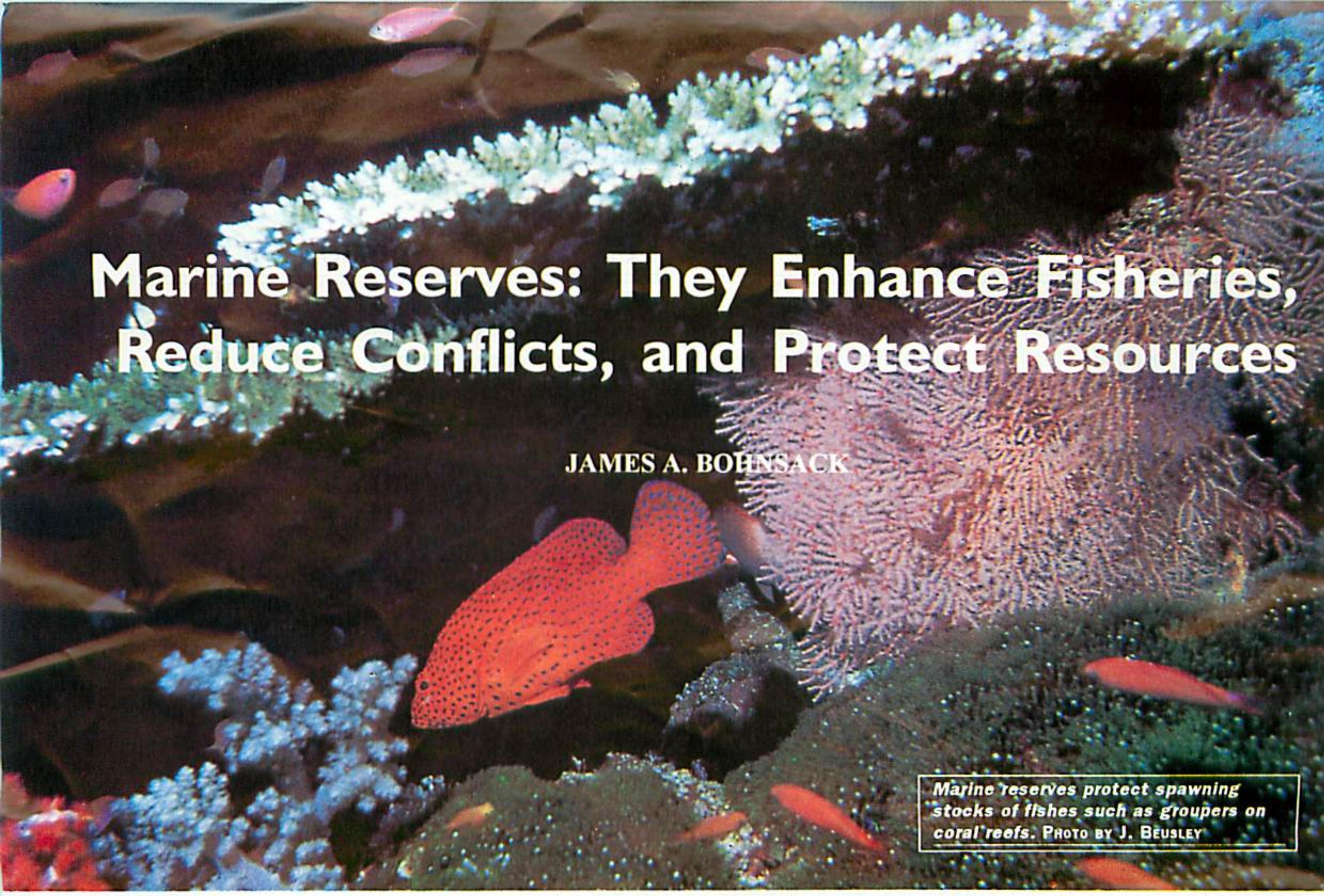
Marine Reserves: They Enhance Fisheries, Reduce Conflicts, and Protect Resources

JAMES A. BOHNSACK



Marine reserves protect spawning stocks of fishes such as groupers on coral reefs. PHOTO BY J. BEUSLEY

In wildness is the preservation of the world.

- Henry David Thoreau, 1862

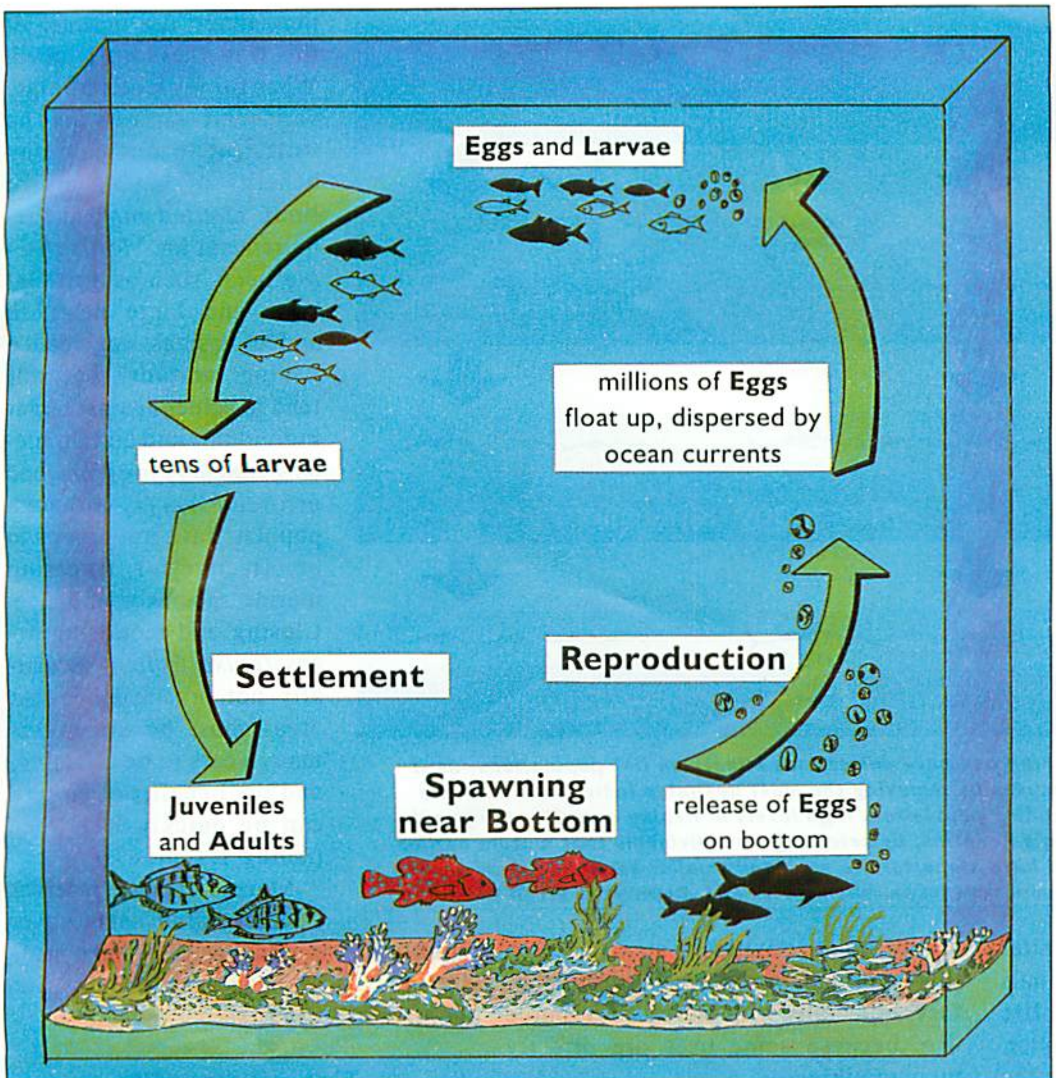
It has taken almost a century for Thoreau's words to be applied to the oceans. In that time, the world population has quadrupled, and more people are migrating to the coast with the hope of utilizing the marine environment as a source of food and employment, and also for recreation, tourism, education, and research. Unfortunately, increased use brings user conflicts, and many fisheries have been depleted or have collapsed. To most people the ocean seems boundless, its resources inexhaustible, and its ability to tolerate human activities unlimited. We now know that these perceptions are false: ocean resources are finite, and human activities can be devastating.

For the first time in human history, we have the ability to catch fish faster than they are produced. Our catch ability must be tempered with new ways of preventing overfishing and resource depletion. Marine fishery reserves, areas protected from all fishing and other harvesting activities, provide one approach. Since the first modern reserves were established in the mid-1970s, they have been increasingly used for fisheries management and resource protection.

Species Protection is a Fundamental Goal

The primary purpose of marine reserves is to ensure that fisheries continue by protecting a portion of the spawning stock from exploitation. In a refuge, abundance, average size, and total egg production can be increased over what it would be if the area were fished. Eggs and larvae produced in reserves are then spread by oceanic currents to both exploited and protected areas.

The concept of marine reserves is simple: If protected from human interference, nature will take care of itself. A large body of scientific literature attests that harvested stocks will recover if fishing stops. The reserve concept is not really new. Until recently, most reef fisheries were probably partly maintained by natural refuges: areas too



The typical life cycle of reef organisms includes a pelagic dispersal phase as eggs and larvae, and a sedentary demersal phase as juveniles and adults. REDRAWN BY J. ESPIRITU FROM THE ORIGINAL ARTWORK BY J. DOUCETTE OF WHOI GRAPHICS

deep, too remote, or too difficult to locate easily. With improved fishing methods and more people fishing, the effectiveness of natural refuges diminishes. Marine reserves are best suited to protecting species with the restricted geographical movements typical of most reef organisms.

Life History on a Reef

The ecology and life history of reef organisms make them vulnerable to fishing. Most species have a two-stage life cycle: a pelagic (open water) egg or larval stage, and a demersal (bottom) juvenile and adult stage. Eggs and larvae are passively transported and dispersed as plankton by ocean currents. Depending on the species and location, eggs and larvae can drift from about a week to several months before larvae settle (recruit) to bottom habitats. Once settled, juveniles and adults live a comparatively sedentary demersal existence.

Planktonic survival is generally very poor. Abundance at settlement can vary by orders of magnitude from year to year due to uncertainties in currents, weather, food availability, and predation. This annual variability results in good or poor recruitment years, reflected by the abundances of various year classes for individual species. Once settled, reef organisms have greatly increased chances of survival, and typically live for many years, often decades. Some corals live for centuries.

Juveniles allocate most of their surplus food energy to growth; reproduction is often delayed for several years. Adults tend to grow slowly because their energy is largely allocated to reproduction. Fecundity (total egg production) usually increases exponentially with body size. For example, one 61-cm red snapper can produce as many eggs as 212 smaller 42-cm females. The result of this size relationship is that a few older individuals may be extremely important to total egg production and population replenishment.

Adults of exploited reef species are typically characterized by slow growth, low adult natural mortality, long life, and large body size. In the natural environment, large body size is often an advantage because it helps in capturing prey and escaping predation. Unfortunately, fisheries tend to selectively target and remove larger individuals because they provide more excitement, food, and revenue than smaller fish.

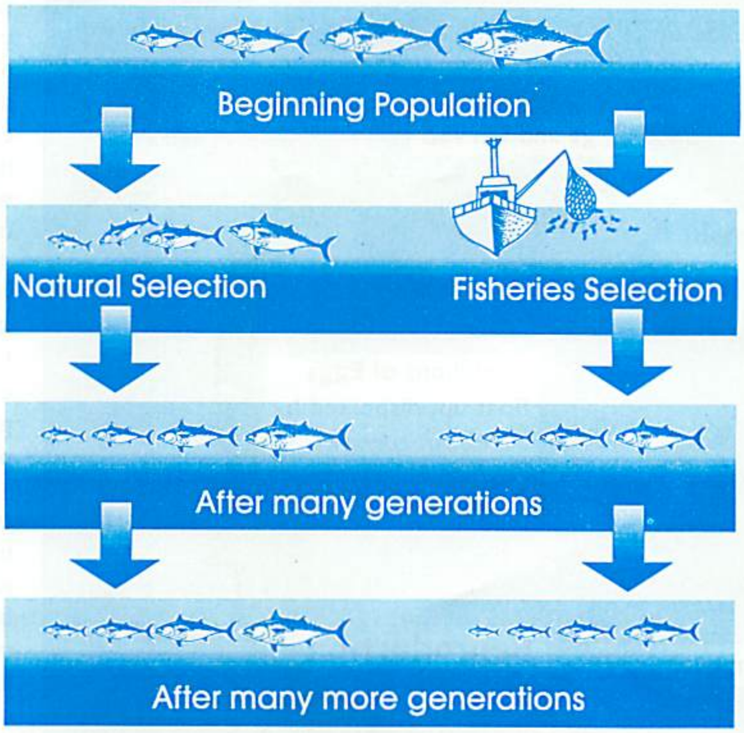
Vulnerability to Fishing

Excessive fishing can deplete the populations (stocks) of certain species, disrupt the marine ecosystem, and damage a coastal area's overall economy. Many fisheries around the world have been depleted or have collapsed entirely, such as the reef fisheries in Bermuda and Puerto Rico. Initial symptoms of overexploitation usually include a decline in average fish size and the disappearance of larger species.

Recruitment overfishing occurs when fishing disrupts the replenishment process. recruitment failure occurs because too few eggs are produced to replace the adult population. For species such as grouper (family Serranidae), which change their sex by switching from female to male with age, size-selective fishing can create a shortage of males to fertilize eggs. Even if fishing levels are acceptable for average conditions, a population could collapse after several years of unusually poor recruitment due to *natural environmental* events.

Reef fishes are also vulnerable to overfishing because they can be predictably located in time and space. Some species form large spawning aggregations at specific places and times, making them easily exploited. Aggressive behavior, curiosity, and inexperience with humans also make many species vulnerable to fishing.

Fishing can also reduce genetic diversity within a species, especially when a stock size is greatly reduced from natural levels. Fishing depends on harvesting a wild stock. Unlike animal husbandry, which protects animals with desirable characteristics from slaughter in order to breed those characteristics into future generations, fishing operates by removing the most desirable individuals (from a fishers perspective) from the breeding population. Excessive mortality can alter genetics by selecting for individuals that mature early and have a shorter life span, smaller adult size, and wary behavior.



Fishing can have deleterious effects on fish populations, as it operates by removing the most desirable individuals from the breeding population. High levels of fishing can alter the population's genetics, by selecting for individuals that mature earlier and have a shorter life span and smaller adult size. REDRAWN BY J. ESPIRITU FROM THE ORIGINAL ARTWORK BY J. DOUCETTE OF WHOI GRAPHICS

Sustained fishing can also lead to the loss of diversity between species by selectively removing vulnerable species. Loss of certain species could cause unforeseen disruptions or permanent alterations to the ecosystem.

Resource Conflicts

Fishing is often a source of conflict between competing fishing interests. Commercial and recreational fishers are often in conflict, partly because of different values and objectives: Commercial fishers usually want to maximize revenue for their effort, while recreational fishers are more interested in having fun, catching their dinner, hooking large fish, or just catching anything.

One traditional way of dealing with conflicts is through "multiple resource use". Multiple use has often been interpreted to mean allowing many, if not all, different activities in an area. Often this approach has proved unsatisfactory, especially with increased resource use, because some uses are directly incompatible.

Traditional Management Actions and Benefits of Marine Reserves

Many of the traditional actions used in fishery management are ineffective or impractical to use with reef fisheries, especially when fishing levels are high. For example, *closed seasons* and *temporarily closed areas* may not be effective, because fish can be caught in other areas and at other times. *Quotas* and *bag limits* can be expensive to monitor and difficult to enforce; they also require timely, accurate data and precise knowledge about the various users and species in the fishery. Bag limits and *size limits* can be ineffective due to unintentional release mortality: Fish often die when caught in deep water because of injuries associated with depth changes, and, even when handled carefully, a certain percentage die because of the way they are hooked. When fishing levels are high, incidental mortality may be sufficient to dissipate any benefits of having a size limit. *Limited entry* and requirements for *selective fishing gear*, such as artificial baits and large net-mesh and hook sizes, may reduce fishing mortality but still tend to select against larger individuals and certain species. *Hatchery programs* and *artificial reefs*, although popular, have not proved to be effective for increasing marine species abundance. Closing and reopening areas *(pulse fishing)* is usually not practical because areas must be closed for many years to be effective, and the benefits of closure can be quickly lost when fishing resumes.

Marine fishery reserves offer several advantages over traditional approaches to fishery management, and have both fishery and nonfishery benefits.

Fishery Benefits

An important fishery management objective is to protect some fishes from harvest to ensure an adequate quantity and genetic quality of offspring. Marine reserves are designed to achieve this objective based on the ecology of typical reef organisms. The dispersal of eggs and larvae from reserves to surrounding areas can maintain, and perhaps improve, fisheries yield, especially if total egg production is higher than it would be if all areas were fished. With fishery reserves, data collection needs are reduced and management can operate without complete information and understanding about different species and their interactions.

There are additional direct benefits to fisheries. Because fishes are never caught or handled, incidental bycatch mortality is eliminated. Also, important species that have become rare or that are particularly vulnerable to fishing will have an opportunity to rebuild their populations in the reserves. Fisheries could also benefit from fishes that occasionally wander out of the reserves into surrounding areas, particularly large trophy fish.

One of the most important functions of reserves is to provide insurance against stock collapse. All fishery management has some degree of uncertainty and risk; it can fail because of inadequate scientific models, errors in the data, inadequate compliance, or ineffective management actions. Chance events, such as environmental uncertainties in recruitment, could also lead to stock collapse even if fishery management were adequate for average conditions. If a stock collapses for whatever reason, fishery reserves can act as a reservoir for rebuilding a stock at a faster rate than would otherwise be possible.

Reserves can also provide indirect benefits to fisheries. They facilitate scientific studies of harvested species. Natural mortality, a critical parameter for most fishery management models, is virtually impossible to measure in an active fishery, but can be measured in reserves.

One benefit to fishers is that regulations, such as quotas and size and bag limits, can be less restrictive. Reserves are also equitable in that they apply to all fishery participants. Enforcement is often simplified, because it is easier to detect fishing than to determine if fishers are using legal methods or have a legal catch.

Nonfishery Benefits

Marine reserves offer many benefits not related to fishing. They can protect biodiversity and provide areas in a natural balance free from direct human disturbance. They can reduce user conflicts by separating incompatible activities, including those involving fishing. Reserves can be used to improve public awareness and understanding of natural systems and human impacts on those systems.

Reserves may be especially important for monitoring long-term environmental changes. The only effective way to have an understanding of the impacts of human activities on natural systems is to have reference areas with minimum human impact.

Marine reserves can enhance some activities and allow new uses not possible in harvested areas. Underwater photographers, naturalists, ecotourists, and scientists can benefit from reserves. Certain kinds of scientific experiments, ecotourism, and education are only possible in natural areas protected from fishing.

Problems with Marine Reserves

Marine fishery reserves alone will not solve all fishery problems. They are not likely to provide much benefit to highly migratory species, which can be caught outside reserves. For species that can be protected, few scientific data exist to precisely determine the ideal number, location, size, and total area that should be included in reserves. While too little area will not provide much protection, too much area could unnecessarily limit fisheries production. Current information, although limited, suggests that 10 to 20 per cent of the continental shelf should be protected for optimum benefit. reserves must be large enough to have some biological integrity and include the normal movements of protected species.

Despite scientific support, the use of reserves is not without controversy and opposition. Fishing interests are usually apprehensive and skeptical about marine reserves because of a lack of direct long-term experience with them. Even when accepted as a good idea, most fishers do not want reserves to include their favorite fishing spot - the NIMBY ("not in my backyard") problem. However, experience suggests that attitudes change over time: Terrestrial wildlife reserves, for example, are now common and widely accepted. In New Zealand, marine reserves initially faced great public opposition when introduced in 1977; however, resistance quickly diminished and marine reserves gained strong support.

For reserves to be successful, public education and awareness about the function and importance of reserves is needed. Also, as resources within reserves increase, adequate surveillance and enforcement will be necessary to discourage poaching. Despite these problems, creating a reserve is a more attractive alternative than dealing with a collapsed fishery, or closing a fishery in order to rebuild depleted stocks.

Henry David Thoreau probably never appreciated how prophetic his words would be or their eventual application to the oceans. Growing scientific evidence indicates that marine reserves are successful and benefit both fishery and nonfishery activities.

While the use of reserves has increased around the world, the first large experimental reserve in the USA was just declared off the eastern coast of Florida in 1994. Other fishery reserves are being planned in the US Virgin Islands, Puerto Rico, and as an essential part of the Florida Keys National Marine Sanctuary.

In conclusion, fishery reserves are based on the fundamental ecology of marine organisms and offer benefits to both fishery and nonfishery interests. Although marine reserves are primarily intended to protect or enhance fisheries by protecting the quantity and quality of reproductive output, they also help protect biodiversity and reduce user conflicts by separating incompatible activities, and they can act as reference areas for study of natural processes with limited human disturbance. Some of these goals are impossible without reserve areas. Finally, reserves provide an insurance policy against fishery collapse. Through networks of fishery reserves, we can protect reef ecosystems and allow sustainable harvests for present and future generations.

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J.A. BOHNSACK *does research on reef fisheries and marine reserves as Reef Resource Team Leader for the Miami Laboratory of the Southeast Fisheries Science Center, National Marine Fisheries Service.*