

# The Biology, Fisheries, and Management of the Queen Conch, *Strombus gigas*

WILLARD N. BROWNELL and JOHN M. STEVELY

## Introduction

The queen conch, *Strombus gigas* (Fig. 1), a large marine snail, has been a principal source of food for the inhabitants of Caribbean coasts and islands since the first American Indians settled there long ago. Today it remains an important source of protein in the region, while imports by the United States have grown. However, stock depletion is now occurring in many areas due to overfishing.

This particular conch is one of six species of the family Strombidae found in the Caribbean and Florida, and is by far the region's most important mollusk. Queen conchs are heavily fished throughout most of their range from Bermuda and southern Florida, all around the Caribbean, south to

Cayenne (Fig. 2). Besides conch (pronounced "konk"), they are also known as botuto (Venezuela), cambombia (Panama), carrucho (Puerto Rico), cobo (Cuba), guarura (Los Roques), lambie (Windward Islands), and lambí (Hispaniola). They are also frequently called "pink conch."

In some places, such as the Caicos Bank, conchs with thick, stubby shells and leathery black skin are found. These are called "samba" or "sanga"

Willard N. Brownell is with the Complex Systems Research Center, O'Kane House, University of New Hampshire, Durham, NH 03824. John M. Stevely is with the Marine Advisory Program, University of Florida, 1303 17th St. W., Palmetto, FL 33561. Views or opinions expressed or implied are those of the authors and do not necessarily reflect the position of the National Marine Fisheries Service, NOAA.

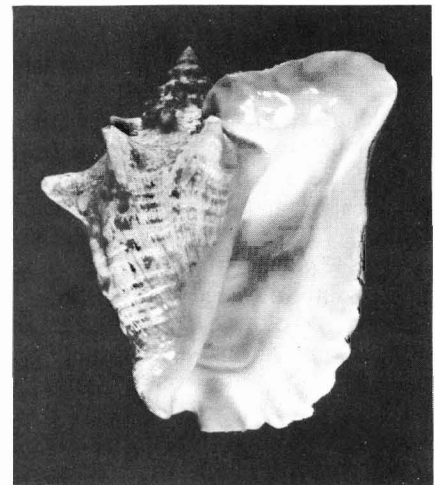


Figure 1.—Adult queen conch, *Strombus gigas*.

conchs. Fishermen consider them to be a different, and far less desirable, animal, while biologists say they are simply a morphological variation of the queen conch (Randall, 1964).

Economically, the queen conch is now the second most valuable Caribbean fishery resource after the spiny lobster. As a protein resource it has been second only to finfish in native diets for at least 100 years. In addition

**ABSTRACT**—Available information on the biology, fisheries, and culture of the queen conch, *Strombus gigas*, throughout its geographic range, is reviewed. Beginning in the early 1970's, development of a lucrative frozen conch meat market in the United States dramatically increased the economic significance of the queen conch. However, the current condition of several conch fisheries indicates that these stocks are insufficient to meet demand. Some conservation measures have been implemented, but lack of fisheries biology data and fisheries personnel hamper development of comprehensive management plans. Problems with stock depletion have focused attention on the possibility of conch culture and/or stocking. In recent years a number of small, local research projects have been initiated to study queen conch biology and larval rearing. However, expanded research is needed to develop larval culture techniques applicable to pilot scale hatchery operation.

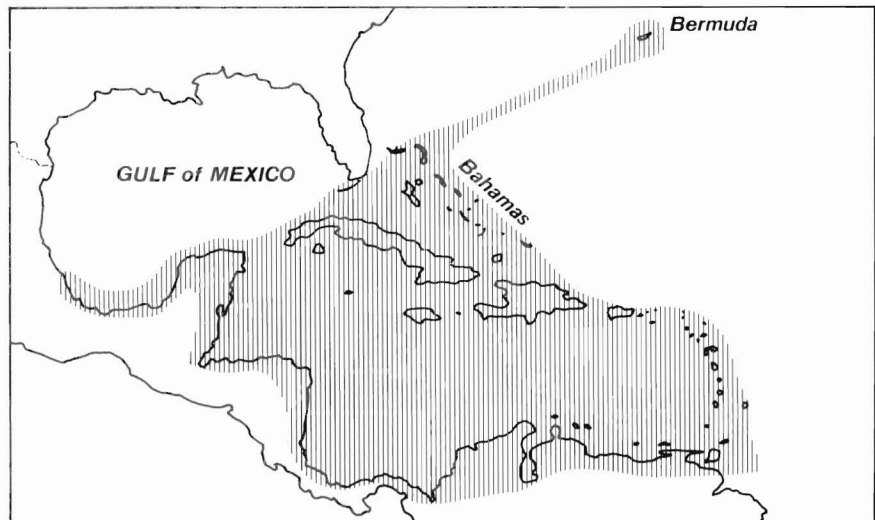


Figure 2.—Geographic distribution of queen conch, *Strombus gigas* (after Warmke and Abbott, 1961).

to the value of the meat, the brightly colored shell is often sold for ornamental purposes and was once used in the manufacture of lime and porcelain. Occasionally, an irritating particle lodged between animal and shell results in production of a conch pearl. Although these pearls often have high market value, demand for them is limited since they fade with age.

Today, rapidly expanding human populations throughout the region have brought more modern fishing methods, more sophisticated processing and marketing structures, and the queen conch has been overfished over most of its range. Catches in most areas now are not even sufficient to satisfy local demand, much less to take advantage of lucrative export markets. This paper reviews the biology and fisheries of the queen conch and also considers management and research strategies for its restoration and culture.

## Biology

### Habitat

Queen conchs commonly inhabit sandy bottoms that are stable enough to support the growth of some of the numerous species of algae and seagrasses upon which they feed. They are also found on gravel, coral rubble, and smooth hard coral or beach rock bottoms. Queen conchs may be found in only a few inches of water or down to 76 m (250 feet), but they seldom go deeper than 30 m (100 feet) (Randall, 1964). Restriction of queen conchs to shallower water has generally been attributed to limitations of light for plant growth (Randall, 1964; Robertson, 1961). Small juvenile conchs (< 80 mm or 3.2 inches) are often buried in sand during the day and are rarely seen (Randall, 1964).

### Food

The queen conch is one of the largest of the herbivorous gastropod mollusks (Yonge, 1932), and uses a long, highly extendable proboscis to graze algae and seagrasses.

In general, Randall (1964) found that the dominant plants of a partic-



Figure 3.—*Strombus gigas* laying eggs in 3 m (10 feet) of water off the Bahamas.

ular habitat in which conchs are found tend to be the principal foods. Although seagrasses such as *Thalassia* are consumed, various species of algae are the principal elements in the diet of *S. gigas*. Robertson (1961) observed conchs feeding on the epiphytic algae on *Thalassia* but found no *Thalassia* leaves in the gut. He noted four species of algae that were ingested by *Strombus*: an unidentified blue-green, *Cladophora* sp., *Hypnea cervicornis*, and *Polysiphonia* sp. Conchs may ingest considerable quantities of sand while feeding on filamentous and unicellular algae (Robertson, 1961; Randall, 1964). Small benthic animals found in the gut are believed to have been accidentally consumed (Randall, 1964).

Preliminary studies by Hesse<sup>1</sup> have found that food preferences of the queen conch change over the course of a year. Although probably due in part to variations in availability of plant species, apparently there is also a clear seasonal difference in the desirability of certain food sources. Feeding by conch during the night was reported by Randall (1964), and

<sup>1</sup>Chuck Hesse, PRIDE, Pine Cay, Turks and Caicos Islands, B.W.I., pers. commun.

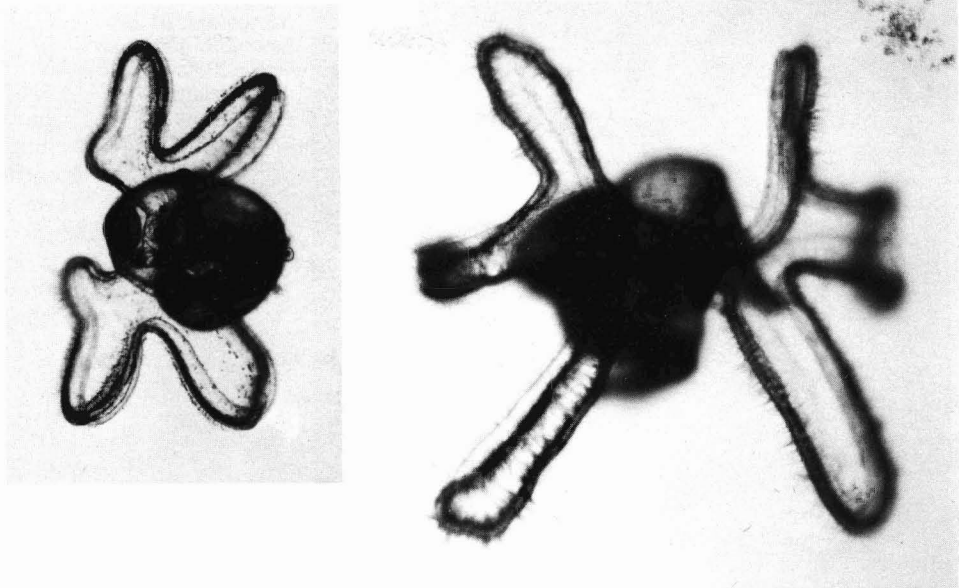
immature animals in particular tend to feed most actively at night, while often spending most or all of the day buried in the sand.

### Reproduction

Copulation and spawning occur during the warmer months of the year (Brownell, 1977; D'Asaro, 1965; Randall, 1964), although in some areas reproductive activity may occur year round (Blakesley, 1977). Fertilization is internal. Under protection of the flaring lip, the penis is extended through the siphonal notch and up into the genital region (Berg, 1975). Randall (1964) observed conchs copulating at night as well as by day. Initial copulation precedes spawning by several weeks (D'Asaro, 1965; Randall, 1964).

Generally, females produce egg masses in clean coral sand with a low organic content. Production of the egg mass (Fig. 3) takes 24 to 36 hours (Randall, 1964; D'Asaro, 1965). The egg mass consists of a long continuous tube which folds and sticks together in a compact mass. Adhering sand grains provide camouflage. The number of eggs per egg mass has been estimated at between 313,000 and 485,000 (Robertson, 1959; Randall,

Figure 4.—Top left is a four-lobed *Strombus gigas* veliger showing beginning formation of third pair of lobes at 10-12 days old. Six-lobed veliger (top right) 15 days old. Below right is a settled larva just prior to metamorphosis. Foot can be seen at upper left of photo, below the shell.



1964; D'Asaro, 1965). Laying of more than one egg mass per breeding season by the queen conch and other *Strombus* sp. has been suggested by several investigators (Robertson, 1959; Randall, 1964; Berg, 1975).

The larvae, or veligers (Fig. 4), emerge from the egg cases after approximately 5 days (D'Asaro, 1965) and immediately assume a pelagic lifestyle, feeding on small phytoplankton. If conditions are right, the veligers settle to the bottom at 17-22 days after hatching, although they continue to be plankton feeders (Brownell, 1977). Metamorphosis is complete (development of the proboscis, disappearance of velar lobes) at 28-33 days (Brownell, 1977). However, larval development can be extremely slow if the supply of phytoplankton does not provide the appropriate types and quantities of required organisms (D'Asaro, 1965; Brownell, 1977).

### Growth

Several investigators have estimated queen conch growth rates (Table 1). Estimates of mean length (tip of spire to distal end of siphonal canal) have ranged from 7.6 cm to 10.8 cm (3 to 4.3 inches) for yearling conch, from 12.6 cm to 17.0 cm (5 to 6.7 inches) at the 2-year mark, and from 18.0 cm to 20.5 cm (7.1 to 7.9 inches) at the end of the third year (Fig. 5, 6).



Table 1.—Calculated lengths of queen conch at 1, 2, and 3 years of age.

Lengths (cm) and years			Method of calculation (geographic location)	Reference
1	2	3		
8.8	12.6	18.0	Size frequency distribution of natural population (Puerto Rico)	Berg (1976)
7.6	12.8	18.0	Size frequency distribution of natural population (Venezuela)	Brownell (1977)
10.8	17.0	20.5	Von Bertalanffy growth curve analysis of Randall's 1964 tag/recapture data (St. John, U.S.V.I.)	Berg (1976) Brownell et al. (1977)
No data	17.0	18.6	Von Bertalanffy growth curve analysis of nine populations using tag/recapture data (Cuba)	Alcolado (1976)

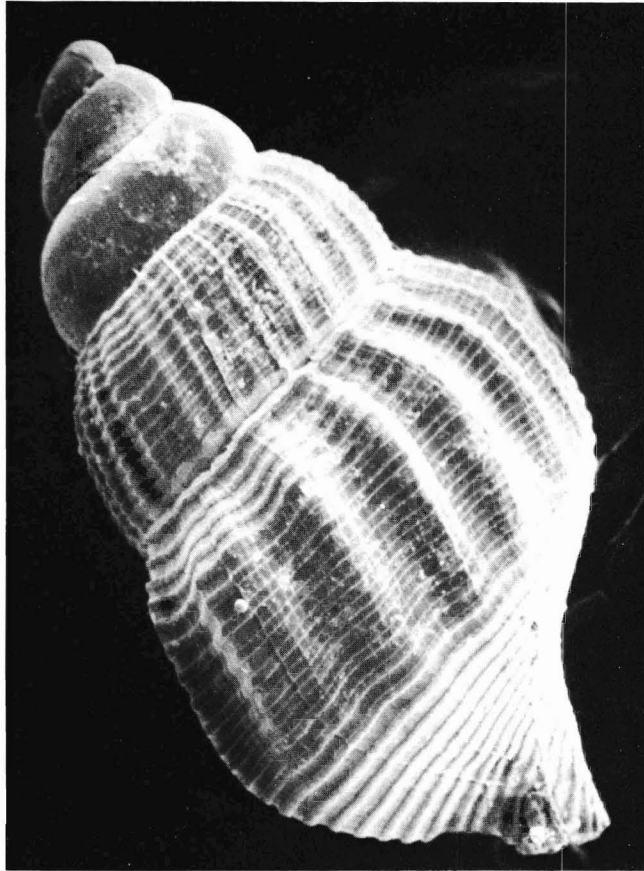


Figure 5.—A photomicrograph of a *Strombus gigas* juvenile 20 days after metamorphosis (4 mm long; 95×). Photo courtesy of Scott Siddall, Rosensteel School of Marine and Atmospheric Science, University of Miami.

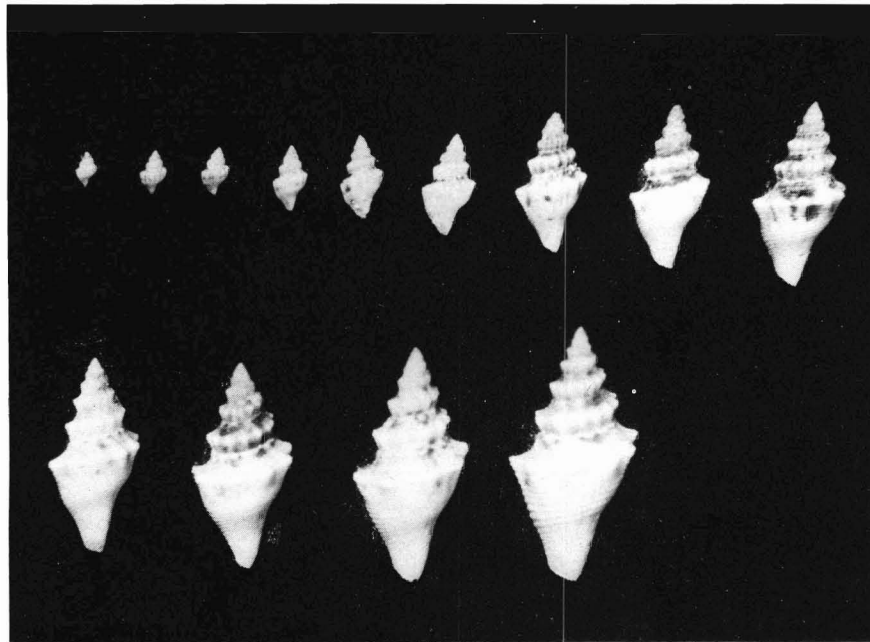


Figure 6.—Size series of queen conchs raised at the Los Roques, Venezuela, station (largest is 18.0 mm long). Photo courtesy of C. Berg.

Hesse<sup>2</sup> and Berg (1976) estimated that at an age of 2.5-3.0 years the conch stops building the shell in a spiral fashion and starts building the flaring lip (Fig. 1). At this time, the animal will continue to grow more meat, but at a much slower rate. Once the shell lip begins forming, more of the total weight is made up of shell weight and nonmarketable viscera. Queen conch most commonly reach an acceptable market size of 18.8 cm (7.5 inches), with a total weight of 845 g (29.6 ounces), and a meat yield of 100 g (3.5 ounces) at age 2.5 years (Berg, 1976).

Sexual maturity is attained after the flaring lip is well developed at an age of 3-3.5 years (Hesse, footnote 2; Berg, 1976). Thus, queen conchs reach marketable size before they are sexually mature. Berg (1976) estimated mean longevity to be 6 years.

Queen conchs with the broadest flaring lips are not the heaviest. When first laid down, the lip is thin and very broad. Soon, boring organisms and normal wear begin to erode the shell, and the thin outer lip crumbles. Periodically, what remains of the lip is repaired with new shell. A progressively shorter but thicker lip is the result (Randall, 1964).

#### Movements and Migrations

Parker (1922) described the unique locomotion of the queen conch. The conch thrusts its foot against the substrate, causing the shell to be lifted and thrown forward in a hopping motion. Berg (1975) suggests that this "hopping" motion may be of considerable adaptive significance. Most gastropods glide along by muscular waves of the foot, leaving a continuous chemical "scent" which enables night-feeding predaceous gastropods, octopuses, and crustaceans to "track" them; the conch's characteristic motion does not result in such a clear trail for these predators to follow.

<sup>2</sup>Hesse, C. 1975. The conch industry in the Turks and Caicos Islands. Unpubl. manusc., 18 p. PRIDE, Pine Cay, Turks and Caicos Islands, B.W.I.

Field studies in the Turks and Caicos Islands by Hesse (1979) have greatly added to our understanding of queen conch movements and migrations. Queen conchs migrate seasonally: Inshore during spring and offshore during autumn. Seasonal regularity of migrations was found to increase with age. Hesse (1979) was also able to estimate a "home range" (area over which a conch habitually travelled when not involved in seasonal migrations) for different size classes. Juveniles from 10 to 13 cm (4 to 5.2 inches) long usually remained within a home range of 1,000 m<sup>2</sup> and most conchs from 13 to 16 cm (5.2 to 6.4 inches) exhibited ranges from 2,500 to 5,000 m<sup>2</sup>. Conchs 17 cm long so often moved out of the survey area that meaningful home ranges could not be determined. Adult conchs appeared to range several kilometers. Tag-recapture studies yielded returns up to 2 km distant as little as 2 months after tagging. Tagged adults were found to commonly move a total linear distance of 50-100 m a day.

Hesse (1979) observed that conchs of all ages periodically bury into the substrate, often in response to winter storms. Longer term burying (up to 6 weeks) occurred independent of daily weather conditions and indicated periods of dormancy, which frequently occurred immediately prior to reproductive activity. Randall (1964) suspected that burying was mainly for the purpose of depositing new shell.

### Predation

Randall (1964) reported the following species as predators of the queen conch: Tulip shell, *Faciolaria tulipa*; Florida horse conch, *Pleroploca gigantea*; *Murex pomum*; hermit crab, *Petrochirus diogenes*; spiny lobster, *Panulirus argus*; spotted eagle ray, *Aetobatis narinari*; permit, *Trachinotus falcatus*; hogfish, *Lachnolaimus macunus*; queen triggerfish, *Balistes vetula*; and porcupine fish, *Diodon hystrix*. Eight species of fish (groupers, snappers, and grunts) with remains of queen conchs in their stomachs but without dentition to crush large shells led Randall (1964) to



Figure 7.—Young conch divers working near Gran Roque Island, Venezuela. Photo courtesy of H. Lander.

believe that these fishes had consumed queen conch after some other predator had made the soft part available. Hesse (footnote 2) indicated that octopus and perhaps nurse sharks also prey upon queen conchs.

Once the queen conchs are fully mature, predation by marine animals is apparently limited to large hermit crabs, certain sharks, rays, and sea turtles (particularly loggerheads), and possibly large octopus. Long before maturity (starting at a length of about 12 cm), the most dangerous queen conch predator is man.

### Fishing Methods

Historically, sailing sloops 6-11 m (20-35 feet) long were used for harvesting conch. These sloops sailed to good fishing areas and several men fished from small dinghies. The bottom was scanned with a glass-bottomed bucket until a conch is located. A pole up to 9 m (30 feet) long was then used to hook the conch and bring it to the surface.

This method is currently practiced, to a limited degree, only in the Bahamas, Bermuda, and Turks and

Caicos Islands. Fishing trips last 1-5 days, with the fishing grounds not normally being more than a 1-day sail away. The conchs are kept in corrals or in the live-wells of the boat until just before leaving for market with fresh meats. Sometimes they are taken to market in the shell. In the past, they were commonly dried in the sun or salt-dried during the fishing campaign.

Currently, small boats with outboard motors have become popular for getting out quickly to increasingly distant conch grounds (particularly in the Turks and Caicos). They are also an important status symbol for young fishermen. Traditional native boats with small inboard engines are still used in many places, such as Venezuela, Colombia, and the Dominican Republic. The fisherman's profit margin continues to decrease as both fuel consumption and costs increase, in spite of increasing conch prices.

Most fishermen today are free-divers (Fig. 7), using a face mask and fins to retrieve as many as eight conchs at a time, or to fill a heavy net bag to be hauled from the boat. A good



Figure 8.—Piles of discarded conch shells in the Las Aves Islands off the coast of Venezuela.

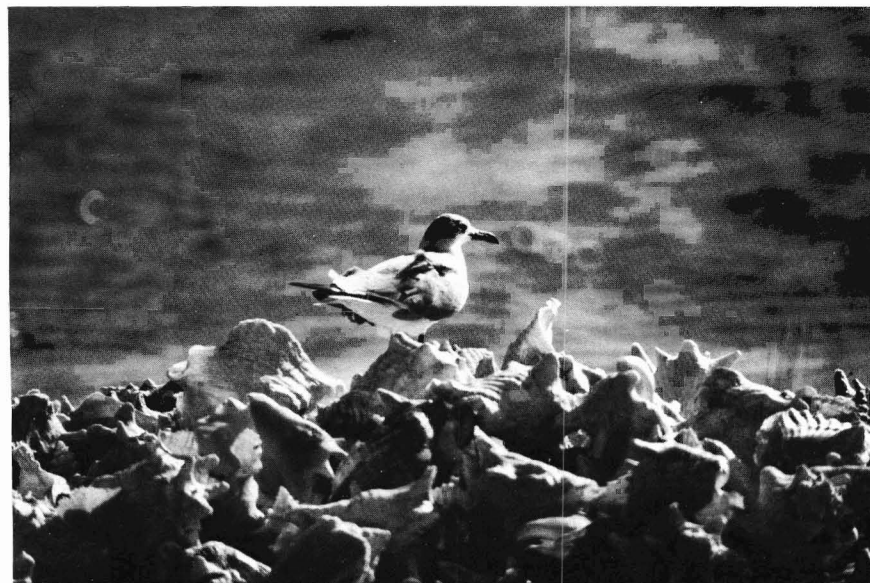


Figure 9.—Laughing gull perched atop a pile of conch shells left behind by fishermen in Los Roques Islands. Photo courtesy of H. Lander.

diver can gather 600 conchs in 4 hours of work on a productive ground in 3-7 m (10-23 feet) of water. But, since a very small portion of the remaining conch stocks can now be found in < 7 m (23 feet), many fishermen are turning to scuba gear for gathering in deeper water, thus increasing their harvesting costs and depleting the

stocks even more. Most conch divers also gather lobsters, usually on different days or during different prescribed seasons.

#### Processing and Marketing

Nearly all present-day fishermen cut the animal out of the shell near the fishing grounds, either on the shore of

a cay or in their boats. This allows the fishermen to carry more meat to market, and at greater speed. The meat is removed by knocking a small elongate hole between the third and fourth whorls of a spire. A narrow sharp blade is inserted in the hole, and the animal is cut free of its attachment to the central axis of the shell. A twisting motion can then be used to remove the animal. In order to keep the shell intact, shell collectors freeze or boil the animal (although boiling may result in fine cracks in the shell). The shells form huge mounds at popular meat removal sites (Fig. 8, 9), or are simply thrown overboard.

Conchs consumed locally are sold uncleaned from buckets at village markets. Processing plants, the majority of which are in Belize and the Turks and Caicos, prepare conch for export to the United States. Teams of cleaners remove the viscera and other soft parts from the muscular foot and peel away the tough dark skin. The cleaned meat is washed and placed in 2.3 or 4.5 kg (5 or 10 pound) plastic bags and cardboard boxes to be frozen, usually <12 hours from the time the animal was removed from the shell.

The waste is used occasionally as bait for fish pots. The marketable meat yield is about one-half the total weight of the shelled animal.

Frozen conch meat is usually shipped by airplane, although occasionally it is transported by lobster carrier boats or cargo ships. Most of it enters the United States through Miami (Table 2).

#### Status of the Resource

The importance of the queen conch fishery has been noted and reviewed by several authors (Doran, 1958; Menzel, 1969, 1971; Boss, 1971; Gunter, 1971). However, it has only been since the late 1960's that an import market for queen conch has developed in the United States, as greater numbers of Caribbean people migrated there (especially to New York City, south Florida, and California). Growing populations and tourism have also increased local de-

mand in countries which have traditionally consumed queen conch.

In Belize (previously British Honduras), queen conch rose from 2.2 percent of the value of fishery export products in 1965 to 23.7 percent in 1976, and the quantity of meat exported rose from 50,000 kg (110,000 pounds) to a peak of 561,000 kg (1,234,200 pounds) in 1972 (Blakesley, 1977). Although export of dried conch from the Turks and Caicos declined during the 1960's to the point of being considered unimportant by the local government, introduction of frozen meat to the U.S. market in the early 1970's resulted in a dramatic increase of queen conch landings (Hesse and Hesse, 1977).

Unfortunately, the available stocks of queen conch are insufficient to meet today's demand. Although conch meat imports through Miami more than doubled from 214,400 kg (471,680 pounds) in 1970 to 550,600 kg (1,211,320) in 1975, in recent years imports have leveled off (Table 2) in spite of rising prices. Blakesley (1977) reported that the export price of conch meat in Belize rose from 0.59 Belize dollars/kg in 1965 to 3.30/kg in 1976. In the Turks and Caicos, prices paid to fishermen rose from US\$0.06 per conch in the 1960's to a 1978 price of US\$0.18 per conch.

Higher prices and improved marketing structures have contributed to severe stock depletion in most of the principal fishing areas around the Caribbean. In Belize total exports declined to 211,000 kg (464,200 pounds) in 1978, considerably less

than half the 1972 production. Reduced abundance has been reported in the Bahamas (Boss, 1971), the Grenadines and Puerto Rico (Adams, 1970), Turks and Caicos (Hesse and Hesse, 1977), and Venezuela (Brownell et al., 1977).

### The Conch Fisheries

The following observations on the status of queen conch fisheries in individual Caribbean countries are mostly the result of a personal tour (July-September 1978) of the region by the senior author, sponsored by the FAO Inter-regional Project for the Development of Fisheries in the Western Central Atlantic (WECAF).

#### Antigua and Barbuda

Conchs are gathered all around Antigua and Barbuda. They used to be sent on flights from Barbuda to Puerto Rico until they became hard to find in the shallow waters of western Barbuda. Local demand is still being satisfied in Antigua, where conch meat sold for US\$1.10/kg (US\$0.50/pound) in 1978. Most conch collecting is now being done by native scuba divers, as the shallow water conch beds have been picked clean. Daily catch is loosely determined by the projected market demand, as the women from the villages who sell conch meat from buckets in the markets do not want to have any left over at the end of the day. Small quantities of conch are air-shipped to Guadeloupe, along with regular exports of iced fish.

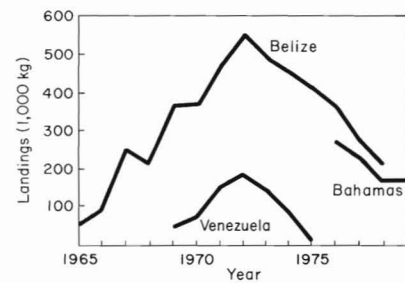


Figure 10.—Queen conch landings in the Bahamas, Belize, and Venezuela (meat weight). Sources: Bahamas (Henry Burrows, Bahamas Fisheries Department, Nassau, pers. commun.); Belize (Blakesley, 1977; data represent queen conch meat exported, estimated at 75-85 percent of total landings); Venezuela (Brownell et al., 1977).

#### Bahamas

Although conch landings in the Bahamas have declined (Fig. 10), there are still collection boats that work their way through the islands (especially around the Abaco, Andros, Berry, Eleuthera, and Exuma islands), buying conchs and delivering them to Freeport, Nassau, and Miami, either live or iced. Since fishable stocks within reach of villages and camps are depleted, fishermen are forced to either terminate their efforts or travel to distant grounds.

To insure maximum local utilization of the resource, export of Bahamian conch meat is prohibited. However, licenses are granted for the export of food products (conch fritters and chowder) that contain no more than 40 percent conch meat. Conch shell jewelry and crushed shell for terrazzo manufacture can also be legally exported. Retail prices in December 1979 averaged US\$4.29/kg (US\$1.93/pound), for conch meat, and reached as high as US\$6.60/kg (US\$2.97/pound) in winter<sup>3</sup>.

#### Barbados

Apparently there never was an extensive conch population around

Table 2.—Conch meat (x 100 kg) imported through Miami, 1970-78.

Country of origin	1970	1971	1972	1973	1974	1975	1976	1977	1978
Belize	145.7	265.0	382.9	245.1	376.7	330.5	222.5	159.9	135.8
Columbia	0	0	39.8	107.7	122.5	50.3	13.5	11.2	62.3
Dominican Republic	0	0	0.5	24.4	10.1	0	2.1	0	0
Haiti	0	0	2.2	4.1	0	0.2	0.2	14.9	58.3
Honduras	58.0	32.4	88.2	83.4	5.7	36.3	57.7	3.7	21.4
Jamaica	0	0	1.5	4.1	28.5	40.7	0.8	0	0
Mexico	0.2	0	8.6	2.2	0	11.7	3.2	1.8	1.5
Turks and Caicos	2.0	2.3	0	0	0	65.9	150.9	221.7	262.8
West Indies	0	0	1.2	22.1	3.9	7.2	2.2	0	0
Other <sup>1</sup>	8.4	0.8	2.7	1.8	2.0	7.8	14.8	2.3	13.2
Total	214.3	300.5	527.6	494.9	549.4	550.6	467.9	415.5	555.3

<sup>1</sup>Bahamas, Cayman Islands, Costa Rica, Guatemala, Nicaragua, Panama, and Venezuela.

Source: National Marine Fisheries Service, Fisheries Development Analysis Branch, New Orleans, La.

Note: Approximately 27,000-32,000 kg of queen conch are imported to the United States each year directly through New York. Most of this comes from Belize, Honduras, and Colombia (J. Ledner, National Marine Fisheries Service, Fisheries Development Analysis Branch, New York, N.Y., pers. commun.). Less conch (in fresh or dried form) enters the United States on small boats, mainly in south Florida.

<sup>3</sup>Henry Burrows, Bahamas Fisheries Department, Nassau, pers. commun.

Barbados. Older fishermen remember only occasional small catches that were consumed locally. Single animals are still seen at times by scuba divers.

#### **Belize**

Conch production is monitored by the Fisheries Department. There is a closed season on conchs from 15 June to 30 September, and the minimum legal size is 18.8 cm (7.5 inches). A conch of this size yields 100 g (3.5 ounces) of marketable meat. Conch demand is high in Belize, but the high export market value (US\$3.19/kg or US\$1.44/pound for the year ending June 1978) means that most is frozen and sold abroad. Within the marketing range of the five fishery cooperatives in Belize, probably only about 10 percent (the minimum required by law) of the total catch reaches local markets. In the rest of the country all of the catch is sold locally, except for small quantities that are dried in fishing settlements near the Guatemalan border, and sold in that country by local traders. In such outlying areas, the catch rate is determined by daily market demand.

Conch meat exports from Belize (estimated at 75-85 percent of the total catch) rose sharply during the late 1960's, but has drastically declined in recent years (Fig. 3). Although conch meat exports have steadily declined since they reached a peak in 1972, rising prices have increased or maintained the value of export sales (US\$716,790 in 1976).

Conch fishing effort has slightly increased every year since 1973, but the catch per diver per 4-hour day has decreased from about 36 kg (78.2 pounds) of meat in 1975 to about 11 kg (24 pounds) in 1978. Blakesley (1977) calculated the average size (shell length) of conchs caught to be 19.1 cm (7.6 inches) in 1976. In 1978-79 the managers of the cooperatives were very concerned about the large number of juvenile conch meats being delivered by fishermen, many in the 50-70 g (1.8-2.5 ounce) range, indicating shell lengths as short as 12.0 cm (3 inches).

#### **Cuba**

Conchs have been an important resource on the southern shelf of Cuba for many years. They are primarily consumed in coastal villages, are often used for bait in fish pots, and are not exported.

#### **Dominica**

Conchs have apparently never existed in significant numbers in Dominica, due to the very limited extent of stable, shallow bottom around the island. Most of the conchs accessible to free divers have long since been taken, but small numbers are still gathered when available by spearfishermen and are consumed locally.

#### **Dominican Republic**

The extremely narrow band of shallow water around the Dominican Republic is not conducive to high conch production. Nevertheless, the Fisheries Department estimated a catch of 132,339 kg (291,146 pounds) in 1977. More than half of the amount harvested came from the offshore banks (Mouchoir, Navidad, Silver, and the southern Bahamas).

Most of the Dominican artisanal fishermen based in the main north coast port (Puerto Plata) use hookah air systems for spearfishing and thus can gather conchs in deeper water than the average native fishermen. Two government agencies (Caza y Pesca and INDOTEC) are concerned about the conch fishery and have identified potential mariculture sites.

#### **Grenada**

The Grenada Grenadines and Grenada proper have traditionally been major suppliers of conch meat to Trinidad, Tobago, and Martinique. The Trinidad trade is basically finished, except for small amounts of conch that are shipped there from the nearly exhausted southeast coast fishery. The main conch grounds are in the north: Conference Point, Bedford Point, Carriacou, Petit Martinique, and all of the shallow waters surrounding the small islands in that area. Some fishermen keep conchs in

natural corrals, bringing them in when the market is most favorable. Most conch divers now use scuba gear and work in depths averaging 12-15 m (40-50 feet).

Domestic conch consumption in Grenada is steady (7,000-9,000 kg or 15,400-19,800 pounds/year), even though the price has more than doubled in recent years. Domestic markets for conch meat are undersupplied by several tons each year. Quantities of conch meat equal to or greater than domestic consumption are shipped on ice through Union Island to Martinique markets<sup>4</sup>.

#### **Haiti**

Despite severe overfishing, Haiti still produces enough conch to supply some local markets, and even to export substantial amounts to Miami. Haitians are traditionally the most dedicated consumers of conch in the Caribbean, and they account for a large portion of the sales of conch meat in Miami and New York. Even in 1943, when there was still considerable local production, Haiti imported 3,900,000 dried conch meats from the Turks and Caicos (Doran, 1958).

#### **Panama**

Conch is still important in the diets of residents of the Caribbean coast of Panama, especially in the San Blas Islands, where most of the fishing activity occurs. Most of the catch is consumed by the Cuna Indian fishermen, but some reaches the markets of coastal towns. Some gets exported along with spiny lobster to Miami, but exports are sporadic.

#### **St. Lucia**

There are many bays and backreef areas in St. Lucia that offer suitable habitat for conchs, but fishermen seldom find conchs in < 9 m (< 30 feet) of water anymore. Currently, they are taken mostly by scuba diving,

<sup>4</sup>Melvin Goodwin, Environmental Research Projects, Inc., New York, N.Y., pers. commun.



25-50 at a time, and are either sold locally or used for bait. Such efforts are very infrequent.

### **St. Vincent**

The Fisheries Officer in St. Vincent is concerned about over-fishing of conchs, especially in the St. Vincent Grenadines, and wants to explore the possibility of raising them somewhere in those islands. No data exist on the current yield of the conch fishery in St. Vincent waters, but stocks have evidently been depleted everywhere. The once-flourishing Union Island fishery (Adams, 1970) now produces only a very limited quantity of conch, most of which is exported to Martinique.

### **Trinidad and Tobago**

Trinidad has never been very productive for conch fishing, due to low salinities and high turbidity in shallow-water areas influenced by the runoff from the big continental rivers and the numerous Trinidadian streams. However, conchs were fairly abundant in Bombshell, Chacachacare, and Scotland Bays until they were fished out several years ago.

Demand for conchs is still high in Trinidad, but the supply is very limited. Only very rarely does a trader boat bring in a small load of iced or dried conch from nearby grounds (Grenadines or Los Testigos).

Tobago has traditionally produced enough conchs to supply local needs, but increased demand there and in Trinidad have led to severe over-fishing. Fishing effort there is now very sporadic, mainly occasional collection of some deeper water conchs for sale to local hotels or for consumption by Tobago residents.

### **Turks and Caicos**

For many years, beginning in the late 1800's, millions of dried conch meats were shipped from the Turks and Caicos Islands to Haiti (Dorna, 1958). Following World War II this trade began to decline. Early in the 1950's there was some export of frozen conch to the United States.

However, in the mid-1950's, fishing effort was shifted toward the newly developed and more profitable export of lobsters. By the late 1960's and early 1970's, the Caicos conch trade was greatly reduced and was neglected by the local government. Queen conchs were fished principally for local consumption, lobster trap bait, and export to Haiti. The catch amounted to only 100,000-200,000 conches per year.

The importance of the queen conch fishery was reestablished in 1973 when export of frozen conch meat to the United States began again. Landings quickly increased in the following years. The exports of conch for 1976 totalled 1,900,000 individuals, valued at US\$470,000. Though accessible stocks are rapidly being depleted, good catches are still being made, due to the fact that there are more fishermen with faster boats fishing far out on the southern and western edges of the Caicos Bank. In May 1978, the South Caicos processors were having a difficult time keeping up with landings, often having to clean and freeze 20,000 conchs or more in 1 day at each facility. Since the ex-vessel price was \$0.18 per conch at that time, divers who gathered 400 conchs in a day (as is commonly done) had very good incomes.

However, the normal U.S. markets were over-supplied at that time (May 1978, just before the closed season started in Belize) and the processors were having to hold back more product than they had space for. The previously active trade in dried conchs to Haiti and the Bahamas is now virtually nonexistent, due to the greater profit associated with the export of frozen product to the United States.

### **Florida**

Queen conch stocks occur along the Atlantic side of the Florida Keys north to the Palm Beach vicinity. They are occasionally seen along the lower southwest coast of Florida. In south Florida, queen conch is popular, and large quantities are used in fritters, salads, chowders, and fried as steaks. Highest recorded meat pro-

duction was 25,503 kg (56,356 pounds) in 1966<sup>5</sup>. However, in recent years, often only ten kilograms have been landed, the result of harvesting restrictions imposed in 1971 due to concern over declining stocks (there is a limit of 10 queen conch per person per day<sup>6</sup>).

Conch meat imports through Miami are handled for distribution to retail outlets by approximately 24 wholesalers. Recent (November 1980) retail prices in south Florida, are commonly \$7.15-\$8.13/kg (\$3.25-\$3.65/pound) for cleaned, frozen meat. Two years ago retail prices at the same stores surveyed in 1980 ranged from \$4.60 to \$5.50/kg (\$2.10 to \$2.50/pound). Because of these high prices, harvesting restrictions are occasionally ignored and an undocumented amount of conch meat is sold by fishermen directly to restaurants.

Although strict harvesting restrictions have essentially eliminated commercial fishing, an undetermined number of conchs are harvested by sport divers. Conspicuous and easy to catch, the queen conch attracts the interest of even the most novice diver and is considered a prized souvenir. In view of its popularity in local seafood dishes and the fact that well over a million tourists visit the Florida Keys yearly, the recreational catch may indeed be considerable.

### **Venezuela**

There used to be small numbers of conchs in some areas of the narrow Venezuelan shelf not excessively influenced by wave action and the runoff of rivers (such as Puerto Santo, Puerto Cabello, and San Juan de Los Cayos). These have been virtually eliminated by overfishing. Some conchs are still available in shallow waters around Los Testigos, Los Frailes, La Blanquilla, and La Tortuga. In La Orchila the conch populations are still extensive due to the fact

<sup>5</sup>Summary of commercial marine landings. Florida Department of Natural Resources, Tallahassee, Fla.

<sup>6</sup>Florida State Statutes, 370.113.

that the island is a military zone and the only fishing permitted is for sport by base residents and visitors. Los Roques and Las Aves de Barlovento y Sotavento still have extensive conch resources, in spite of heavy fishing pressure during the 10 years ending in 1974. Conchs are also present at Miniscule Aves (Bird) Island, but now only at depths >25m (>85 feet) where they cannot be reached by free divers.

Venezuelan production dropped from an estimated 180,000 kg (396,000 pounds) of conch meat in 1972 to 10,000 kg (22,000 pounds) in 1975 (Fig. 3), mainly due to a closed season and licensing of conch fishermen imposed by the National Fisheries Office. Still, much poaching occurs, especially in the isolated Las Aves Islands, from whence the catches can easily be carried directly to eager markets in Bonaire and Curacao. The reported catch for 1978 was 5,363 kg (11,800 pounds), but the actual figure probably would surpass 20,000 kg (44,000 pounds). The price in the La Guaira market in July 1979 was US \$3.75/kg (US\$1.69/pound).

By placing timely controls on the conch fishery, Venezuela has succeeded in maintaining the natural stocks in the Orchilla, Los Roques, and the two Las Aves archipelagos. However, the pressure is intense, even when the controls are working, and the conch populations could be virtually destroyed in a very short period of time if the controls were relaxed.

### Mariculture

Because of increasing economic importance and concurrent reports of overfishing, the technical and economic feasibility of conch mariculture has attracted the attention of several investigators (Berg, 1976; Brownell et al., 1977; Brownell, 1977). These researchers have succeeded in raising conch from eggs through metamorphosis and have achieved normal growth and development with the resulting juveniles.

D'Asaro (1965) was the first to examine and describe queen conch larval development but was unable to rear larvae through metamorphosis,

mainly due to nutritional limitations. Berg (1976) reported on growth of the queen conch and potential for mariculture.

Optimum larval density of 10 veligers/liter was reported by Brownell (1977) in a system of little or no aeration, inefficient removal of metabolic wastes, and a purely random assortment of food organisms. Larvae were raised on natural cultures of phytoplankton in large fiberglass tanks and aquaria with coarsely filtered, untreated seawater at a remote island research station. Films of algae coating the tanks and covering flat stones collected from the intertidal zone were utilized as food sources for juvenile conchs, which grew in length at a rate of 0.2-0.3 mm/day. Brownell (1977) also noted that under conditions of abundant food and absence of predators, juvenile conchs fed actively both day and night.

Even though these studies have demonstrated that queen conchs can be raised in captivity, considerable work still needs to be done before the proper techniques for conch culture can be defined. Once the technical practicality is demonstrated and conchs can be consistently raised in a hatchery situation, it still will have to be determined if mariculture is economically and environmentally feasible, either under intensive culture or for reseeding of depleted conch grounds.

### Current and Proposed Research

In recent years, several researchers, particularly in Belize, Turks and Caicos, and Grenada, have studied habitat, food preferences, and migration behavior of queen conchs >7 cm (>2.7 inches) in length with the objectives of defining optimum environmental conditions, fishing pressure, and the potential for recuperation of overfished stocks. Such information is essential for helping local governments to establish effective management programs and for determining if conchs can be "farmed" in certain natural areas. Results of these studies have so far been inconclusive, due to the follow-

ing difficulties:

1) Characteristic habitats are hard to define and even harder to map because the vegetation and bottom type undergo seasonal variations and the conch's preferences change as well.

2) Observation of conch densities and movements is limited by the animals' burying tendencies, unpredictable migrations, and periodic concentrations in deep water that are hard to survey.

3) Fishing activities cannot be controlled, since local fisheries departments throughout the Caribbean have little or no enforcement or record-keeping personnel; besides, fishermen are always reluctant to specify where they get their conchs.

The first comprehensive research on conchs was carried out by Randall (1964) in the Virgin Islands. Soon after, a basic conch fishery research program was initiated by the Belize Fisheries Department. Studies on stock density, length frequencies, distribution, harvesting rates, and landings have been carried out fairly regularly there since 1973. A new, expanded research project began in October 1980, primarily to study the biology of the species as it relates to practical considerations of productivity, growth rate, and increasing sustainable yields. The work is being carried out by the Belize Fishery Department with support from the Canadian International Development Research Centre<sup>7</sup>.

The PRIDE (Protection of Reefs and Islands from Degradation and Exploration) Foundation at Pine Cay in the Caicos Islands is carrying out research on the rearing of conch larvae, the behavior and growth of subadult conchs in various types of enclosures, plus continuation of earlier work (Hesse, 1979) on conch ecology as it relates to fisheries problems.

PRIDE currently emphasizes mariculture research through two main approaches: Fundamental work at the

<sup>7</sup>H. Allsopp, Canadian International Development Research Centre, Vancouver, Canada, pers. commun.

wind-powered Pine Cay laboratory using filtered ocean water and controlled monocultures of phytoplankton plus a joint effort with the New York Zoological Society's Osborn Laboratory at the New York Aquarium using an established larval culture and monitoring facility. Both approaches have yielded some success in the rearing of small numbers of queen conch larvae. Much of this work is supported by the Griffis Foundation.

Environmental Research Projects, Inc.<sup>8</sup> (ERF) of Grenada has carried out field studies of conchs at Carricou since 1977 as part of a broad reef ecology and fisheries development program. In 1980 the ERF staff also did some larvae culture experiments. With primarily local people doing the research, ERF is searching for better sources of food and more effective holding systems for laboratory-reared larvae, studying the growth rates and feeding habits of juveniles under extensive culture conditions, and searching for natural nursery grounds of early juveniles. Most of this work, plus some of the PRIDE field work, is supported by the Rockefeller Brothers Fund.

A major research and development effort with emphasis on mariculture was planned by the U.S. National Marine Fisheries Service in collaboration with the University and the Government of Puerto Rico, plus some regional support from the FAO WECAF fisheries program. So far, the desired funding has not been acquired, but a preliminary effort was initiated in Puerto Rico with some support from the island's government and from the NMFS Aquaculture Program operating out of the Galveston, Tex., laboratory.

Three major proposals for conch research emphasizing mariculture have been submitted to Sea Grant (NOAA) since 1978. All were rejected for numerous reasons, the most important one being that there still is no

clear indication that conch production can be increased through mariculture.

Another joint program for conch research was established in early 1980 by the Wallace Groves Aquaculture Foundation and the Rosenstiel School of Marine and Atmospheric Sciences (University of Miami). Field studies are being conducted on the growth and feeding of juvenile conchs (primarily 1-2 years old) at the Foundation's facilities in the Bahama Islands. Larval rearing is being carried out at an established molluscan culture laboratory at the University of Miami, to the specific culture conditions required which will eventually lead to hatchery-scale rearing.

### Conclusions

Increased demand for conch has resulted in rapid expansion of fishing effort to the point where overfishing is now occurring. It is unlikely that current production levels can be maintained unless: 1) Currently intensively fished stocks can be managed to stabilize their presently falling levels of production; 2) conch culture and/or subsequent stocking prove to be useful for increasing production in overfished areas; and 3) new fishing areas can be located and utilized.

Due to rapid and severe declines in several major conch fisheries, a number of management regulations and export restrictions aimed at preserving the resource have been implemented by several countries. These include: Closed season (Belize), minimum size (Belize), requirement that a portion of the catch be reserved for local consumption (Belize), establishment of sanctuaries (Venezuela), daily catch quotas (Florida), and the prohibition of export of unprocessed product (Bahamas).

However, we believe that in some cases where queen conch stocks are clearly in peril, conch fishing should be terminated until adequate stock assessments can be made and sound management plans developed. Unfortunately, lack of biological information, and inadequate enforcement and recordkeeping personnel in local fisheries departments throughout the

Caribbean, hamper development of a comprehensive management strategy.

Mariculture and/or stocking is a possible alternative for increasing or maintaining production. Conch larvae have been reared in the laboratory through metamorphosis. However, larval culture techniques suitable for establishment of pilot scale hatcheries are not yet available.

Existing research programs should be expanded enough to accurately evaluate the feasibility of both intensive and extensive mariculture practices. If it can be shown that it is possible to raise conchs consistently under controlled conditions with low capital investment, small hatcheries could be established at key locations, and local residents could be trained to operate them.

Because of the importance of the queen conch as both a source of food and money, it is important that significant efforts be made to save the resource. It is imperative that there be close cooperation and coordination among all appropriate research and management groups.

### Note Added in Proof

In January 1981 the Wallace Groves Aquaculture Foundation sponsored a queen conch fisheries and mariculture meeting in Freeport, Bahamas, to bring together conch biologists and fishery managers and review conch fisheries, biology, and larvae culture, and define future research needs. Although recent successes with rearing conch larvae through metamorphosis were reported, more work is still needed to properly understand larval nutrition, triggering mechanisms for larval metamorphosis, and maximum rearing densities. At this writing, limited publication of the proceedings is anticipated.

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<sup>8</sup>Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

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