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NON-DETRIMENTAL FINDINGS FOR THE QUEEN CONCH (*STROMBUS GIGAS*) IN COLOMBIA

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I. Background information on the taxa

The queen conch (*Strombus gigas*) has been a highly prized species since pre-Columbian times, dating the period of the Arawak and Carib Indians. Early human civilizations utilized the shell as a horn for religious ceremonies, for trade and ornamentation such as bracelets, hairpins, and necklaces. Archeologists have also found remnants of conch shell pieces that were used as tools, possibly to hollow out large trees once used as canoes (Brownell and Stevely 1981).

The earliest record of commercial harvest and inter-island trade extend from the mid 18th century, when dried conch meat was shipped from the Turks and Caicos Islands to the neighboring island of Hispaniola (Ninnes 1984).

In Colombia, queen conch constitutes one of the most important Caribbean fisheries, it is second in value, after the spiny lobster. The

oceanic archipelago of San Andrés, Providence and Santa Catalina produces more than 95% country's total production of this species. This fishery began in the 1970´s when the continental-shelf archipelagos of San Bernardo and Rosario, following full exploitation were quickly depleted due to a lack of effective management (Mora 1994).

The archipelago of San Andres, Old Providence, and Santa Catalina is located in the south-western Caribbean (11° 30′ to 16° 30′ N, and 78° 28′ to 82° 0′ W) extending over an area of 250,000 km^2. Related to the Lesser Antilles in historical and ethno-cultural terms, it has been an important and strategic Colombian territory since the 1800s and gained the status of Colombia's only oceanic department in 1991 (Article 309 of the National Constitution). The archipelago consists of three inhabited islands (San Andres, Providence and Santa Catalina), and six additional atolls in the north (Serranilla, New, Alice, Quitasueño, Serrana, Roncador), and two in the south (East-South-East and South-South-West).

The San Andres archipelago is the Colombia's northern frontier, bordering on Nicaragua, Honduras, Costa Rica, Panama, Jamaica and Dominican Republic, making a conch a transboundary species and demanding collaborative fisheries management in order to overcome current population declines. By means of bilateral treaties, Colombia shares its fish stocks with USA (Quitasueño, Serrana and Roncador), Honduras (Serranilla), and Jamaica (Serranilla, New and Alice); however few regional management measures are currently in place (Figure 1).

At present, Colombia's queen conch production is fourth in the south-western Caribbean after Pedro Bank in Jamaica, Rosalind Bank and other banks in Honduras, and around Miskitos and Perlas Keys in Nicaragua.

Experiencing a generalized decline in the wild population, the stability of this stock and traditional fishery is at risk. Several factors are responsible for the species´s critical situation: a) its preferences for sandy and shallow reef areas; b) its characteristic slow rate of movement (10 m/hour); c) the need to find mates for copulation, thus require some minimum densities for successful reproduction; d) high value markets values for its products; and e) the possible effects of global climate change for the species (at present not fully understood).

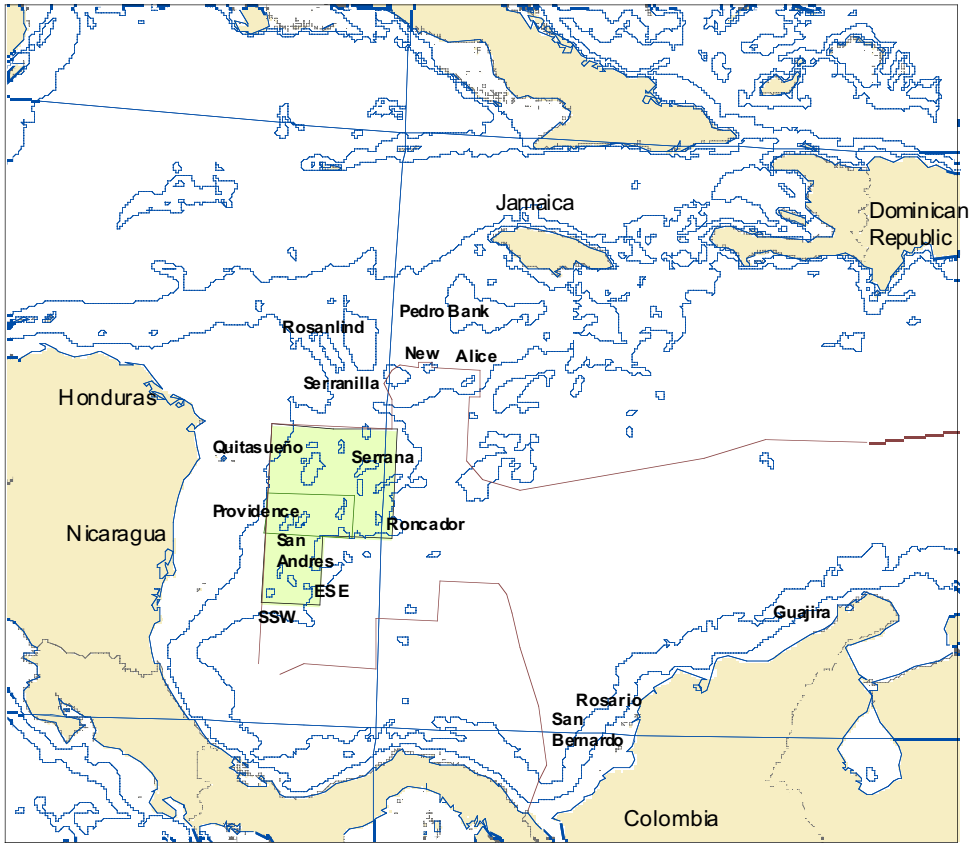


Figure 1. Location of Colombia's queen conch major fishing grounds with respect to neighboring south-western Caribbean. Brown lines denote Colombia's boundaries while green area shoes the Seaflower MPA within the San Andres archipelago.

As a consequence, queen conch was included in the CITES Appendix II in 1992. As a CITES signatory country, Colombia has made progressive improvements in queen conch fisheries management, but it has been also involved in illegal international trade. As a consequence, the queen conch fishery was closed between 2004 and 2007, and just recently re-opened, now following the principles of 1995 FAO code of conduct for responsible fisheries.

Considering the cultural relevance of queen conch and its high market value, there is strong potential for user conflicts, as well as strong incentives for poaching. This case study will describe the Colombia situation, with emphasis on the San Andres archipelago, and propose recommendations to strengthen national and international alliances needed to overcome major threats, in this manner updating information provided in the most recent Significant Review of queen conch trade conducted by CITES in 2003.

1. BIOLOGICAL DATA

1.1. Scientific and common names:

The queen conch, *Strombus gigas*, has a large lipped pink shell (25 cm or 9 inches SL), and has the highest commercial fisheries value of the six species within the western Atlantic Strombidae.

First described by Linnaeus in 1758, the species varies in common names throughout the Caribbean: caracol pala (Colombia), caracol rosa (Honduras, Nicaragua), caracol reina (Mexico), botuto o guarura (Venezuela), carrucho (Puerto Rico), cambombia (Panamá), cambute (Costa Rica), cobo (Cuba), lambi (Dominican Republic), queen or pink conch (in Caribbean English speaking countries), and lambie in the french speaking Caribbean.

FAO Species Identification Sheets separate this species from others in its family because of the large and moderately heavy shell, the outer large and thick lip with a U-shaped notch, the numerous short, sharp spires, the brown and horny operculum, and the bright pink shell with yellow borders.

1.2. Distribution

The species has been reported in Florida, Bermuda, the Bahamas, the Caribbean Islands and Gulf of Mexico, as well as the Caribbean shelves of the Central and South America (Figure 2). Seasonal migrations of adult conch have been reported in several locations. In the Bahamas, conch were observed migrating from the food rich rubble community to sand habitats for reproduction (Stoner and Sandt 1992). In the Turks and Caicos, adult conch moved from a seagrass dominated community to a sand-algal community associated with the onset of winter (Hesse 1979).

Recent scientific surveys in Quitasueño and Roncador banks, within the San Andres archipelago, identified the back-reef and the adjacent lagoon zones as juvenile nursery habitats. In addition, the deeper leeward pre-reef terrace was found to be a nursery habitat in SERRANA bank. The effects of major cuts through the forereef are believed to favor larval retention and deposition (Appeldoorn *et al*. 2003).

On the other hand, spawning areas were observed both on the north and south tips of the archipelago atolls, including the "*Acropora*" reefs in the Roncador´s lagoonal environment. Older adults were found in coral and sand-patch habitat as well as the deeper leeward reefs.

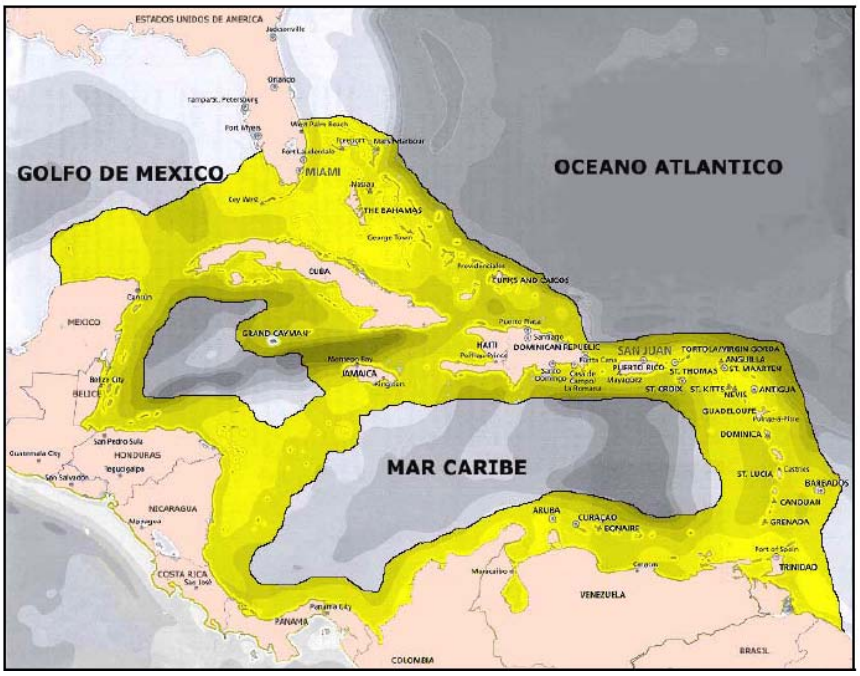


Figure 2. Queen conch distribution across the Caribbean Sea. Taken from Ávila (2004).

1.3. Biological characteristics

1.3.1 Biological and life history characteristics

Queen conch has separate sexes and internal fertilization; usually, they do not reach sexual maturity until their shell lip is fully developed at 3-4 years of age (Appeldoorn 1988). Queen conch exhibits seasonal reproduction, which varies throughout its geographic range. Typically it has 6 - 8 month egg-laying season between March and October (Davis *et al*. 1984, Davis *et al*. 1994, Stoner *et al*. 1996a). During the reproductive season, large numbers of conch will migrate towards shallow waters (10m or less) and breed in coarse sandy habitats near reefs and *Thalassia testudinum* seagrass beds (Robertson 1959, Randall 1964, D'Asaro 1965, Brownell 1977, Weil and Laughlin1984, Stoner and Schwarte 1994), making them vulnerable to exploitation.

The female lays a crescent shaped egg mass which can contain up to 1,000,000 eggs. Under optimal conditions, females can lay an average of 13.6 egg masses per season or an estimated 750,000 eggs each, or an estimate of 10.2 million eggs per season. A female conch camouflages the egg mass with sand grains to help in its survival through the three to four day incubation period.

The planktotrophic veligers resulting from the egg masses progress through a three to eight week developmental cycle while drifting in

the water column. Veliger larvae eat microscopic algae that live in sea water and maybe some marine bacteria. The veliger larva has a tiny transparent shell, and once the veligers are morphologically ready (1-2 mm SL), they will respond to trophic cues and settle and undergo metamorphosis into a fully benthic animal.

The juvenile queen conch remain buried for most for the majority of first year of life, and are a nocturnal possibly as a means to avoid predation (Randall 1964, Sandt and Stoner 1992).

As herbivorous gastropods, the juvenile and adult conch feed on a variety of algae, detritus, and diatoms all commonly found in sand, seaweed, and seagrass blades (Robertson 1961).

During its early years, juvenile queen conch will add length to its shell, until it begins to form a flaring lip at approximately 2.5 - 3 years of age. Once the lip is formed, conch is a sexual mature adult. Wild populations in healthy conditions exhibit a 1:1 sex ratio (Sandt and Stoner 1992).

In the San Andres archipelago aggregations of 150-200 queen conchs have been observed within an area of approximately 30 x 100 m surrounded by a halo of open sand. Mating and pairing behavior were common within the aggregation (Appeldoorn et al. 2003).

Accordingly to Ávila (2004), conch with a shell length ?170 mm and a lip thickness >5 mm, exhibited the complete gameto-genic maturation cycle during April-September with spawning occurring in two seasons in March-April and September.

For management purposes, adults are classified into four categories as defined in Table 1.

Table 1. Definitions of adult queen conch age classes. Bold numbers in parentheses give an estimated measurement of lip-thickness measures (Taken from Appeldoorn *et al*. 2003).

Adult category	Characteristics	Lip thickness (mm)	Picture
Newly Mature	—Flared lip starting to grow or very thin. —Periostrocum tan and clean.		
Adult	—Thin lip enough to allow the periostrocum to give color to the underside.	<5 - 7	
Adult	—Flared lip fully formed, minimal to moderate erosion. —Periostrocum tan but may be sand covered or with some algal growth. —Lip underside generally white with pink interior.	15	
Old Adult	—Outer lip starting to erode (as viewed from bottom). —Top of shell still well formed, but periostrocum is lost and spines have rounded moderate erosion and fouling on the outside shell. —Lip under-side may have platinum color, with darker pink interior.	30	
Very Old	—Lip is very thick and flared portion may be completely eroded away. —Outer shell is highly fouled and eroded, often resulting in a short total length. —The lip is squared off, white portion is often completely eroded and the interior is a dark pink.	>40	

1.3.2 *Habitat types*

Adult queen conch have been documented throughout their range occupying shallow seagrass beds and rubble habitats (Randall 1964, Alcolado 1976, Stoner 1994, Stoner and Schwarte 1994, de Jesús *et al*. 1999, Delgado 1999). Deep water stocks (~25-35 m) have been less documented, but suspected to be as important as shallow ones (Rathier 1993, Stoner and Schwarte 1994, Mateo *et al*. 1998).

Juvenile conchs inhabit shallow banks covered with submerged aquatic vegetation such as seagrass beds and macroalgae (e.g. *Lobophora, Halimeda*) plateaus, over bio-turbated sands (Alcolado 1976, Weil and Laughlin 1984, Stoner and Waite 1990, Wicklund et al. 1991, Stoner *et al*. 1993, Posada *et al*. 1997).

Within Colombia's archipelagos, adult queen conchs are usually seen in coarse sand, with deep water populations found over dispersed coral stratum along the leeward slope, which consists of rugose coral within a sandy matrix. Adult conchs have also been found over

rodolith beds in the Bernardo and Rosario archipelago's (Gómez *et al*. 2005). On the other hand juvenile conch are commonly seen in back reef areas or in the broad reef lagoons.

1.3.3 *Role of the species in its ecosystem*

Queen conch is categorized as a specialist, being primarily an algal/detritus feeder as adults, and in large number can therefore have a major influence upon benthic productivity processes (Stoner 1989 a, b). For example, young individuals feeding on seagrass remains, seagrass epiphytes and macroalgae (Randall 1964), can play an important role in regulating the abundance of seagrass detritus and thus the overall structure of the macrofaunal communities (Stoner *et al*. 1995). Young individuals

As a key species in the scheme of marine biodiversity and shallow marine throphic dynamics, there are several predators of the queen conch, including the tulip snail (*Fasciolaria tulipa*), apple murex (*Murex pomon*), and other carnivorous species such as octopus (*Octupus vulgaris*), spiny lobster (*Panulirus argus*), old wife (*Balistes vetula*), spotted eagle ray (*Aerobatus narinar*i), tiger shark (*Galeocerdo cuvieri*, nurse shark (*Ginglymostoma cirratum*) and loggerhead turtle (*Careta careta*) (Jory and Iversen 1983, Iversen *et al* 1986).

1.4. Population

1.4.1. Global Population size

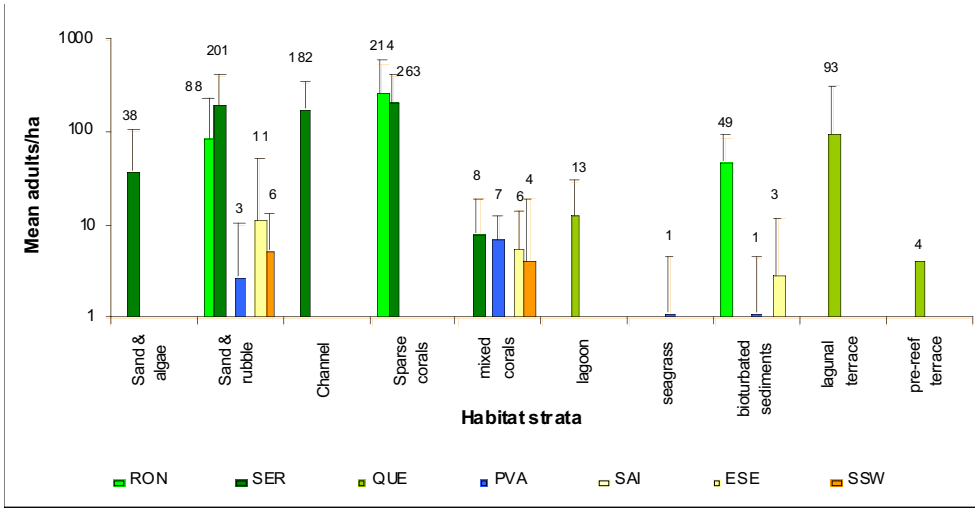
The most recent estimate of the queen conch population size within the San Andres Archipelago was obtained in 2007 from a series of scientific expeditions (Castro *et al*. in press). Surveys that replicated methods and stations from previous surveys conducted in 2003-2002 (Appeldoorn et at. 2003). A total of 282 stations in six atolls were revisited and an additional 69 stations were sampled for the first time in order to estimate population densities.

The potential population was estimated at more than 10.7 millions individuals, with 56% adults and 44% juveniles (variable by atoll) and representing by a total of 1,674 (Table 2).

In general, the population exhibited an aggregated pattern, with adult queen conch on unconsolidated coarse sands with or without rubble and over sparse and mixed coral. Juveniles occupied algal plains and back reef environments (Figure 3). Conch densities were highest at Serrana in comparison to all survey areas. High juvenile densities at this atoll were attributed to the presence of reef channels.

Table 2. Population size estimates of queen conch in the San Andres Archipelago from the 2007 surveys, excluding Serranilla, New and Alice Banks.

Archipelago atoll	Estimated No. Individuals	Mean adult density (ind/ha)	Mean % adults	Mean juvenile density (ind/ha)	Mean % juvenile	Mean Biomass mt
Roncador	513,171	110.0	25.7	83.0	74.3	716
Serrana	5,929,310	151.0	64.3	84.0	35.7	814
Quitasueño	4,008,248	37.5	77.2	11.0	22.8	91
Providence	138,542	1.8	57.0	3.3	43.0	37
San Andres				0.6		
East-South-East	84,501	8.7	51.1	8.4	48.9	6
South-South-West	55,037	5.1	59.0	3.6	41.0	9
Total	**10,728,809**					**1,674**



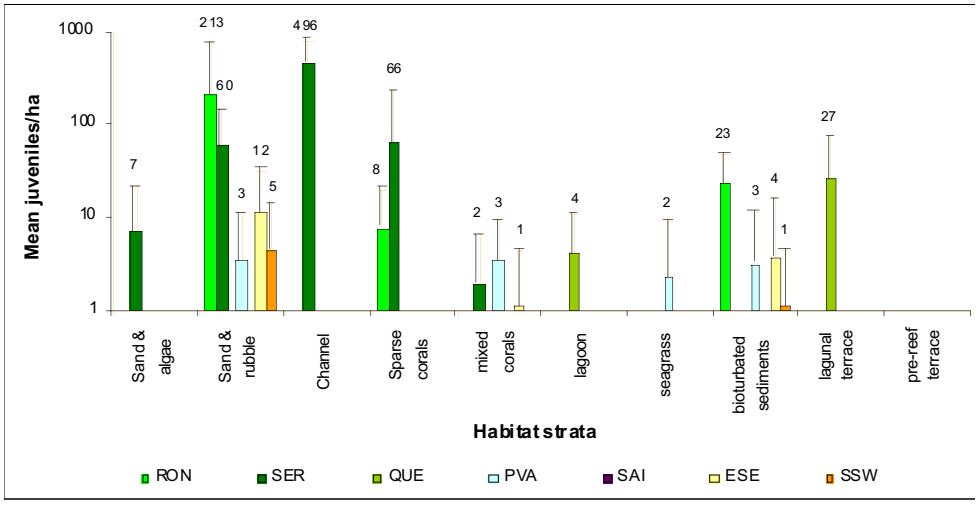


Figure 3. Mean queen conch densities across the San Andres archipelago banks (RON= Roncador, SER=Serrana, QUE=Quitasueño, PVA=Providencia, SAI=San Andres, ESE=East-South-East and SSW=South-South-West) by habitat strata. Error bars are one standard deviation.

Although isolated surveys have been conducted to estimate average densities, there are no population estimates available for conch in other areas of Colombia. For example works by Ballesteros *et al*. (2005), Garcia *et al*. (2005) and Gomez *et al*. (2005) all reported a population dominated by adults in Rosario's Islands and by juveniles in San Bernardo (Table 3). Within these archipelagos, which were declared National Parks in 1977 and extended in 1988 only subsistence fishing is allowed, however illegal commercial fishing still taken place. No data is available for other regions in Colombia.

Table 3. Estimates of queen conch population density in the Rosario and San Bernardo archipelagos. Data taken from Ballesteros *et al.* (2005), Garcia *et al*. (2005) and Gomez *et al*. (2005).

Archipelago	**Islands**	**Mean adult density (ind/ha)**	**Mean juvenile density (ind/ha)**
Rosario	Bajo Tortugas	11.4	2.9
	Tesoro	0.9	0.2
	Arena	12.8	3.2
	Overall	3.1	0.8
San Bernardo	Maravilla	3.2	12.9
	Panda	1.3	5.2
	Múcura	1.3	5.2
	Overall	1.9	7.8

1.4.2. *Global population trends*

___increasing _X_decreasing ____ stable ____unknown

TRENDS FROM FISHERY INDEPENDENT DATA

Based on fisheries independent data, it has been established that queen conch population density had exhibited progressive negative trends across the San Andres archipelago until 2003, when the fishery was closed for three years. Surveys conducted in 2007 showed a population recovery at the northern atolls (Figure 4). This closure roughly coincided with the moratorium on queen conch exports imposed on Honduras, Haiti and the Dominican Republic. This recovery was attributed to the significant reduction in fishing pressure from both legal and illegal fishers. Illegal activities from neighboring countries during that time were significantly lower in response to the CITES exports restrictions. Conch populations did not recover in Colombia central and southern atolls because artisanal fishing did not cease continued during the closure and continue to date.

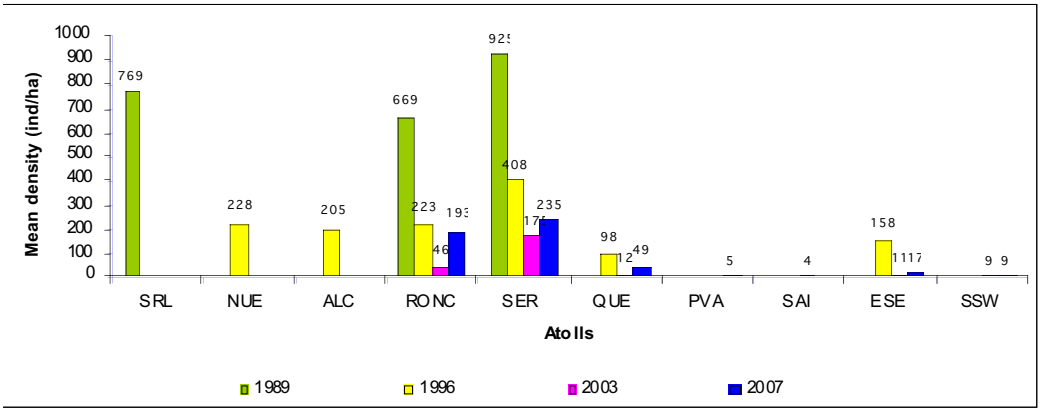


Figure 4. Historical queen conch density (ind/ha) across the San Andres archipelago (RON= Roncador, SER=Serrana, QUE=Quitasueño, PVA=Providencia, SAI=San Andres, ESE=East-South-East and SSW=South-South-West). Data labels are showed to facilitate analysis. Data obtained from Garcia *et al.* (1997), Valderrama *et al*. (1999), Appeldoorn *et al*. (2003), and Castro *et al.* (in press).

Trends From Fishery Dependent Data

Declining trends were also seen in the queen conch landings from the fishery dependent data, despite unreliable statistics during the most productive portion of the fishery trade in the 70´s (Prada and Castro in press). Delays in monitoring landings by national institutions and local ones unable to access private archives from a fleet that was dismantled in 1998 resulted in poor quality data.

Landings of queen conch meat declined from 813 m-ton in 1988 to almost half (465 m-ton in 1993) in less than a decade, to a 186 m-ton in 2000 to only 81 m-ton in 2003 (Figure 4). Declining catch in recent years also reflects the imposition of a global catch quota first fixed at 203 mt and further reduced to 96 mt in 2001, following management measures taken to counteract reductions in wild populations.

When analyzing indices of population abundance, such as CPUE, the negative trend was not evident. For instance, from 1988-1996, CPUE averaged 31 kg/day/diver, but no clear trend was observed. When better quality data became available, a reduction in CPUE from 56 to 27 kg/day/diver was reported from 1998-2002 (Figure 6).

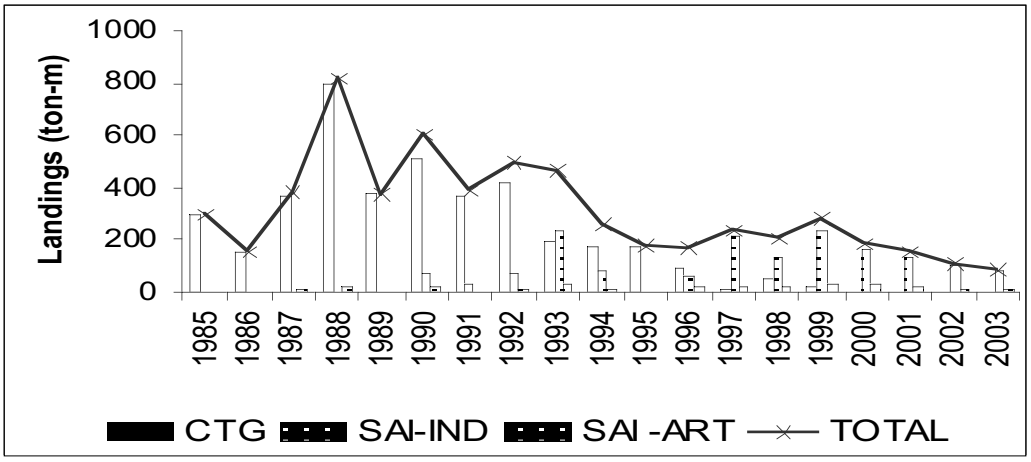


Figure 5. Landings (metric tons) of queen conch from the San Andres archipelago commercial fishery. Data from Prada and Castro in press.

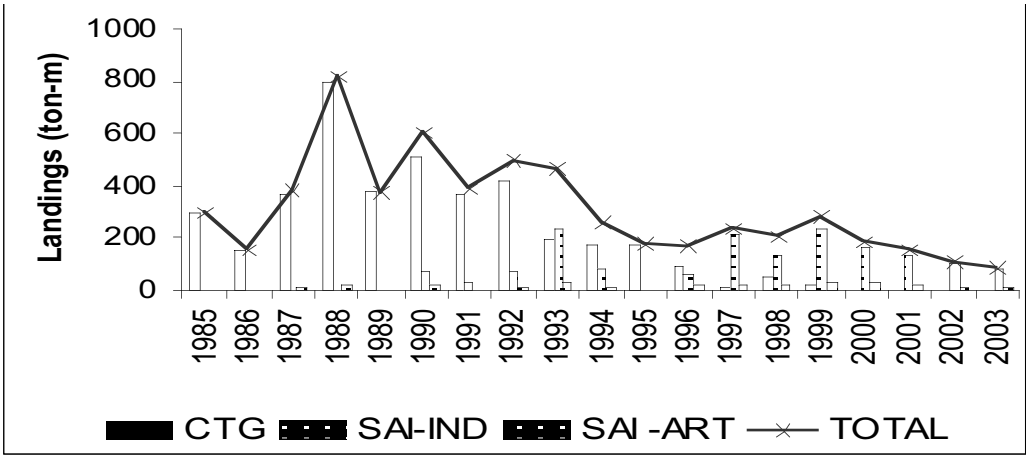


Figure 6. CPUE for the queen conch commercial fishery from the San Andres archipelago. Data from Prada and Castro in press.

Trends viewed through in fisheries dependent data are uncertain because:

1) Databases are incomplete
2) Fishing effort had not been properly standardized to account for the progressive increase in power (illegal use of autonomous diving gears or hookah; shift from sailing canoes to outboard engines)
3) Landings might not always be clean conch meat, particularly at the onset of the fishery
4) Production is not reported by atoll, thus key spatial information is missing

5) Illegal trade flows in two directions, Colombian production being sold to neighboring countries or foreign products being sold in Colombia

No substantial or quantitative information is available to estimate how the decline in queen conch populations may affect other sites in Colombia, with the exception of three isolated studies in the San Bernardo Archipelago. Goodman (1974) reported an average queen conch density of 5,778 ind/ha, which decline to 38 ind/ha in 1997 (Hernandez *et al* 1997) and to less than 3 ind/ha in 2005 (Ballesteros *et al* 2005).

In conclusion, different recent population trends were found within the geographic range of Colombian waters. While an increase is reported at Serrana, Quitasueño and Roncador atolls, a decrease was reported at Providence, San Andres, East-South-East and South-South-West atolls. Atolls further north such as Serranilla, New and Alice Banks, remain to be explored, and negative trends are expected along the continental shelf.

1.5. Conservation status

1.5.1. *Global conservation status* (according to IUCN Red List):

___Critically endangered ___Near Threatened
___Endangered ___Least concern
___Vulnerable ___ Data deficient
IUCN has not assessed.
Commercially threatened, CITES Appendix II.

1.5.2. *National conservation for Colombia*

Queen conch is a protected species in Colombia following CITES regulations and procedures. The Ministry of Environment included the species in a national red list, thus allocating funds to promote more sustainable management. CORALINA, the environmental authority within the San Andres Archipelago, selected the species as one of the key bio-physical indicators to measure MPA effectiveness.

1.5.3. *Main threats within the case study country*

___No Threats
_X_Habitat Loss/Degradation (human induced)
___Invasive alien species (directly affecting the species)
_X_Harvesting [hunting/gathering]
___Accidental mortality (e.g. Bycatch)
___Persecution (e.g. Pest control)

_X_Pollution (affecting habitat and/or species)
_X_Other: a) Seasonal river discharge introducing fresh, turbid and polluted water into the marine ecosystems, increasing vulnerability to global climate change; b) The overgrowth by the incrusting sponge, *Cliona*); c) The reduction of population density to a level where by Allee effects may affect reproduction.
___Unknown

2. SPECIES MANAGEMENT WITHIN COLOMBIA

2.1. Management measures

2.1.1. *Management history*

The first management measure for the queen conch stocks was the establishment of a permanent fisheries closure in the Quitasueño Bank and a closed season in the remaining archipelago atolls from June 1st to September 30th declared by INDERENA (Instituto Nacional de los Recursos Naturales Renovables) in 1987. A second INDERENA Resolution (17/1990) extended the closed season for an additional month, prohibited the use of scuba gear and established a minimum weight of 100g of clean meat or 225 g if an unclean. However, a legal definition of an unclean state was not included, nor were weight equivalents for inbetween states of processing. In 1991, INDERENA was replaced by a new national fisheries management institute (INPA-Instituto Colombiano de Pesca y Agricultura).

A Total Allowable Catch quota (TAC) was established in 1997 by the Comité Ejecutivo de la Pesca (CEP) with a 203 mt designated for the archipelago's fishery, and 300 mt CITES quota was established for Colombia. In 2001, the TAC for the San Andres archipelago was reduced to 96 mt. INPA was liquidated in 1998, and a new national fisheries authority, INCODER (Instituto Colombiano del Desarrollo Rural) was established.

Unique regulations for the San Andres archipelago (laws 47/1993 and 915/2004), created a new legal entity to manage the local fisheries: the Departmental Fishing Board (JDP in Spanish). INCODER transferred its functions to the JDP and its technical branch, the Fishing and Agriculture Secretariat. However, CEP is in control of national policies such as the establishment and distribution of catch quotas and determination of the closed seasons. Licensed fishers are awarded individual quotas not transferable, but valid for a specific time, and requires reporting.

In 2007, ICA (Instituto Colombiano de Agricultura) a corporation within the Ministry of Agriculture and currently the national fisheries

authority replaced INCODER. A new and more collaborative management approaches are now in place in conjunction with the re-opening of the queen conch fishery in 2008.

2.1.2. *Purpose of the management plan in place*

Currently, there is no national management plan for the queen conch, although the Colombian Ministry of Environment is leading an initiative to prepare one for this important fishery. The process began in May 2008, when preliminary agreements, work assignments and the potential use of existing international tools were examined. A second meeting was held in July, 2008 to define a time table and embrace the broader stakeholder participation needed for its completion.

CORALINA drafted an action plan for the species, as part of the Seaflower MPA policies (Garcia 2005). However, while this plan has not yet been submitted for approval neither to the JDP nor the CEP, it will be used as basis for the national plan.

2.1.3. *General elements of the management plan*

The CORALINA action plan contains an introduction and seven chapters. The first three described the species as a fishery stock including information on habitat distribution and potential sources of food. A fourth chapter deals with threats to the stock and considers surveillance and enforcement issues. The fifth chapter is dedicated to the legal framework, while the remaining two chapters propose management alternatives and define conservation goals and objectives.

2.1.4. *Restoration or alleviation measures*

CORALINA in association with Harbor Branch Oceanographic Institute, Blue Dream Ltd and Fish and Farming Cooperative all supported by Wildlife Conservation Fund and the Sheila Johnson Brutsch Charitable Trust conducted a pilot project where more than 1,000 juvenile queen conch were raised and released after seven months into three MPA conservation zones (Shawl *et al*. 2007). This success project engaged artisanal currently working to increase the scope of the recovery actions. In addition, a new project is commencing soon funded by the National Petroleum Agency and the Colombian fisheries management institutions.

Conch larviculture methods for marine biology students oriented towards stock enhancement have been developed in the San Bernardo and Rosario islands (Osorio 1992), and a small scale laboratory was assembled at a facility within the Rosario National Park and is managed by a private business (CEINER).

The reopening of the conch fishery after three years of closure was preceded by innovative, participative procedures that were unique in

Colombia. Two days of negotiations and clear rules were established to reach participant consensus on the following issues: a) allocation of TAC at only two atolls following a highly precautionary scenario only in two of the Archipelago's atolls; b) reduction in industrial fishing vessels (from 8 to 5) and time at sea (from 7 to 3 months); c) 28% increase in participation of artisanal fishers in traditional industrial fishing zones; d) allow participation of artisanal fishers in monitoring landings and in research projects as alternative to offset the indefinite closure of the traditional artisanal fishing in the central and southern sections of the MPA.

2.2. Monitoring system

2.2.1. *Methods used to monitor landings*

In December 2007, institutions based in San Andres reached consensus to develop collaborative field surveys every three years to assess the condition of the queen conch stock, as well as additional habitat and biodiversity observations, incorporating an ecosystem management approach.

Fishery independent monitoring is following the Appeldoorn *et al*. (2003) protocol, in which data are acquired from diver-based visual surveys along strip-transects to cover a total area of 960 m^2 per station. Initial stations locations correspond to a random stratified sampling protocol based on eight habitat strata obtained from existing benthic maps by INVEMAR (Diaz *et al* 2000). Again this were visual surveys and no queen conch were collected during sampling.

Fishery dependent monitoring is conducted by the local fishery management authority (Secretaría de Agricultura y Pesca), and maintains the registry for 100% industrial queen conch landings in San Andres Island. There was a ≥ 70% increase in artisanal fishing reporting in 2008. Data obtained are entered into a database called SIPEIN (Sistema de Información Pesquera) created cooperatively between the Fishing and Agriculture Secretariat and INVEMAR. Starting in November 2008, additional fishery dependent data will be collected from an onboard observer program.

In the past, at least two surveys were conducted by INPA in order to assess queen conch populations (Ospina *et al*. 1997, Valderrama et al. 1999). Additional isolated efforts to monitor artisanal fishing have been conducted by CORALINA (Chiquillo 1996). Finer scale field work have been conducted by students as part of their biology degrees such as the cases of Goodman 1974, Cano 1983, Garcia 1991, Ballesteros *et al*. 2005, Gómez *et al*. 2005.

An oceanographic current model, larval supply and recruitment studies needed to understand connectivity patterns are also about to

start. A complete survey to determine the queen conch genetic population diversity through 8 microsatellites is currently in progress.

2.2.2. *Confidence in the use of monitoring*

Mean density estimates from diver observations are expected to have lower confidence limits because they followed a random stratified protocol (habitat strata) and sample a large number of stations. Divers were selected from a mixed group of marine biologists with excellent diving qualifications and experienced conch fishermen working together. Lack of detailed bathymetric charts was counteracted by the availability of detailed benthic maps.

Fisheries dependent monitoring will improve in quality once the onboard observer program is initiated. However, concerns about possible interactions between these observers and illegal drug transactions by fishing vessels.

2.3. Legal framework and law enforcement

Colombia as signatory Party to CITES and abides by all international restrictions regarding international trade of queen conch. In addition, the queen conch has benefited from the creation the Seaflower MPA in June, 2005 by the Ministry of Environment (the Colombian CITES authority) and CORALINA (the local counterpart), which created a permanently closed areas to all fisheries activities, including those for queen conch. The species has been selected as one of the Seaflower indicator key species to measure the effectiveness of MPA policies.

Fishing activity is highly restricted within the Rosario and San Bernardo Islands National Park, where only subsistence fishing is allowed, and there is also an indefinite ban in effect for La Guajira area, until data on conch abundance become available.

3. UTILIZATION AND TRADE OF RANGE STATE FOR WHICH CASE STUDY IS BEING PRESENTED

3.1. **Type of use** (origin) **and destinations** (purposes)

Three different products are obtained from the queen conch fishery: the conch fillet, conch pearls and conch shells. Conch fillet is the most commonly traded product in international markets, with approximately 90% of the harvest being exported. National consumption of the queen conch meat was estimated in 5% of national fish production (Gallo y Valderrama 1995), but most probably this percentage has increased since then.

Conch pearls are considered jewelry, and therefore are by far the most valued of the conch products, while the conch shells are decora-

tive pieces which are increasingly traded as souvenirs for the tourism industry.

3.2. Harvest:

3.2.1. *Harvesting regime*

The queen conch is legally harvested in Colombia by free diving. The use of any autonomous diving gear is prohibited. The fishing unit consists in one canoe and three fishermen, one operator and two divers. Conchs are collected in bags and taken to the surface, where the meat is extracted (and the pearl, if present). The meat is stored mainly in one of two levels of processing, "semi-clean" (trimmed by an additional 22% to export quality) for majority of industrial fishers, and "clean" (trimmed by an additional 15% to export quality) for most artisanal fishers.

Empty shells are usually returned to the sea, trying not to form big piles at any particular site. An industrial boat is allowed to carry up to ten canoes, but it can be less depending on the vessel size. Artisanal fishers use the same procedures, although fishing effort is not exclusively dedicated to queen conch, but also includes fish and lobster. Fishing trips for the queen conch last around a month for the industrial fleet and couple of days for the artisanal fleet.

Illegal fishing from of Colombian industrial vessels has been controlled, therefore most of the illegal harvest is conducted by divers from neighboring countries such as Honduras, Nicaragua, Jamaica and the Dominican Republic. Foreign industrial fleet utilizes SCUBA or hookahs, carry triple the number of divers and capture queen conch, lobsters, fish and turtles. The duration of illegal foreign activities fishing is quite variable, but it is expected to happen on a regular basis from a couple of days to a couple of weeks per month.

3.2.2. *Harvest management/ control* (quotas, seasons, permits, etc.)

As mentioned before, in the 2008 TAC was established of 112 mt of clean meat, distributed into 105 mt for Serrana and 7 mt for Roncador Banks. Fishing in other atolls remains prohibited. A closed conch season from April 1st to October 31th of each year has been in place for nearly 2 decades. Currently, there are 12 legal industrial licensed companies utilizing 5 vessels and employing an approximately 100 divers. Additionally, there are nearly 200 artisanal divers in 90 smaller boats registered to San Andres, Providence and Santa Catalina.

3.3. Legal and illegal trade levels:

According to the CITES national office (Vladimir Puentes, personal communication), the proportion of legal exports of conch fillet betwe-

en 2000 and 2004 totaled 571.5 mt and represented an annual increased of 10%, with Miami and New York as the major destination (Figure 7). During the time of CITES export restriction imposed in Honduras and the Dominican Republic, it estimated that approximately 29.3 mt of illegally harvested queen conch was transshipped through Colombia, and in precaution a complete closure of the fishery was ordered in 2004, until better controls on illegal trade can be implemented.

A total of 6,960 conch pearls have been legally exported during 2000-2008, with an annual average of 1005 units (SD=469) in 2000-2004 and 300 units (SD=54) in 2007-2008. Major pearls importers are located in Narita (46%) and Tokyo (42%) Japan, and minor importers in Geneva (10%) and New York (2%) as presented in Figure 7.

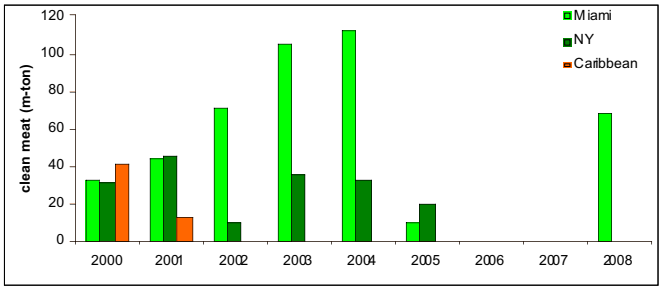
Approximately 4,112 conch shells have been legally exported during the last 8 years, with importers located in Hanoi (84%), Narita, Japan and Paris, France (6%) (Figure 7).

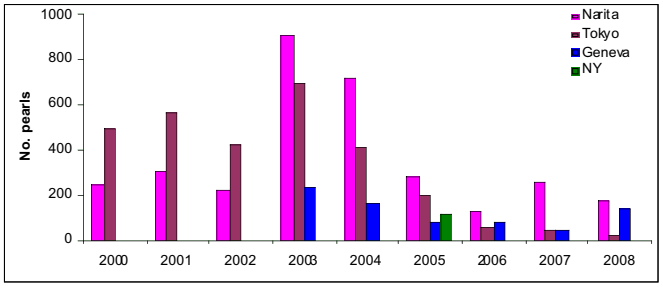
Accordingly to ICA (Instituto Colombiano Agropecuario) registries (Carlos Borda, personal communication), between the years 2000 and 2003, Colombia queen conch exports totalized more than $USD 3.2 millions with pearls accounting for 63%, conch fillets 36% and shells less than 1% (Figure 8).

Illegal conch fishing varies in time and location, and only isolated quantitative information is available. For instance, the Colombian navy, the national operational enforcement authority, estimates that there are between 3 to 7 illegal foreign vessels regularly entering to Colombian waters to fish. This fleet does not seek conch exclusively, but target lobsters with occasional captures of fish and sea turtles.

Approximately 50% of foreign illegal vessels have Honduran flags and resemble the legal Honduran fleet fishing on behalf of Colombian companies. In general, each illegal vessel acts as a mother boat, carries approximately 30 canoes, and 60 divers thought to be from Honduras, Nicaragua, Jamaica and the Dominican Republic which utilize SCUBA tanks and sometimes hookahs. Te potential number of illegal divers might be around 400 or higher (Prada et al 2004), a value that duplicate the legal divers.

The combination of diving with old and poor quality gear, fishing deep (140 feet) and frequently (up to 15 times a day) threatens serious decompression sickness and results in significant socio-economic impacts to already poor communities such as the Miskitos Indians (The NicaTimes, 2008).





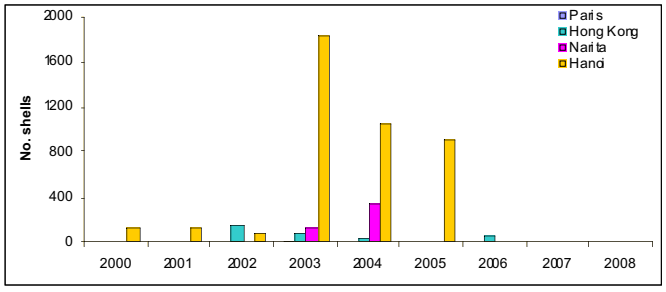


Figure 7. Colombia queen conch exports by destination. Data from Min-Ambiente (Vladimir Puentes, personal communication).

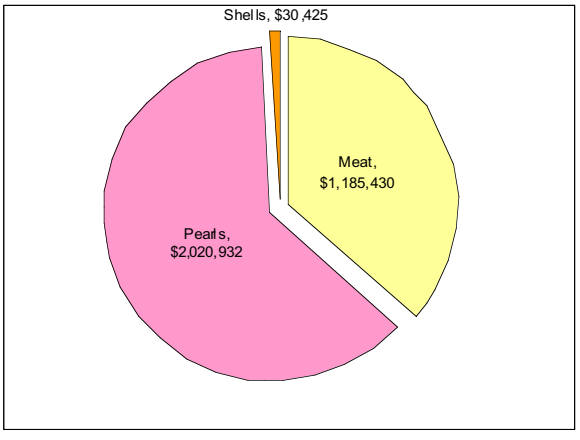


Figure 8. Value of Colombian queen conch exports during 2000 - 2003. Values expressed in US dollars. Data from Carlos Borda (personal communication).

Based on recent spiny lobster stock assessment (Nowlis *et al*. 2008), illegal conch captures may represent 2 to 14% of the illegal lobster captures (under a low and high scenarios), therefore the potential take of illegal queen conch could approximate 1.4 to 21.8 mt of clean meat. These estimates were based on the catch composition from three illegal fishing boats captured between 2005 and 2005 by the Colombian navy (Steeward Ariel, captain Jones and Tony Jr.), and assuming than only 50% of the time they were fishing in Colombian waters. Usually illegal fishing is conducted near to the country's borders, facilitating quick displacements to legal fishing grounds. Interviews from several captains of the lobster industrial fleet have confirmed the regular operation of the illegal fishing in these remote fishing areas as reported by the Colombian military authorities. The low illegal fishing scenario estimated three permanent illegal vessels, while the high illegal fishing scenario was set at 7 illegal boats, all being divers using SCUBA and belonging to an industrial fleet.

In a similar situation, Barnutty (2006) reported for the Caribbean Nicaraguan landings that unreported conch landings might be around 20% of the reported conch landings. Serious pouching by industrial vessels, mainly from Honduras, have been also reported in Pedro Bank, Jamaica taken advantages of the poor high seas enforcement, specially during the closed seasons (Aiken *et al*. 2006). Indeed, in 2003 the minister of agriculture Roger Clarke reported that conch poachers harvested about $20 million of conch from the island's waters every year and resulting in drastically reduction of Jamaica catchable quota (http://www.sidsnet.org/archives/coastal-newswire/2003/frm00076.html).

The amount of the illegal queen conch trade in the whole southwestern Caribbean region is of concern. Indeed, 2007 law enforcement personnel from the US offices of law enforcement of the US Fish and Wildlife Service and the Canadian Wildlife Enforcement Directorate prosecuted smugglers from seven countries attempting to ship 119 mts of queen conch fillets valued in more than $USD 2.6 millions (1.05 to 1.32 millions of individuals) to US and Canadian markets (Mclearn 2008). Additional substantial illegal trading is assumed to continue.

II. Non-detriment finding procedure (NDFs)

Provide detailed information on the procedure used to make the non-detriment finding for the species evaluated.

1. IS THE METHODOLOGY USED BASED ON THE IUCN CHECKLIST FOR NDFs?

_X_ yes ___ no

2. CRITERIA, PARAMETERS AND/OR INDICATORS USED

Following are the criteria used in Colombia for NDF:

a) Clear definition of the stock including its spatial variability and benthic habitats for the various atolls of the archipelago.
b) A methodology, data analysis and evaluation protocols based on independent surveys in place. Information from landings reports utilized to complement the stock analysis.
c) Definition of a TAC introducing precautionary principles, in which only two out of nine atolls (Serrana and Roncador) are allowed to sustain fishing. In Serrana, the MSY was estimated in 130 mt, but TAC was fixed in 107 mt, discounting 18% for illegal fishing and uncertainties. In the case of Roncador, a much conservative decision was made by allocating only 10% of the 79.8 mt calculated for the MSY. Roncador is the smallest and eastern- most atoll and the area with highest coral development, thus stricter conservation measures are being developed there. The queen conch fishery will benefit by protecting the larval long-distance dispersal expected because of the dominant westerly current flow.
d) An additional precautionary approach refers to the adoption of a new and more participative decision-making in fisheries management procedures seeking the overall reduction of the fishing effort, the participation of artisanal fishers in other ways traditional industrial fishing zones, and elaboration of a proposal to improve sustainability in the queen conch pearl trade. Colombia is the first country within the south-western Caribbean than began the inclusion of NDF for the queen conch pearl international trade.
e) Promotion of participative stakeholder agreements oriented to species conservation policies and regulations.
f) Initiation of large scale stock enhancement activities and complementary research agenda allowing broad national involvement and users participation.

g) Broad educational and outreach activities involving industrial and artisanal fishermen, teachers, students, politicians and general public.
h) Promotion of international collaborative work looking for integrated management and better communication and information exchange mechanisms.

In comparison the queen conch fishery in Jamaica, by far the most productive Caribbean ground (Pedro Bank), the director of Fisheries Division at the Ministry of Agriculture Stephen Smikle, reported that the adaptive fisheries management and inclusion of CITES NDF criteria proved successful to relative stable landings. Those criteria consider the following aspects:

- Realization of compulsory stock abundance surveys (Pedro Bank – south of mainland Jamaica, is the only commercial fishing zone for queen conch) to estimate potential queen conch population and generation of a TAC recommendation annual quota. Surveys in the 1990's were carried out with financial assistance and equipment provided by the fishing industry, however since the year 2000, surveys have been government or NGO funded.
- Stock assessment combining surveys and reported (operators and captains) data carried out by fisheries managers with the participation of national and international experts. Data subjected to quality control protocols.
- Annual adjustment of the TAC based on useable MSY (maximum sustainable yield) once illegal fishing is excluded. Illegal fishing is estimated from fishermen interviews and specific workshops. In fact, TAC has been gradually reduced from 3,000 mt in 1992 to 1999 mt in 1997 to 946 mt in 2004 and 500 mt in 2005.
- Allocation of individual non-transferrable quotas to industrial fishers to operate in industrial fishing zones which are valid for a season and require reporting.
- The establishment of exclusively artisanal fishing zones, and extension of the closed season.
- The use of SCUBA and hookah is regulated.

However, Jamaica fisheries managers still face major challenges to overcome increases in the growing illegal fishing (estimated at the same level as the legal production) in remote reef banks. The inclusion of shell size and lip thickness to the existent weight regulation proved difficult to control since only meat conch is landed. All conch products exported, including those originating from the Artisanal fishers, have to meet the same standards. Exporters are forced to take products

from only those artisanal operations that meet the export health standards. The cumulative impacts from major hurricanes affecting Pedro Bank such as Ivan (2004), Emily (2005), Dean (2007) and Gustav (2008) are known to be detrimental but quantitative effects are still not determined.

In a similar case, Honduras fisheries managers following recommendations from the expert Dr. Nelson Ehrhardt have addressed the NDF by determining the level of fishing mortality that affects the population density needed to secure the queen conch reproductive success. Therefore, basic criteria for conch stock assessment methodologies and management are used as the first step in order to formulate Non-Detriment Findings. In 2005, a 210 mt TAC was authorized to assess annual population densities and abundance in each of the 13 fishing banks previously identified as conch fishing grounds. At present, assessments of the conch have been accomplished and densities appears to be well above of minimum population densities adopted by the CITES as the limit for acceptable exploitation (56 ind/ha). In the near future, it is expected that monitoring surveys in conjunction with appropriate statistics from the fisheries will be used to elucidate the status of exploitation of the conch stocks in each fishing ground. See details in ANNEX 1.

3. MAIN SOURCES OF DATA, INCLUDING FIELD EVALUATION OR SAMPLING METHODOLOGIES AND ANALYSIS USED

Fisheries managers have access to historical fisheries dependent and independent data, but data confidence is higher during the last decade. Field survey data are available at fine scale in the San Andres archipelago, but only dispersed data exist for other continental sites in Colombia. Assessment of queen conch populations in the Guajira area is commencing.

4. EVALUATION OF DATA QUANTITY AND QUALITY FOR THE ASSESSMENT

Funding has become available to conduct inter-institutional workshops for data analysis and technical report writing. Technical reports are under reviewed by national and international fisheries experts. Decision-making process is derived from participatory workshops, and local participation is allowed at the national level.

5. MAIN PROBLEMS, CHALLENGES OR DIFFICULTIES FOUND ON THE ELABORATION OF NDF

With respect to population stability

- Increases in fishing effort during the month prior to the closed season (April), may have negative long term consequences since a

recent studies have identified April as a month with an intense reproductive activity indicating a need to adjust the closed (Ávila 2004), or maybe a need to better determine seasonal reproductive activity.

- There are areas where conch densities are below the estimated level for reproductive success (Appeldoorn 1995), thus demanding more effective enforcement mechanisms, reduction in catch or longer closures. Conch reproductive behavior (mating, spawning) shows a marked decrease at densities below 50 conch/ha (Stoner and Ray-Culp 2000). While lacking studies on larval supply, the best alternative is to ensure viable spawning stocks are maintained throughout the fishing areas. This suggests that each bank must be managed as a separate stock.
- Low capacity and insufficient budgets to exercises the enforcement and surveillance needed to counteract levels of illegal fishing occurring in this region. Collaborative international efforts are needed to overcome political constraints and poor communication among managers.
- Potential detrimental effects from conch parasites and global climate change are not yet well understood and should be considered when designing the research agenda.

WITH RESPECT TO CONCH MEAT

- Removal of the shell before landing makes it difficult to account for important biological indicators with respect to growth and maturity (maturity is measured by morphometric characteristics of the shell). Minimum size may facilitate direct enforcement efforts, but remains dubious as a population indicator.
- The definition of an export TAC for CITES integrating the various stages of clean queen conch meat landings is needed to standardize losses and established equivalents classification to add to the regulations.
- The estimation of TAC based on surveys is expensive, thus requiring multi-source funding. Appropriate estimations also require the existence of accurate habitat maps, precise calculations of natural mortality rates and accurate determination of the spawning stock.
- Females reach larger sizes than males (Randall 1964). In the case of the San Andres Archipelago, Ávila (2004) found mature females averaging 249 mm TL and 17.5 LW mm, while males averaged 234 mm TL and 13 mm LW for males. Similar results have been reported by Márquez and Dávila 1994, Ospina *et al.* 1996, Chiquillo *et al* 1997. Therefore, having only one minimum size regulation may affect females in greater proportion than males.

- Dwarf conch have been documented throughout its range, which is not accounted for under regulations based on individual size. Small-sized stocks may result from the shallow depth, generally softer substratum, and potentially lower food concentrations in sand areas or at high density (Alcolado 1976, Martin-Mora and James 1995).
- In certain areas, the fishery may be sustained by large sub-adults and juveniles, thus perhaps selecting for smaller sizes with serious consequence for the fishery in the long run (Appeldoorn 1994).

With respect to conch pearls:

- Currently, there are three legal pearl traders and an unknown number of illegal ones. Legally licensed companies pay their fees based only in weight units, which is perhaps inappropriate in comparison to pearl value.
- There is no adopted protocol in place to monitor the pearl origins, therefore it has been difficult to certified whether or not it was captured on a sustainable way.
- A fishermen's perception that juvenile conch are prone to produce higher quality pearls may trigger unsustainable fishing practices.
- The small size of the pearls and their high market value encourages illegal trading including smuggling, which are difficult to control in ports and airports.

6. RECOMMENDATIONS

For population stability:

- Improve regional controls regarding illegal fishing and get consensus among managers in the south-western region to account for illegal fishing when defining TAC for CITES. Fishing characteristics in the region are relatively similar (Table 4), thus unified management approaches may be not that difficult if cooperative agreements and better communication strategies are in place.
- It may be adequate to include a minimum spawning population density as a fundamental sustainability criterion in regional conch fishery management regimes.
- Conduct regional connectivity studies to determine the level of larval supply and connectedness to maintain key "stepping stone" populations. Considering the prevailing west flowing current patterns, the protection of eastern atolls should be a priority to maintain long-distance larval supply. Such connectivity may explain the significant recovery of the queen conch populations observed in Serrana and Queena, which are down-current from Roncador, the eastern most atoll and the one with maximum densities (up to 2,250

ind/ha).

- Strengthen precautionary measures if a population is composed mostly by very old adults (perhaps low recruitment) or juveniles (reducing reproductive output). Deep water queen conch stocks may be critical to maintain spawning stocks in shallow areas.
- Promote bi-national agreements to reach consistent regional management strategies and policies, particularly in the areas with existent international treaties.
- CITES may continue acting as a dominant force in enforcement. In fact, specific enforcement workshops and better communication among managers in the South-western Caribbean region were recently identified as a priority to strengthen the functionality of a queen conch networking.
- To overcome budget limitations, a more coordinated research agenda and collaborative work should be explored to address critical knowledge gaps. Additionally, ecosystem based management requires management to determine direction and rates of change over time; thus, there is a need to agree on points of reference to control rates of extraction.

Table 4. Characteristics of the queen conch fishery in the south-western Caribbean. Data taken from: Sanchez et al. 2005, Aiken *et al*. 2006, Mateo 2008 and Eloisa Spinoza and Stephen Smikle personal communication.

Subject	Descriptor	Colombia	Nicaragua	Honduras	Jamaica	D. Republic
Overall status						
	Actual status	Only two areas open	conch is not directly target	export only from scientific fishing	Only two areas open	no exports permitted
	National production (ton)	96 (2203), expected 112 in 2008	47 (2004), 71 (2005) 113-151 (2006)	1,359 (1991), 1,000 (2003), 210 (2007)	3,000 (1992), 1,999 (1997), 946 (2004), 600 (2007)	~580 -829 (2005)
	% exports	80-90	85-75	90	95	47%?
	Estimates illegal fishing	2 to 14 mt	20% of legal reports		equal or larger than legal reports	
Surveys	stations	351 (2007)	110 (2005)	230 (2006)	63 (2007)	61 (2006)
	station sampling area (m^2)	960	2,070			1,250
	No. conch survey	19,590 (counted)	83,792 (fished)		1,398 (counted)	
	% adults	56	82		64	15
	Length shell (mm)	240-350	105-320			
	Lip width (mm)	17	19.9			5.6
	density estimates (ind/ha)	0.63 to 2,250 (2007)	50-950 (2006)		378 ind/ha (0-10 m depth); 50 ind/ha (10-30 m depth)	0.53 to 114.2 (2006)
	mean density (ind/ha)	158.8 North, 7.8 south	123.5 (204), 230 (2005)	198 (2005-.2006)	124 (1998)	53(1998)
	sex ratio (female/male)	1.03	1.17			2.25
	population size	10,728,809			75,474,652	1,076,169
Fishery	industrial vessels	5	22	13	7	40
	canoes/industrial vessel	10	40	45		5
	artisanal boats	90	70			200
	trip duration (days)	20 to 25	12 to 15	17 to 22	15 to 20	
	No. divers	8 to 20	26	40-60	10 to 20	
	CPUE	27 kg/diver/day (2003)	1.32 kg/diver/h (1987)			
	No. fishing banks	10	5	13	1	4
	extension fishing areas (km^2)	~3,200	~4,000	~10,000	~8,000	
	processing facilities	2	15		18	
Management	CITES TAC (ton)	112 (2008)	114 (2006)	210 (Scientific)	400 (2008)	n.a.
	closed season	May 1 to Oct 31	Apr 1 to Sep 30		Aug 1 to Jan 5	Jul 1 to Oct 31

FOR CONCH MEAT:

- Continue incorporating the NDF process into conch fisheries management and strengthen the international component.
- Adjust meat weight regulations to equivalent processing categories that can be accepted throughout the south-western Caribbean. Recent surveys conducted to address this concern in Honduras, Nicaragua and Dominican Republic generate baseline information to complement local information, which can be used to try and reach consensus within the region and include this criteria into the CITES TAC (Table 5).

Table 5. Description of the various types of conch meat with respect to nominal losses needed for export standards. Data from: Tewfik 1996, Smikle 1997, Galo and Earhart 2006, Barnutty 2006 and Mateo 2007.

Type of conch meat landed	Description	Honduras % losses	Nicaragua % losses	Dominican Republic % losses	Jamaica % losses
50% – 65 clean	Animal gutted and operculum removed.	44	45		12
75 - 85% clean	Additional removal of mantle, eyes, proboscis and skin.	55.8		25	28.2
100% clean	Only clean meat (except in Colombia where the operculum remains).	61.4	60	42	42.9

- Facilitate national and international discussion about potential modification of the closed season to include all spawning peaks. Perhaps compensation measures need to be allocated as well.
- Permanent closures have proved difficult to enforce, thus success is not always achieved. Therefore it might be necessary to find economic alternatives to promote reduction of fishing pressure in artisanal fishing zones.
- It may be more useful to view essential fish habitat for conch as a mosaic of habitats, and account for it when establishing marine reserves that support a full range of biological functionality (Glazer and Kidney 2004).

FOR PEARLS:

- Complete and adopt a protocol for the conch pearl trade including the following aspects: establishment of a TAC, creation of a mobilization certificate, agreements to strengthen controls by fisheries

managers, appropriate fees, education and outreach programs and support for research program.

- The establishment of a TAC will consider the estimation of the adult population size and the proportion of the pearl production. In the case of san Andres archipelago estimated in 1:1,025 for a regular one (Ortegón 2006). However, not all pearls have export quality, therefore only a fraction of this amount can be set as a CITES quota. In consequence, that TAC should be a fraction of 538 pears for Serrana and 25 for Roncador. Unfortunately, not scientific information is yet available to determine what fraction would be then recommended.
- Create the pearl origin and the mobilization certificates to legal users. It might then be necessary to link the pearl trade to the fishing licensing and certification procedures. If the pearls come from unlicensed artisanal fishers, legal inspectors should certify its origin. It is expected that 100% of the conch pearls to be reported to inspectors during the following five days of the landing date. This certificate will make difficult the triangulation procedures.
- Several enforcement mechanisms will help the legal pearl trade, among them are: a) have a dedicated phone line reporting illegal activity; b) special surveillance operations at landing sites and jewelry stores; c) give ID to legal pearls traders; d) broad informative campaigns with educational materials not only about the conch pearl trade, but in general about responsible conch fisheries conducts.

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