceedings of the Gulf and Caribbean Fisheries Institute 42: ~38.

The red hind *(Epinephelus guttatus)* is an important component of the shallow-water fishery resources of Puerto Rico and St. Thomas. Declining landings and the possible loss of larger individuals from commercial catches have led to concern over the condition of stocks in both areas. A preliminary yield-per-recruit analysis indicated that in Puerto Rico and SL Thomas, the current fishing levels approximately 50 percent and 20 percent greater than theoretically optimum levels of fishing. Fishing pressure should be reduced considerably in Puerto Rico, and to a lesser extent in St. Thomas. Yield-per-recruit would not increase significantly by increasing size at

entry to the fishery at current levels of fishing pressure. A short-term management option is the protection of the annual spawning aggregations from all fishing activity. A more long-term option for the reduction of fishing pressure on all components of the fishery unit would be the creation of marine reserves.

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81. Salm, RN. 1984. Ecological boundaries for coral-reef reserves: principles and guidelines. Environmental Conservation Ii: 2()~215.

As marine conservation activities intensity, planners and managers of protected areas are finding themselves with few guidelines or tools that are specific to the marine realm. Consequently, the principles, criteria, and practices of terrestrial protected areas tend to be transferred to the marine environment, where they are often inappropriate. In contrast to the situations with all comparable sites on land, there is a paucity of published material on the application of ecological principles to the design and management of marine protected areas. sing examples of coral reels, guidelines are presented in this article in the hope that they will elicit comment and stimulate the publication of similar guidelines for different marine environments. Coral reef protected area boundaries must fulfill two requirements: they must include appropriate coral reef, confluent and neighboring habitats, and a sufficient area of each. The first requirement defines the type, and the second the quantity of habitats to be included in a protected area. Studies in the Chagos Archipelago, Indian Ocean, indicate that the core zone of a protected coral reef area should encompass 300 hectares of diverse reef habitats if preservation of biotic diversity is the principle objective. The buffer-zone size needed will vary according to activities planned within the area, the extent of neighboring coastal habitats, and the proximity of up-current sources of potential contamination.

82. Samoilys, M.A. 1988. Abundance and species richness of coral reef fish on the Kenyan coast: the effects of protective management and fishing. Proceedings of the 6th International Coral Reef Symposium 2:261-266.

Underwater censuses were used to measure species richness and abundance of coral reef fish at nineteen study sites on the Kenyan coast. While species richness was highest in marine parks where no fishing or collecting was allowed, the same was not true for fish abundance or biomass of commercially important species. Some of the highest densities and weights of fish were found in the marine reserves where traditional fishing, was allowed. Areas with higher fishing intensity had smaller standing crops of fish, but not comparably smaller abundances. This suggests that the average fish size is lowered by more intense fishing. Two factors, siltation from rivers and dynamite fishing, have a major impact on the fish assemblages. Reels badly damaged from dynamiting, including Mako Kakwe in Kisite marine park were characterized by low species richness and a low biomass of commercially important species. At Malindi, densities and biomass of fish were of a similar magnitude to dynamited reels, despite the prohibition of all fishing and collecting for the last 20 years. The reef has been subjected to a heavy influx of sediment from the Sabaki River since the early 1970's. Thus, the effects of protection and fishing on reef fish assemblages were confounded by other major impacts on Kenya's reels, namely siltation and dynamiting.

83. Savina, G.C. and White, A.T. 1986. A tale of two islands: Some lessons for marine resource management. Environmental Conservation 13:107413.

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A comparison of two island fishing communities in the Visayas, Philippines, showed significant differences in coral reef habitat and in the diversity of selected reef fishes, as well as important differences in fishing customs and catch composition. During the sampling months of April-May, 1985, fishermen on the 72-hectare Apo Island, Negros, caught more than two thirds of their total fish 'catch on the reef, whereas fishermen on the 200 hectare Pamilacan Island, Bohol, caught less than 20 percent of their total catch on the reef during the same period. This discrepancy may be attributable to reef quality or fishing customs, or to both these factors. Past efforts to manage Apo and Pamilacan through local marine reserve systems have not been effective. Different biophysical features at the two sites, and differences in fishing customs, means that the management needs of the islands are not alike. Effective management should weigh many factors. Four lessons which apply to Apo and Pamilacan are given, namely 1) management plans should consider habitat differences, 2) fishing pressures vary from island to island, 3) traditional fishing practices influence the kind and amount of fishing pressure on a reef and must be reckoned with in choosing management guidelines, and 4) the fishermen themselves must be committed to the concept of marine management and should help to formulate the guidelines governing a reserve.

84. Schwartz, M.W. 1994. Conflicting goals for conserving biodiversity: Issues of scale and value. Natural Areas Journal 14: 21~216.

Differing conservation values create a multiplicity of goals toward which conservation activities are directed. Multiple and differing goals also are inherent in conservation at differing spatial and temporal scales. In many cases these different goals result in management actions that are complementary and that simultaneously benefit many species and habitats. In contrast, there are instances in which conservation for one set of values, or at one spatial scale, suggests a management action that would violate other conservation goals. The author defined the goals and value systems used to support biological conservation and presented three cases where differing conservation objectives conflict. Specifically, this study addressed how 1) a proposed translocation of an endangered species outside its historic range, to prevent its extinction, would violate the historic integrity of the recipient community; 2) the use of fire, to maintain plant community composition in grasslands, may threaten native insect biodiversity; and 3) assisting the process of long-distance seed dispersal to aid plant-range shifts disrupted by anthropogenic dimatic warming, would violate the integrity of recipient plant communities. While examples of conflicting goals are not hard to describe, they are hard to resolve and pose challenges to conservation biology that are not adequately addressed at the present time. Increased use of goal-setting would improve our ability to explicitly measure the success of conservation projects. Failure to set priorities and goals in conservation management implies a misplaced faith in the balance of nature.

85. Shepherd, S.A. and Brown, LD. 1993. What is an abalone stock: implications for the role of refugia in conservation. Canadian Journal of Fisheries and Aquatic Sciences 50:2001-2009.

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This paper concerns the conservation of abalone stocks in a genetic and fisheries sense. The article reviews genetic and ecological information relating to the differentiation of abalone stocks in South Australia and proposes that metapopulation theory provides an apt framework in which to develop the concept of an abalone stock. The study considered the minimum viable population for abalone which is illustrated with a case study of an abalone population that declined through a combination of fishing, recruitment failure, and inadequate protection by a refugium. Refugia can play an imp ortant role in abalone conservation by maintaining egg production and genetic diversity and by preserving populations for scientific study.

86. Sheridan, A.K. 1995. The genetic impacts of human activities on wild fish populations. Reviews in Fisheries Science 3:91408.

A review of the literature confirms that human activities have caused genetic changes in some wild fish populations, with most of these changes being adverse. These genetic effects include a reduction in growth rate and/or possibly in age/size at sexual maturity in some heavily fished populations. There was also considerable evidence of hybridization between wild and released populations and the extinction of some wild populations due to habitat changes and to competition and/or predation from introduced species. There is a need to monitor wild fish populations for genetic changes, with particular emphasis on exploited populations of prominent economic or recreational value. This is best done by directly examining either the genome or gene pro ducts. In order to detect genetic change, it is necessary to have access to at least two chronologically distinct samples of the same population. As DNA is also relatively inexpensive to store, DNA depositories could be established in order to provide a historical record of the genetic composition of populations of either commercial or scientific interest.

87. Simberloff, D. and Cox, J. 1987. Consequences and costs of conservation corridors. Conservation Biology 1: 6-71.

There are few controlled data wit h which to assess the conservation role of corridors connecting refuges. If corridors are used sufficiently, they could alleviate threats from inbreeding depression and demographic stochasticity. For species that require more resources than are available in single refuges, a network of refuges connected by corridors may allow persistence. Finally, a corridor, such as a riparian forest, may constitute an important habitat in its own right. A dearth of information on the degree to which different species use corridors makes it difficult to tell which of these potential advantages will be realized in any particular case. Corridors may have costs as well as potential benefits; they may transmit contagious diseases, fires, and other

catastrophes, and they may increase exposure of animals to predators, domestic animals, and poachers. Corridors also bear economic costs. It may be cheaper to manage some species by moving individuals between refuges rather than by buying and maintaining corridors. Each case must be judged on its own merits because species-environment interactions differ.

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88. Simberloff, D.3. and Abele, LG. 1976. Island biogeography theory and conservation practice. science 191: 283-286.

The application of island biogeography theory to conservation practice is premature. Theoretically and empirically, a major conclusion of such applications - that refuges should always consist of the largest possible single area - can be incorrect under a variety of biologically feasible conditions. The cost and irreversibility of large-scale conservation programs demand a prudent approach to the application of an insufficiently validated theory.

89. Sluka, R. 1995. Influence of habitat on density, species richness, and size distribution of groupers in the upper Florida Keys, USA and central Bahamas. Ph.D. Dissertation, University of Miami, Coral Gables, Florida. 229pp.

The influence of habitat on the density, species richness, and size distribution of groupers (Serranidae) was studied in the upper Florida Keys and central Bahamas from 1992-94. Four major reef types were selected for study: patch reefs, high-relief spur and groove, relict reef flat, and low-relief spur and groove. The size distribution of groupers differed among reef types; the majority of groupers ill deeper, low profile habitats were less than 15 cm TL Protection from fishing influenced the frequency and size distributions of species. A discussion of marine fisheries reserves as a potential management tool for conserving grouper assemblages is provided.

90. Sluka, R., Chiappone, M. and Sullivan, K.M. 1994. Comparison of juvenile grouper populations in southern Florida and the central Bahamas. Bulletin of Marine science 54:871-880

Visual surveys conducted in shallow-water (< 10 m) reef habitats were used to compare grouper abundance, size distribution, and species richness in the central Bahamas and northern Florida Keys. The mean density of groupers was three times greater in a marine park in the central Bahamas closed to fishing. Although a higher percentage of larger groupers were observed in the Bahamas, differences in the size distribution between the two areas were not significant. Species composition differed between the two areas and were attributable to different habitat requirements. For example, graysby, red grouper, red hind, and black grouper dominated the species assemblage in the Florida Keys, while Nassau grouper and coney constituted the majority of individuals in the central Bahamas.

91. Sluka, R., Chiappone, M. and Sullivan, K.M. 1996. Habitat preferences of groupers in the Exuma Cays, Bahamas. Bahamas Journal of science 4:844.

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Habitat has been shown to affect the abundance of groupers at many spatial scales. This study examined the potential relationship between quantified benthic features of coral reef and the abundance and biomass of groupers in the Exuma Cays, central Bahamas. Data were collected at 21 sites north of and 19 sites within the park during October to November 1995. Haphazard quadrats were used to quantify percent coverage of bottom types in three habitat types: channel reefs, flinging reefs, and windward hard-bottom. Vertical relief and depth were also measured. Data on the species composition, abundance, and size of groupers were collected using strip transects measuring 2(~m x 5-m. Results indicated no significant correlation between grouper size or biomass and benthic habitat features within the park. However, graysby *(Epinephelus cruentatus)* biomass and size outside of the park were correlated to coral cover, whereas coney *(E. fulvus)* biomass and size were negatively correlated with coral cover, but positively correlated with algal cover. In particular habitats, some species were prevalent. Rock hind (F *adscensionis)* and tiger grouper *(Mytceroperca tigris*) were most abundant in fringing reef while graysby was most abundant in channel ~4s. Coney were most prevalent in windward hard-bottom habitats. Outside of the park, fishing pressure was considered to be a more significant influence on abundance and distribution of targeted grouper species.

92. Sluka, R., Chiappone, M., Sullivan, K.M. and Wright, R. 1996. Habitat and Life in the Exuma Cays, Bahamas: Status of groupers and coral reefs in the northern cays. Supplemental Volume: Appendices. The Nature Conservancy, Florida and Caribbean Marine Conservation Science Center, Coral Gables, Florida. 216 pp.

This supplemental volume to the document, Habitat and Life in the Exuma Cays, Bahamas: Status of groupers and coral reefs in the northern cays, presents site-specific data on groupers and benthic community structure. Field surveys of groupers and coral reef habitats were made during October and November of 1995 to evaluate the species composition, abundance, size, and biomass of commercially important groupers in relation to the Exuma Cays Land and Sea Park. Surveys were also made to quantify depth, vertical relief, and percent coverage of bottom types in quadrats. The supplemental volume includes figures illustrating the spatial extent of the study area and location of reef habitats surveyed over 90 km of the Exuma Cays archipelago. Figures are also included to illustrate the coverage distribution of algae, sponges, corals, and octocorals using visual estimates in quadrats. Tables provide species presence-absence and percent coverage data. Data on grouper density, size, and biomass are also included.

93. Sluka, R., Chiappone, M., Sullivan, K.M. and Wright, R. 1996. Habitat and Life in the Exuma Cays, the Bahamas: The status of groupers and coral reef in the northern cays. Media Publishing, Nassau, Bahamas. 83 pp.

The role of the Exuma Cays Land and Sea Park, central Bahamas, in protecting groupers within the Exuma Cays was investigated from October-November 1995. Four hard-bottom habitats were surveyed for

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benthic community structure and grouper species composition, abundance, and size. Habitats included patch reefs, channel reef windward hard-bottom, and fringing reef. Surveys were conducted at 74 sites from Sail Rocks to Staniel Cay, a distance of roughly 90 km. In each site, 10 20m x 5m strip transects were surveyed for groupers, while 25 l-m x 1-m quadrats were used to visually estimate bottom coverage using cover classes as well as point-intercept measurements of coverage. Results indicated that the park is protecting the size, abundance, and reproductive output of the most targeted grouper species, Nassau grouper *(Epinephelus striatus).* However, the entire park is not effectively protected; the area of effective protection is limited to what the park ranger can patrol There was evidence that groupers were moving across park boundaries to potentially become available to legal catch by the fishery. There were also second-order effects in which non-targeted species, such as graysby and coney, were more abundant outside the park.

94. Sluka, R., Chiappone, M., Sullivan, K.M. and Wright, R. 1997. The benefits of a marine fishery reserve for Nassau grouper *Epinephelus striatus* in the central Bahamas. Proceedings of the 8th International Coral Reef Symposium 2: 1961-1964.

Nassau grouper *(Epinephelus striatus)* are an important coral reef fish, both economically and ecologically. Intense fishing pressure has been shown to decrease the abundance and average size of this species. Marine reserves have been suggested as areas which can ameliorate the effects of intense fishing pressure while protecting the size, abundance, and reproductive output of targeted species. The benefits of marine fishery reserve in the central Bahamas, the Exuma Cays land and Sea Park, were evaluated with regard to these factors. Seventy-four sites among four coral reef and hard-bottom habitat types were sampled along 90 km of the Exuma Cays during the fall of 1995. Survey sites were selected north, inside, and south of the reserve. Underwater strip transects (2O~ m x 5-m) were carried out to inventory grouper species, density, and size. The average biomass and size of Nassau grouper was statistically greater inside reserve. Size and biomass of Nassau grouper did not differ significantly among habitat types. Estimated reproductive output of adult, female Nassau grouper was over 6 times greater inside the reserve. It is concluded that: 1) the reserve is protecting Nassau grouper resources and 2) the reserve is likely exporting grouper biomass across park boundaries.

95. Smith, PJ. 1994. Genetic diversity of marine fisheries resources: possible impacts of fishing. FAO Fisheries Technical Paper Number 344, FAO, Rome. 53 pp.

This report reviews the evidence for the genetic impact of fishing on marine fisheries resources. The most widely used method for measuring genetic diversity in natural populations has been protein electrophoresis; marine teleosts have levels of genetic diversity ranging from 0.~18 percent and marine invertebrates from OA-32 percent. Genetic studies have shown that populations of marine species are less differentiated than freshwater

species, experience temporal changes, can be changed locally by pollution, and contain cryptic species. In natural populations fishing is a major source of mortality and is non random with

respect to age and size of individuals. A common observation in heavily exploited teleost fisheries has been a decline in the age and/or size at sexual maturity. Size selective fishing would favor early maturity. However, growth rate in some fishes is density dependent and increases when the stock is reduced'. Thus it is not possible to determine if the observed changes are genetic or compensatory in response to reduced stock density. Genetic drift is unlikel y to be a major factor influencing levels of genetic diversity in many marine fisheries, except for some populations which have been reduced to near extinction levels. There is no evidence for loss of genetic diversity in collapsed stocks of pelagic species. The use of hatcheries to produce seed for aquaculture and enhancement could lead to loss of genetic diversity in natural populations through escape of farm stock or inappropriate choice of broodstock. Experimental studies are required to determine the heritability and the response to selection of life history characters of exploited species, and to determine if relaxation of fishing pressure allows the recovery of fast growing and late maturing genes or gene complexes in populations. A combination of exp erimental and field studies would permit a more rigorous testing of genetic changes in exploited populations. If genetic changes are demonstrated in exploited species then changes to management would be needed to conserve natural levels of diversity.

96. Soegiarto, A. 1981. The development of a marine park system in Indonesia. Proceedings of the 4th International Coral Reef Symposium 1: 288~29l.

For centuries the Indonesian people have used the marine environment for many purposes: transportation, trade and communication, recreation, sources of food and minerals. Unfortunately, however, the Indonesian marine environment is under heavy stress due to pollution and other destructive forces. In order to ensure the quality of the marine environment as a whole, a master plan for a marine park system is being developed in Indonesia. This master plan is an integrated part of the Nature Conservation Program in Indonesia. Basic criteria to develop marine parks and conservation areas have been established. Currently, more than 4() potential sites are under study to evaluate the feasibility of establishing them as marine parks and conservation areas. A national commission on Marine Park Systems has been formed for this purpose. International organizations and UN specialized agencies, such as World Wildlife Fund, Food and Agriculture Organization, UNESCO, and UNDP, cooperate and assist with this program. This paper briefly reviews the plan, the implementation and constraints of the marine park development in Indonesia.

97. Somerton, D.A. and June, J. 1984. A cost-benefit method for determining optimum dosed fishing areas to reduce trawl catch of prohibited species. Canadian Journal of Fisheries and Aquatic Sciences 41: 93~98.

Red king crab *(Paralithodes camtschatica),* a prohibited species, are incidentally caught by United States trawl fisheries for yellowfin sole *(Limanda aspera)* and other groundfish in the eastern Bering Sea. To reduce this incidental catch, the authors propose a method for determining a king crab conservation zone where trawling would be prohibited. This method considers the gross revenue potentially gained by the yellowfin sole fishery and lost by the king crab fishery by allowing trawling in each of a number of equal-size

areas. Utilizing exvessel prices and research survey estimates of species densities, areas are assigned relative values equal to the value of groundfish minus the value of king crab. By including all areas with negative relative values in the conservation zone, the potential gross revenue that could be obtained from the groundfish and king crab resource is maximized.

98. Soule, M.E. and Simberloff, D. 1986. What do genetics and ecology tell us about the design of nature reserves? Biological Conservation 35:1940.

The SLOSS (single large or several small) debate is no longer an issue in the discussion about the optimal size of nature reserves. The best way to estimate the minimum sizes of reserves may be a three step process: 1) identify target or keystone species whose disappearance would significantly decrease the value or species diversity of the reserve; 2) determine the minimum number of individuals in a population needed to guarantee a high probability of survival for these species; 3) using known densities, estimate the area needed to sustain a minimum number. The forces that affect population viability and determine MVP (minimum viable populations) are extremely complex. Thoughtful estimates of MVPs for many animals are rarely lower than an effective size of a few hundred. Attempts to save only common or smaller species in a community will usually be ill4ated because of the web of ecological relationships between species, including the importance of predation and herbivory in the maintenance of species diversity. Other topics discoed include the complementarily of conservation goals, the problematic function of corridors, and the value of buffer-zones.

99. Stoner, A.W. and Ray, M. 1996. Queen conch, *Strombus gigas,* in fished and unfished locations of the

Bahamas: effects of a marine fishery reserve on adults, juveniles, and larval production. Fishery Bulletin 94:

551-365.

Marine fishery reserves have been set aside in coastal areas throughout the world with the hope of reversing population declines commonly observed in many marine resources. In this study, a comparis9n of population structure of the commercially important queen conch *(Strombus gigas)* was made between a fished area and a marine fishery reserve Exuma Cays Land and Sea Park) in the central Bahamas. There were 31 times more adult conch on the shallow (<5 m) Great Bahama Bank in the park, and in a survey at 7 depth intervals (to 30 m) on the island shelf in the Exuma Sound, mean adult density was always higher in the park, by as much as 15 times.

Shell length and lip-thickness measurements indicated that adults in the park migrate with age from bank nursery sites into deeper water, whereas those on the bank in the fished area were harvested before reaching water sufficiently deep to protect them from free-diving fishermen. Total larval densities in the park were frequently an order of magnitude higher than those in the fished area, and densities of late-stage larvae were ~17 times higher. Based on current patterns in the Exumas, larvae found in the park must have been spawned outside of the park; thus the high densities of juveniles and adults are the result of natural accumulation of larvae and protection from fishing.

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100. Stoner, A.W. and O'Connell, S.M. 1994. Concentrations of queen conch larvae in the Exuma Cays Land and Sea Park. Preliminary Study -1993. Technical Report to the Bahamas National Trust. Caribbean Marine Research Center, Vero Beach, Florida. 9pp.

This report discusses efforts to quantity the abundance of queen conch *(Strombus gigas)* larvae in the Exuma Cays Land and Sea Park, central Bahamas. Plankton tows were conducted during 5 cruises between June and August 1993 to determine larval abundance and size distribution off of Waderick Wells, the park headquarters. Results indicated greater larval densities in the park compared to stations at Cat Island, Lee Stocking Island, and Eleuthera. Concentrations of larvae near Waderick Wells were over 5 conch per cubic meter. Densities in the park are the highest ever recorded for the wider Caribbean. The great larval supply to the park is likely related to the high density of juvenile conch. Late-stage larvae (2-3 weeks old) likely have their source in the southern Exumas, while early stage larvae may be derived from egg masses produced in the p ark.

1()1. Thorpe, J.E., Koonce, J.F., Borgeson, D., Henderson, B., Lamsa, A., Maitland, P.S., Ross M.A., Simon, R.C. and Walters, C. 1981. Assessing and managing man's impact on fish genetic resources. Canadian Journal of Fisheries and Aquatic Sciences 38:18994907.

Historically, human activities have adversely affected the genetic resources of many fish species. The authors suggest that a continuum of vulnerability to loss of genetic resources exists for fishes. Primary determinants of vulnerability are extent of stock structure in populations and fundamental life history features, such as length of Juvenile period, sex ratio, and fecundity. The genetic basis for this trend is the relationship between the subdivided state of a population (its stock structure) and important processes of genetic change, which include selection, gene flow, and genetic drift. This study related various human activities to their effects on genetic resources through these genetic processes. In general, the authors found that those species whose populations are subdivided into nearly isolated stocks (e.g., Pacific and Atlantic salmon) are more vulnerable to directional changes in genetic composition as well as reduction in overall genetic diversity through loss of some stocks. It was also found that similar changes will be difficult to detect, if they occur at all, in less stock-structured species like walleye.

102. Tisdell, C. and Broadus, J.M. 1989. Policy issues related to the establishment and management of marine reserves. Coastal Management 17:37-53.

Several hundred marine reserves now exist and their number is growing. The demand for additional marine reserves can also be expected to grow, especially since they seem to be relatively undersupplied compared to terrestrial biosphere reserves. Basic socioeconomic reasons are given as to why governments should establish marine reserves. Management problems are illustrated by reference to the Great Barrier Reef Marine Park and the National Oceanic and Atmospheric Administration's (NOAA) governing of Title III of

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the Marine Protection, Research and Sanctuaries Act. The nature, clarity, and precision of objectives as set out in legislation are discussed, and the importance for management of public and political support is considered. Using economic analysis, an approach different to that used by some ecologists for determining the optimal size of reserves is outlined. The natural difficulties involving managing marine reserves are highlighted by comparison with land-based parks. Zoning and multiple-use are common features of marine reserves and require important management and policy decisions to be made about optimal zoning and multiple-use arrangements. Issues that ought to be taken into account and techniques for making such decisions are discussed, and it is suggested that there should be greater input from the social sciences in the management of marine reserves.

103. Towns, D.R. and Ballantine, WJ. 1993. Conservation and restoration of New Zealand island ecosystems. Trends in Ecology and Evolution 8: *452A57*.

An ecological collapse has precipitated pioneering conservation initiatives in New Zealand. Many terrestrial communities in the New Zealand archipelago have been devastated by overexploitation, introduced mammals, and habitat destruction. More recently, marine ecosystems have been depleted by over-harvesting. To mitigate against these losses, conservation in terrestrial environments has focused on protection of species and habitats. A similar approach is now under way in marine environments with the establishment of marine reserves. On land, conservation is now reaching beyond protection to the eradication of pests from island and restoration of their terrestrial ecosystems. Restoration on islands not only reduces threats to rare species; it also raises opportunities to investigate how species interact. In the marine environment, reserves not only enhance the diversity of depleted marine communities, they may also augment stocks of commercially harvested species. These initiatives provide many lessons that could be applied to degraded habitats elsewhere.

104. Tundi-Agardy, M. 1994. Advances in marine conservation: the role of marine protected areas. Trends in Ecology and Evolution 9:267-270.

The world's oceans are now attracting the serious attention of conservationists. Paradoxically, as the value of marine biological diversity is recognized, the ecosystems that harbor this diversity are fast becoming degraded.

New thinking about how to conserve coastal areas has resulted in protected-area models that incorporate principles of landscape ecology, adaptive and ecosystem management, and zoning in protected-area plans.

1()5. Van't Hof, T. 1983. The economic benefits of marine parks and protected areas in the Caribbean region. Proceedings of the 5th International Coral Reef Congress 1:351-556.

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Most of the marine parks in the Caribbean are associated with coral reef and found in developing countries. As. exploitation of marine resources for short4erm profits has often prevailed over careful management ensuring lasting returns, it is important that marine biologists and conservationists use all available arguments to convince administrators and politicians of the need to establish marine parks as a means of marine resource management. Although the benefits of resource management in connection with fishing and other collecting at sustainable levels are fairly well known, the economic benefits of marine parks in relation with marine tourism have been less well documented. The economic benefits of marine parks are a dirt result of management actions. Firstly, marine parks aim at protection of the resource base and hence, guarantee a certain quality of the environment to park users. Secondly, marine parks regulate use so as to ensure sustainability of uses and to avoid conflicts between users groupers with different interests. Finally, marine parks provide services and facilities to users. These factors are believed to cause an increase in tourism compared with the situation where no management is existing. From the survey of marine parks in the Caribbean and adjacent regions, it appears that marine parks are generally considered economically beneficial, but hardly any d4ta exist to substantiate this assumption Two studies have focused on the economic benefits of marine parks with a substantial marine component: Virgin Islands National Park at St. John and Cahuita National Park in Costa Rica. Analysis of the costs and benefits of the existence of the parks demonstrates a high benefit to cost ratio for both parks. In order to make marine parks economically beneficial or to increase their benefits, it is recommended that active, ongoing management is ensured, that adequate user facilities and services are provided$_1$ and that the promotional value of the existence of a park be fully exploited.

1()6. Watson, M. and Ormond, R.F.G. 1994'. Effect of an artisanal fishery on the fish and urchin populations of a Kenyan coral reef. Marine Ecology Progress Series 109: 11~129.

An investigation of the effects of artisanal fishing on coral reef fish assemblage structure was undertaken through a comparison of fish stocks on 2 apparently identical sets of reef one (within the Kisite Marine National Park) on which all fishing is prohibited, and one (within the Mpunguti Marine National Reserve) on which artisanal fishing is allowed. Replicate visual censuses of fish along 250 x 10 m band transects at 6 study sites demonstrated that there were large differences in population density and biomass of the principal families of commercial reef fish (Lethrinidae, Lutjanidae, and Serranidae) between the unfished marine park area and the adjacent fished marine reserve area. Commercial species within the park were up to 10 or more times abundant than those in the reserve. In addition, 6 species of butterflyfish (Chaetodontidae) and 2 species of triggerfish

(Balistidae) were significantly more abundant on shallow and/or deep transects within the park. For most species of commercial fish, larger individuals were observed in the park than in the reserve. In contrast, smaller grouper species, one species of butterflyfish, and sea urchins were significantly more abundant C n transects in the reserve. It is suggested that these increased abundances may be second order effects (mediated by reduced competition or predation) of increased fishing pressure. Overall results allow an assessment of the effect of the artisanal fishery on the fish stocks, and provide a measure of the effectiveness of protection afforded by the marine park

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1()7. White, A.T. 1986. Marine reserves: How effective as a management strategy for Philippine, Indonesian and Malaysian coral reef environments? Ocean Management 10:137-139.

This study evaluated the effectiveness of marine reserves as an approach to coral reef management in southeast Asia and isolates the most effective management techniques. Seven reserve areas in the Philippines were compared with two similar management areas in Indonesia and two in Malaysia. Two control areas in the Philippines were also considered. Comparison of the areas included the following: 1) documentation of the status of various reefs in the three countries, in terms of biology, management approaches, patterns of human use, and the larger environmental setting; 2) examination of the effect of various factors, including formal management schemes, human exploitation, and general setting, on the reef; and 3) a summary of those generalities found among sites in terms of environmental conditions, management and use by humans. The following coral reef parameters were used to evaluate reef condition: substrate cover, density of coral genera, Acanthaster and Tridacna abundances, chaetodontid diversity, topographic relief, and noticeable damage. Sites were ranked in terms of reef quality and compared to remoteness, human exploitation, destructive uses, and management types. Municipal and national management approaches were contrasted and the effects of local education, scientific and tourist interest were noted at each site. Those sites with active local participation in management showed the greatest potential for environmental maintenance and improvement At other sites where some form of management exists, except one, the management showed a positive impact and a potential for sustainable use. Control sites and those proposed for management without protection show some form of degradation.

108. Wolfenden, J., Cram, F. and Kirkwood, B. 1994. Marine reserves in New Zealand: A survey of community reactions. Ocean and Coastal Management 25:31-51.

The social aspects in relation to the establishment of marine reserves have received little attention compared with the study of bio-physical phenomena. Subsequent to the passing of the Marine Reserves Act (1971), New Zealand led the world in protection of the marine environment with an area of non-extraction at Goat Island, Leigh. During the intervening years, no additional mainland marine reserves were created until the designation of Cathedral Cove marine reserve in 1993. The present study examined the nature of community reactions to

marine reserve proposals. Beliefs, attitudes, and knowledge regarding marine reserves were explored and related to the stance of the respondent. Sample populations of 200 rate-payers from four target areas (two high-impact and two low-impact control areas) participated in a questionnaire study. Results confirmed the hypothesis that the establishment of marine reserves would be supported by the majority of respondents, dependent on the implementation of comprehensive social and environmental impact assessments, resulting in the identification of appropriate sites. Public involvement in the planning process, concomitant with information, communication, and compromise were identified as strategies for reducing intergroup conflict. The findings of the present research have implications for legislation, implementation, policy-making, management, and public relations relevant to the establishment of marine reserves.