

# Gulf of Mexico's Shared Ecosystem and Shark Fisheries



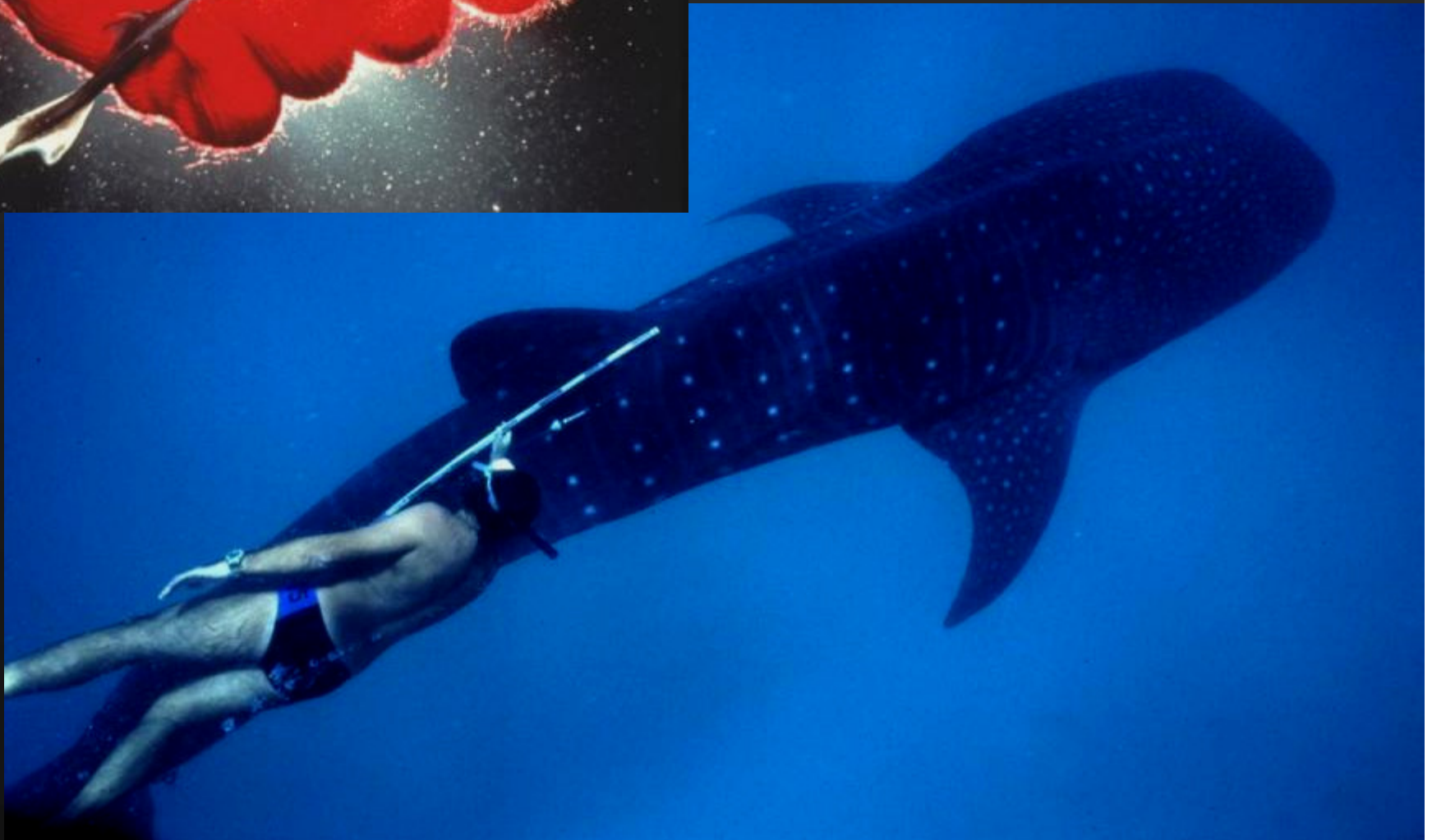
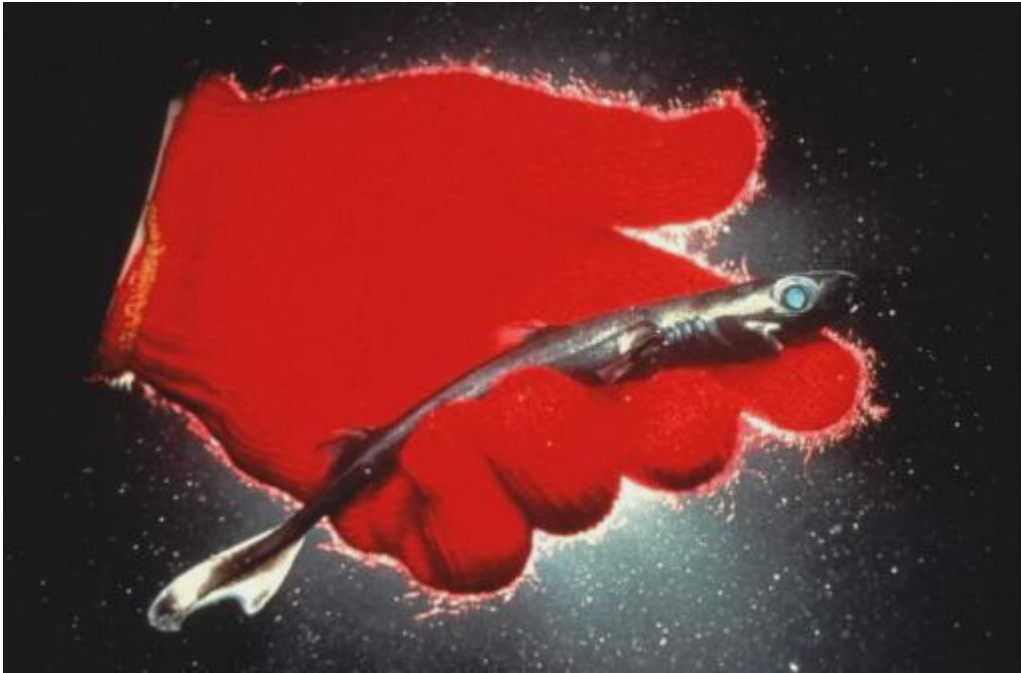
Robert E. Hueter, Ph.D.

*Center for Shark Research  
Mote Marine Laboratory  
Sarasota, Florida USA*





# Shark Biodiversity in the Gulf of Mexico and Caribbean Sea



ORDER HEXANCHIFORMES (Cow and Frilled Sharks)

Chlamydoselachidae  
Frilled Sharks

*Chlamydoselachus anguineus*

Hexanchidae  
Cow Sharks

*Heptanchias perlo*  
*Hexanchus griseus*  
*Hexanchus nakamurai* (= *H. vitulus*)

ORDER SQUALIFORMES (Dogfish Sharks)

Squalidae  
Dogfish Sharks

*Cirrhigaleus asper*  
*Squalus acanthias*  
*Squalus cubensis*  
*Squalus mitsukurii*

Centrophoridae  
Gulper Sharks

*Centrophorus granulosus*  
*Centrophorus tessellatus*  
*Deania profundorum*

Etmopteridae  
Lantern Sharks

*Centroscyllium fabricii*  
*Etmopterus bigelowi*  
*Etmopterus bullisi*  
*Etmopterus carteri*  
*Etmopterus gracilispinis*  
*Etmopterus hillianus*  
*Etmopterus perryi*  
*Etmopterus polli*  
*Etmopterus pusillus*  
*Etmopterus robinsi*  
*Etmopterus schultzi*  
*Etmopterus virens*

Somniosidae  
Sleeper Sharks

*Centroscymnus coelolepis*  
*Centroscymnus owstoni*  
*Somniosus rostratus*  
*Zameus squamulosus*

Oxynotidae  
Roughsharks

*Oxynotus caribbaeus*

Dalatiidae  
Kitefin sharks

*Dalatias licha*  
*Isistius brasiliensis*  
*Isistius plutodus*  
*Squaliolus laticaudus*

ORDER PRISTIOPHORIFORMES (Sawsharks)

Pristiophoridae  
Sawsharks

*Pristiophorus schroederi*

ORDER SQUATINIFORMES (Angelsharks)

Squatinae  
Angelsharks

*Squatina dumeril*

ORDER ORECTOLOBIFORMES (Carpetsharks)

Ginglymostomidae  
Nurse Sharks

*Ginglymostoma cirratum*

Rhincodontidae  
Whale Shark

*Rhincodon typus*

ORDER LAMNIFORMES (Mackerel Sharks)

Odontaspidae  
Sandtiger Sharks

*Carcharias taurus*  
*Odontaspis ferox*  
*Odontaspis noronhai*

Pseudocarchariidae  
Crocodile Shark

*Pseudocarcharias kamoharai*

Mitsukurinidae  
Goblin Shark

*Mitsukurina owstoni*

Megachasmidae  
Megamouth Shark

*Megachasma pelagios*

Alopiidae  
Thresher Sharks

*Alopias superciliosus*  
*Alopias vulpinus*

Cetorhinidae  
Basking Shark

*Cetorhinus maximus*

Lamnidae  
Mackerel Sharks

*Carcharodon carcharias*  
*Isurus oxyrinchus*  
*Isurus paucus*

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Dario  
Guitart  
Manday,  
1966

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ORDER CARCHARHINIFORMES (Ground Sharks)

**Scyliorhinidae**  
**Catsharks**

*Apristurus canutus*  
*Apristurus laurussoni*  
*Apristurus parvipinnis*  
*Apristurus riveri*  
*Galeus antillensis*  
*Galeus arae*  
*Galeus cadenati*  
*Galeus springeri*  
*Parmaturus campechiensis*  
*Schroederichthys maculatus*  
*Scyliorhinus boa*  
*Scyliorhinus haeckelii*  
*Scyliorhinus hesperius*  
*Scyliorhinus meadi*  
*Scyliorhinus retifer*  
*Scyliorhinus torrei*

**Proscylliidae**  
**Finback Catsharks**

*Eridacnis barbouri*

**Triakidae**  
**Houndsharks**

*Mustelus canis*  
*Mustelus higmani*  
*Mustelus minicanis*  
*Mustelus norrisi*  
*Mustelus sinusmexicanus*

**Carcharhinidae**  
**Requiem Sharks**

*Carcharhinus acronotus*  
*Carcharhinus altimus*  
*Carcharhinus brachyurus*  
*Carcharhinus brevipinna*  
*Carcharhinus falciformis*  
*Carcharhinus galapagensis*  
*Carcharhinus leucas*  
*Carcharhinus limbatus*  
*Carcharhinus longimanus*  
*Carcharhinus obscurus*  
*Carcharhinus perezii*  
*Carcharhinus plumbeus*  
*Carcharhinus porosus*

**Carcharhinidae**  
**Requiem Sharks**

(CONTINUED)

**Sphyrnidae**  
**Hammerheads**

*Carcharhinus signatus*  
*Galeocerdo cuvier*  
*Isogomphodon oxyrinchus*  
*Negaprion brevirostris*  
*Prionace glauca*  
*Rhizoprionodon lalandei*  
*Rhizoprionodon porosus*  
*Rhizoprionodon terraenovae*

*Sphyrna lewini*  
*Sphyrna media*  
*Sphyrna mokarran*  
*Sphyrna tiburo*  
*Sphyrna tudes*  
*Sphyrna zygaena*



***97 species in 24 families from 7 orders  
in Gulf of Mexico & Caribbean Sea***

**(Worldwide there are ~500 spp in 34 families in 8 orders)**

# Sharks' Use of Gulf & Caribbean Waters

(U.S., Mexico & Cuba)

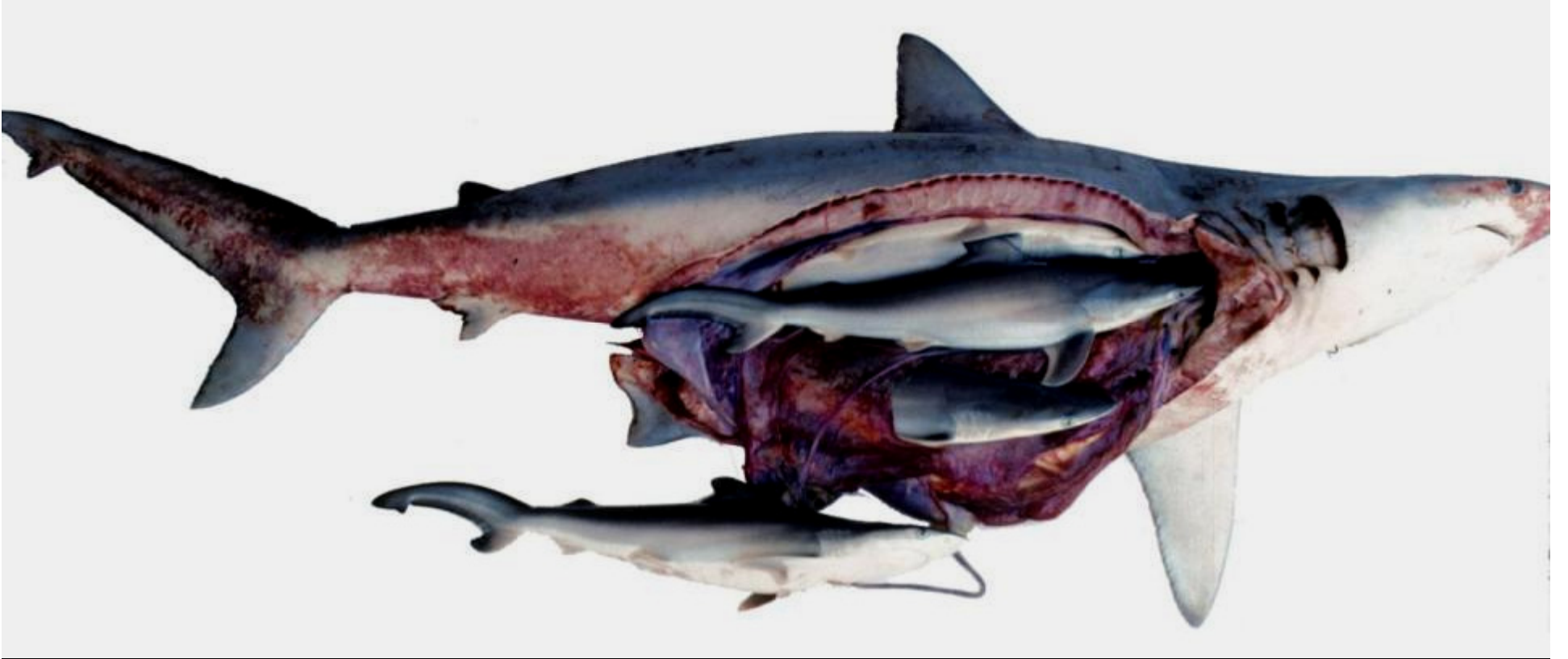
- Mating areas
- Nursery areas
- Feeding grounds



# SHARK MATING AREAS



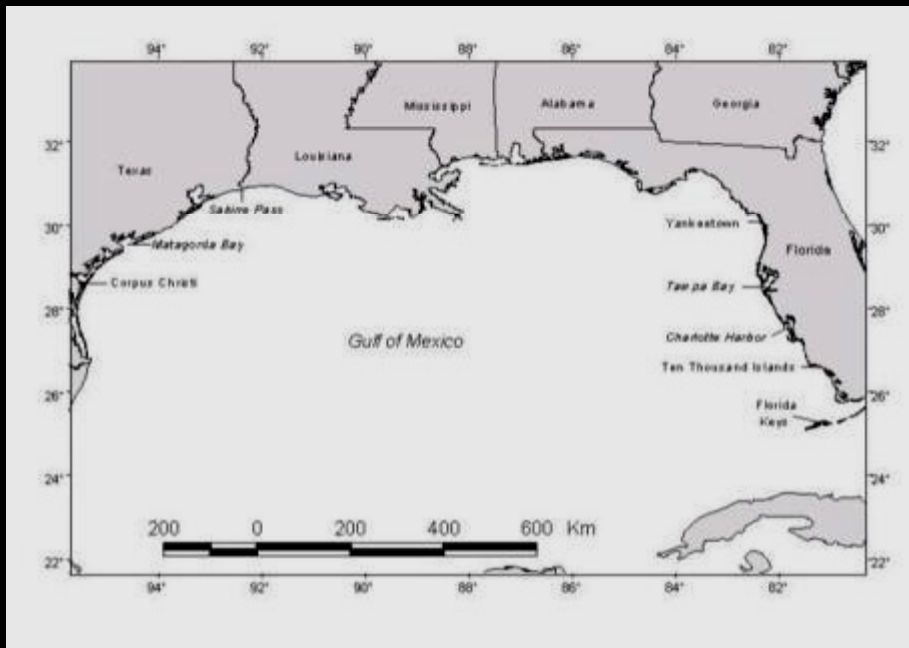
Nurse sharks mating in the  
Dry Tortugas, Florida



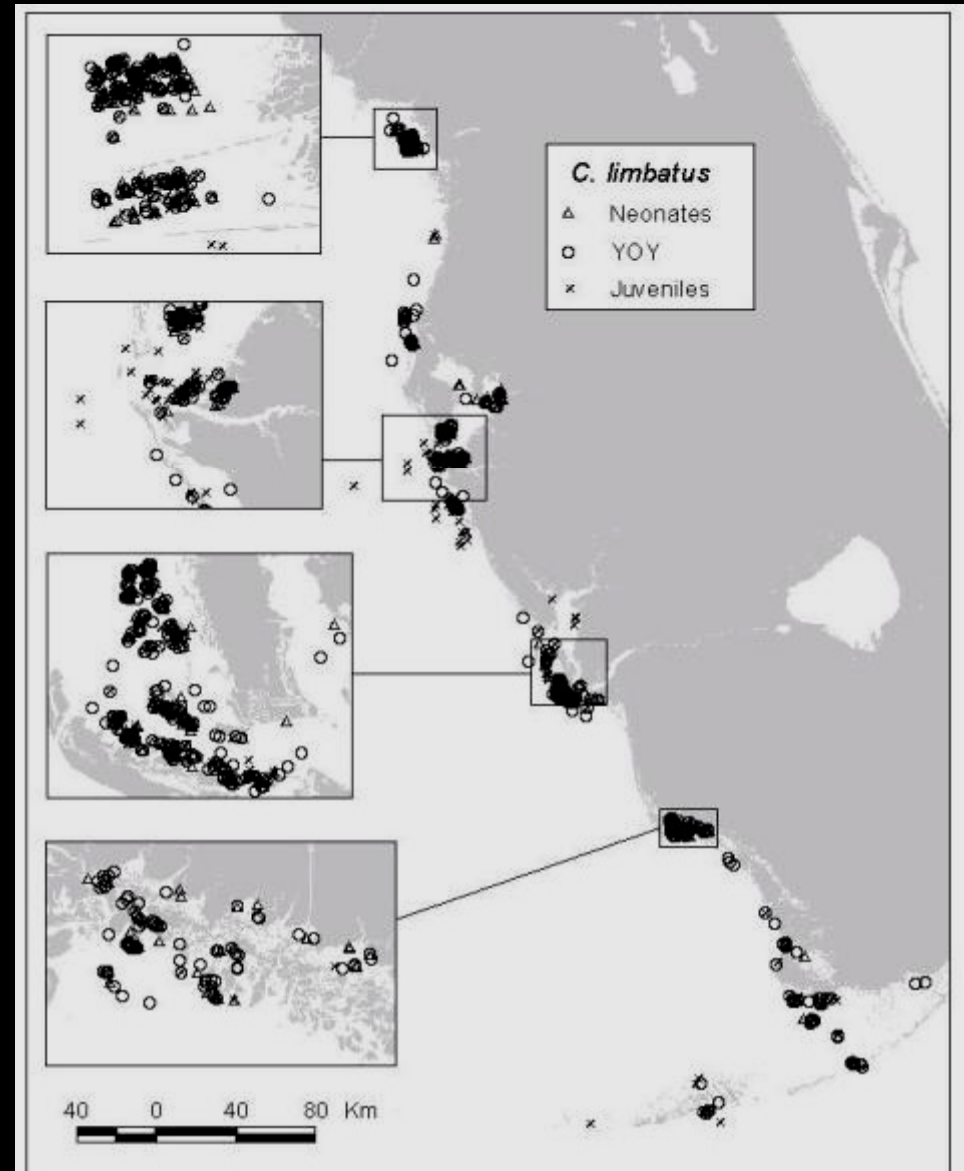
# SHARK NURSERY AREAS



*At least 16 coastal shark species  
have nurseries in U.S. GOM  
coastal waters*



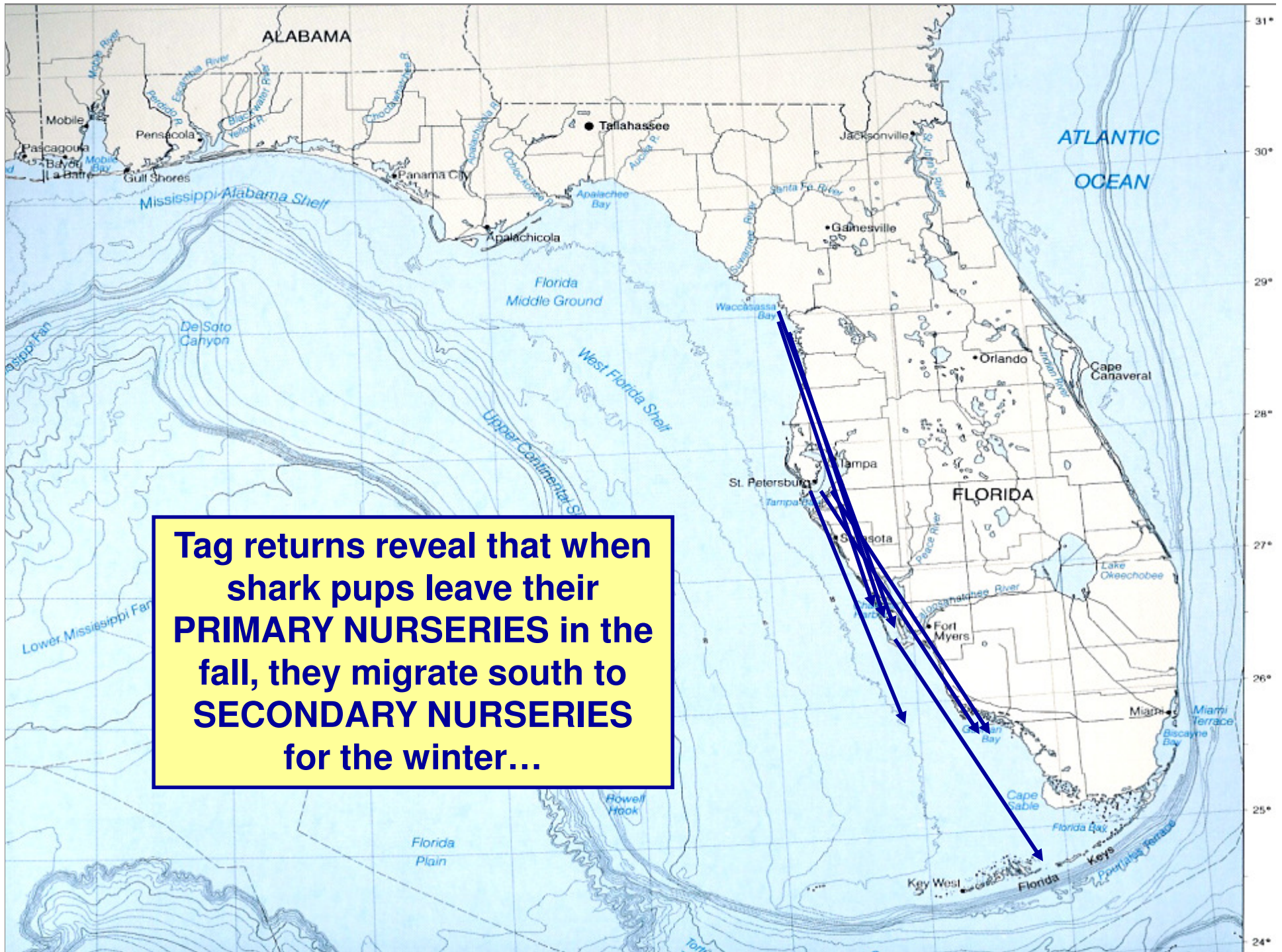
Hueter and Tyminski (2007) Species-specific distribution and habitat characteristics of shark nurseries in Gulf of Mexico waters off peninsular Florida and Texas. *American Fisheries Society Symposium* 50:193-223.



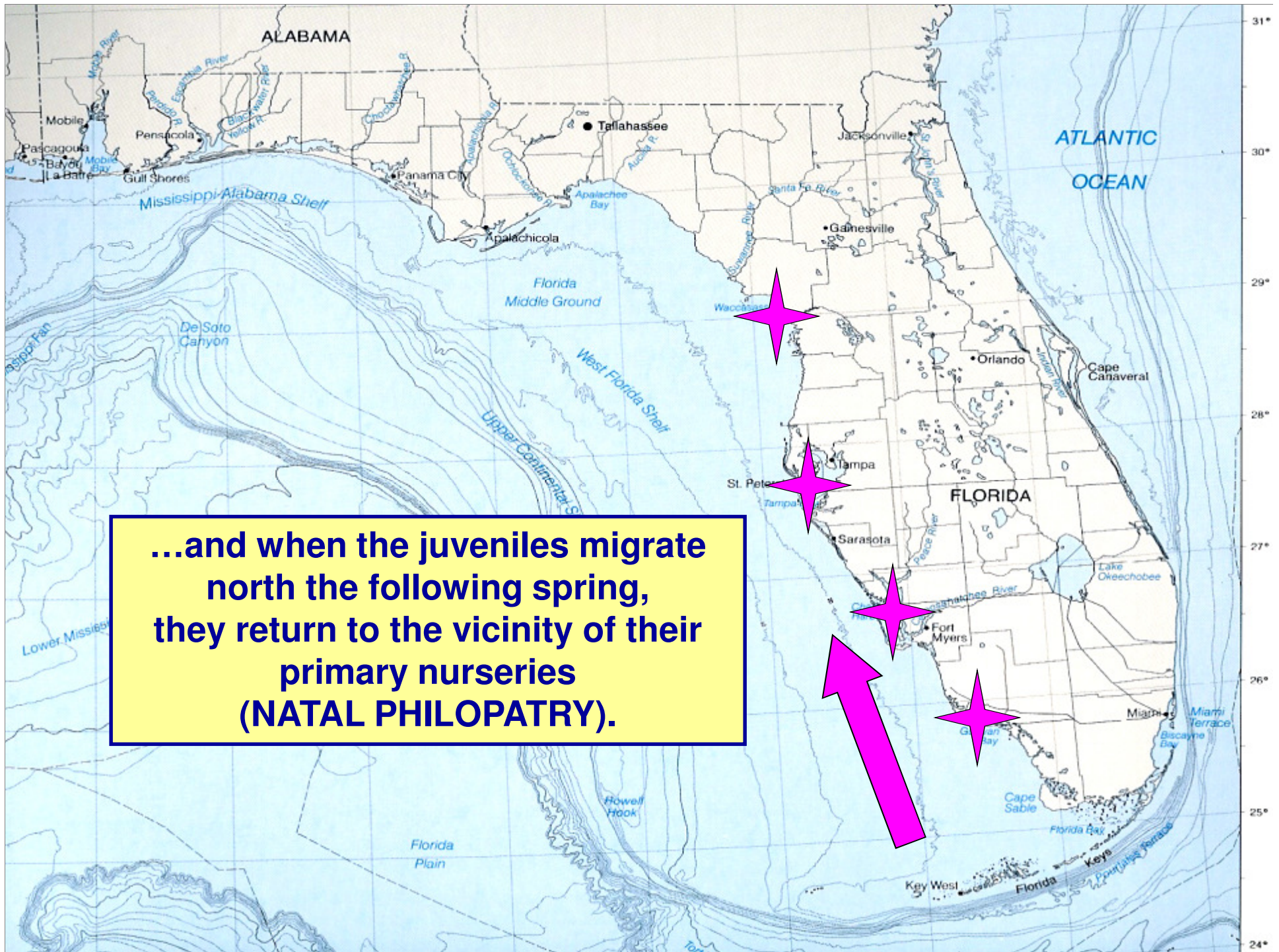






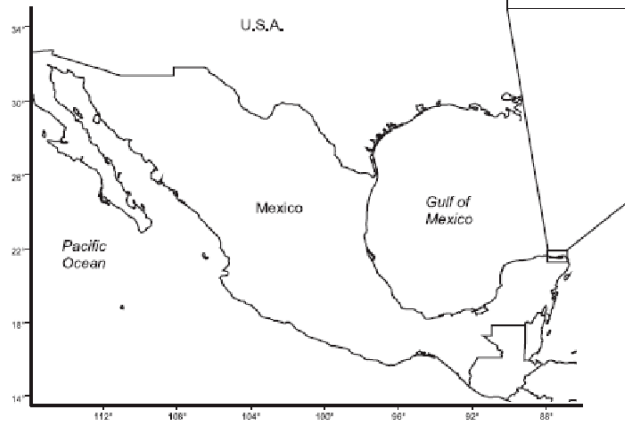
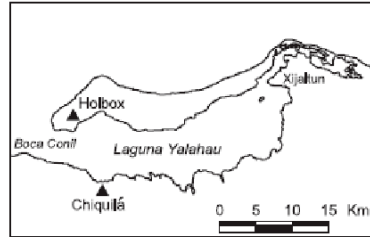




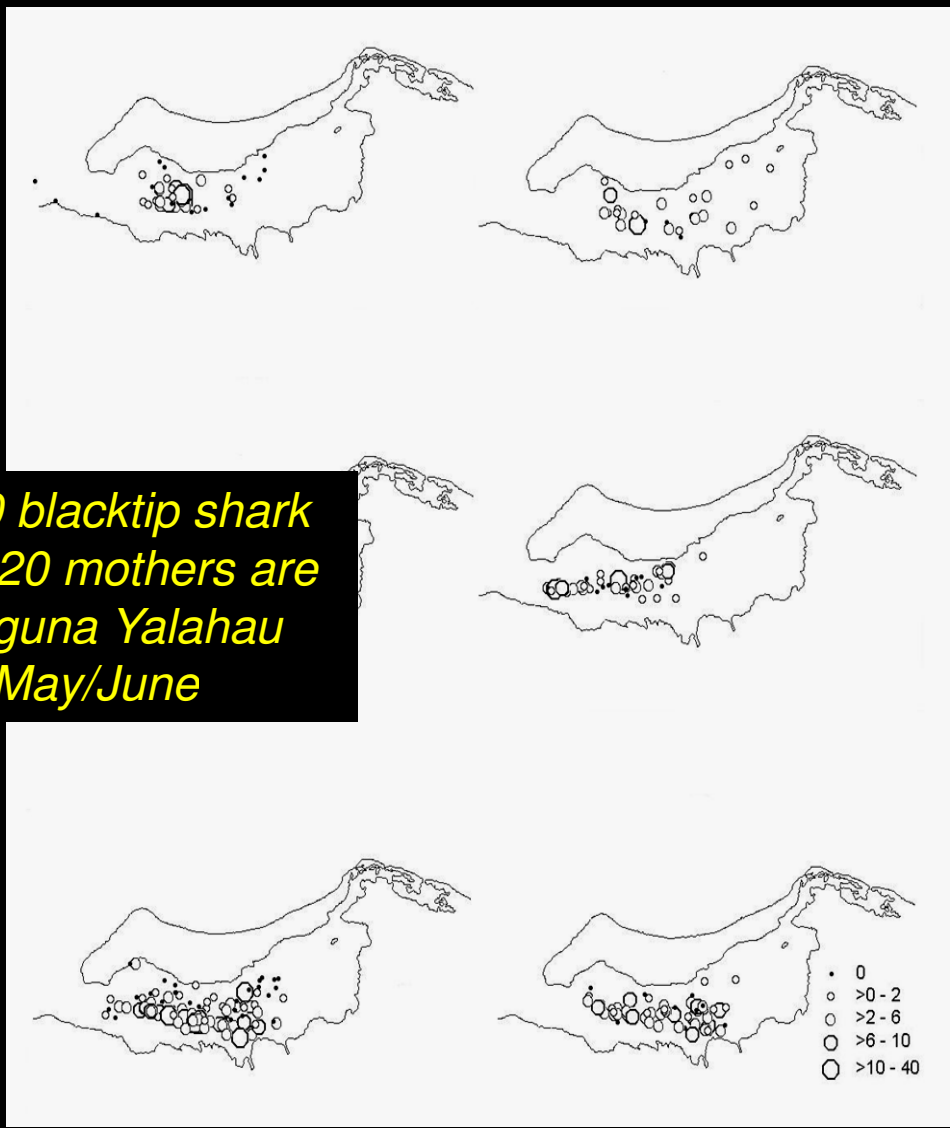


**...and when the juveniles migrate north the following spring, they return to the vicinity of their primary nurseries (NATAL PHILOPATRY).**

# MEXICAN SHARK NURSERIES



*At least 900 blacktip shark pups from 220 mothers are born in Laguna Yalahau every May/June*



Hueter, Castillo-Géniz, Márquez-Farias and Tyminski (2007) The use of Laguna Yalahau, Quintana Roo, Mexico as a primary nursery for the blacktip shark. *American Fisheries Society Symposium* 50:345-364.



# JUVENILE SHARKS IN CUBAN COASTAL WATERS



Caribbean reef shark  
*Carcharhinus perezii*



Nurse shark (Gata)  
*Ginglymostoma cirratum*



Tiger shark  
*Galeocerdo cuvier*



Lemon shark  
*Negaprion brevirostris*

*Coastal surveys with CIM, Universidad de la Habana*





**SHARK FEEDING AREAS**

# Chlorophyll Imagery – 16 August 2004

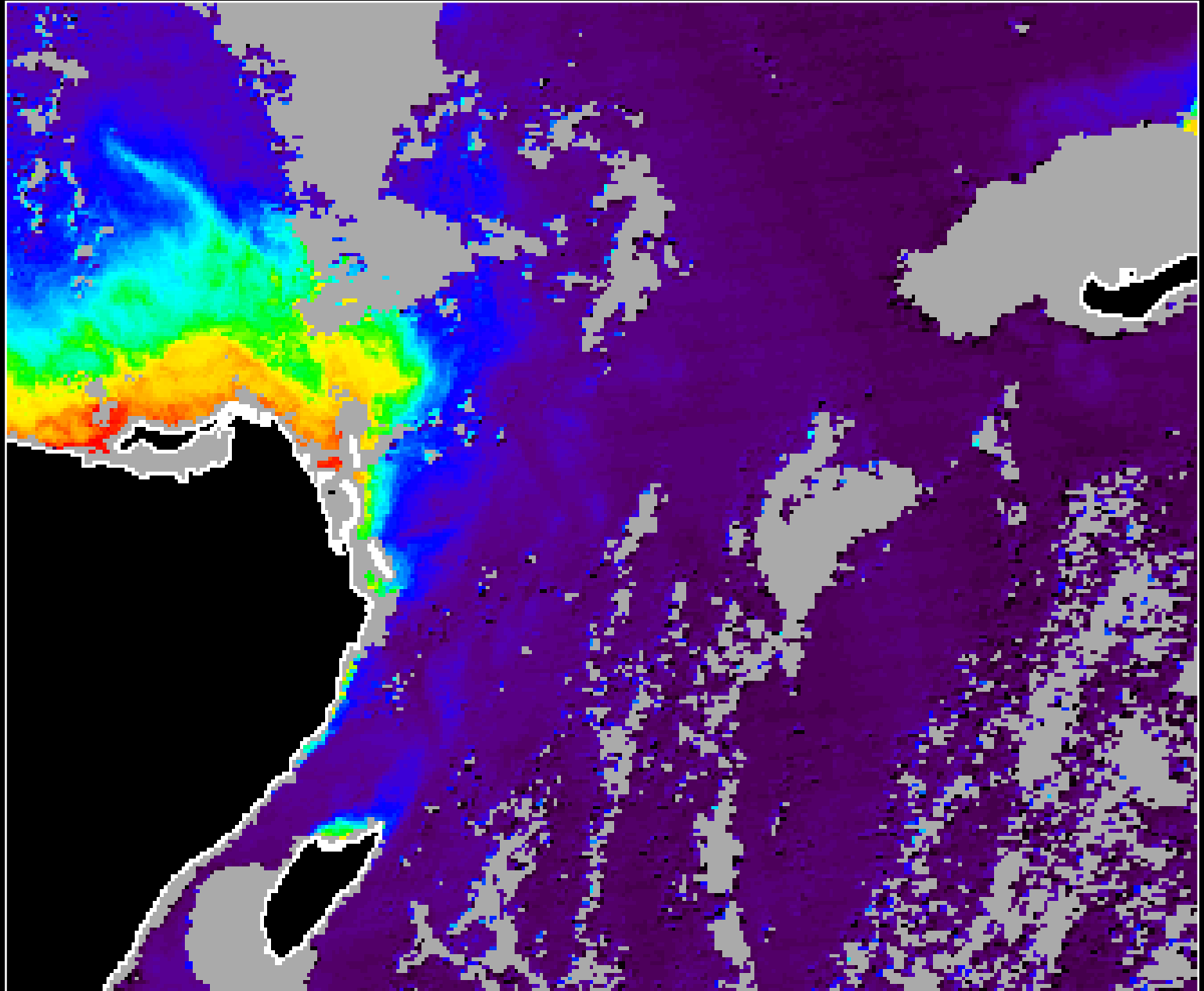




Photo by  
Oscar  
Reyes







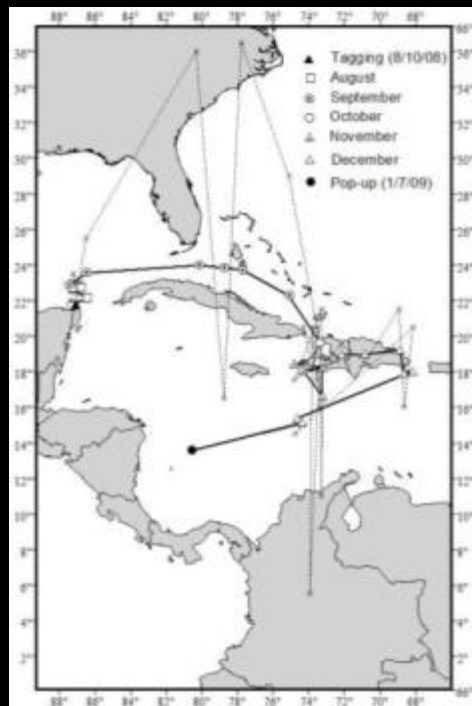
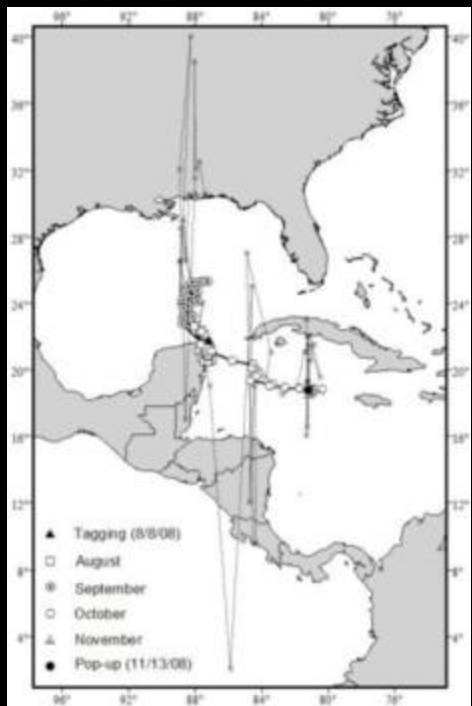
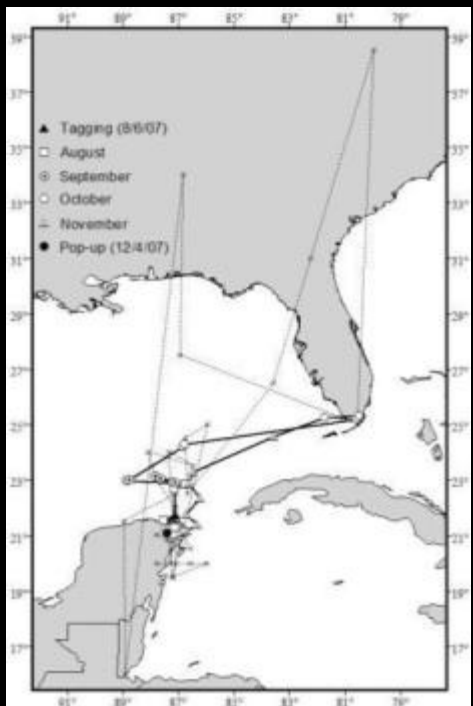
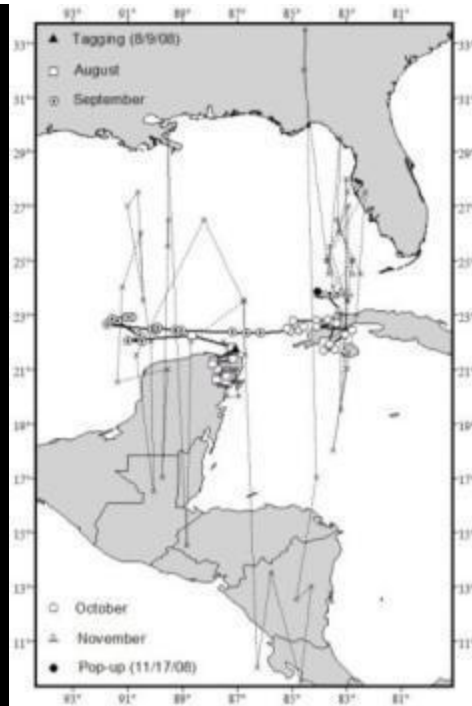
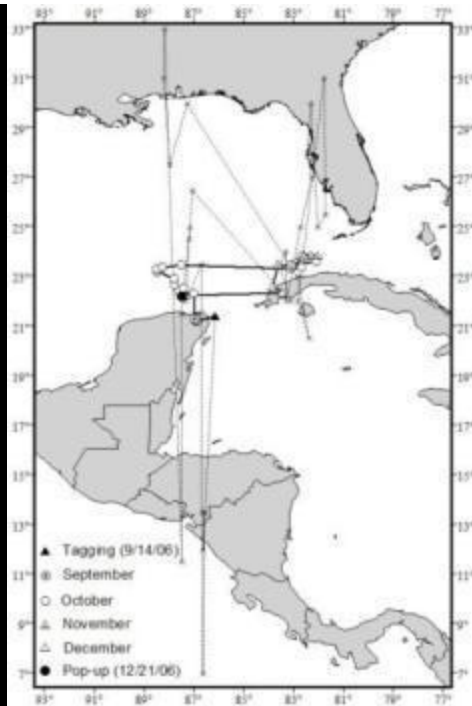
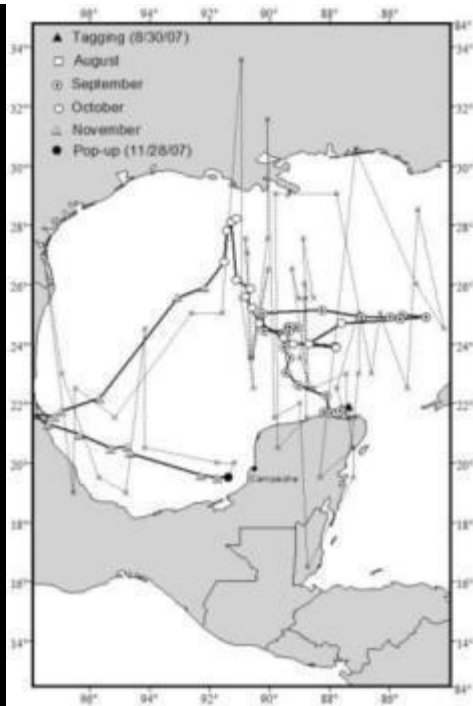


# Connectivity



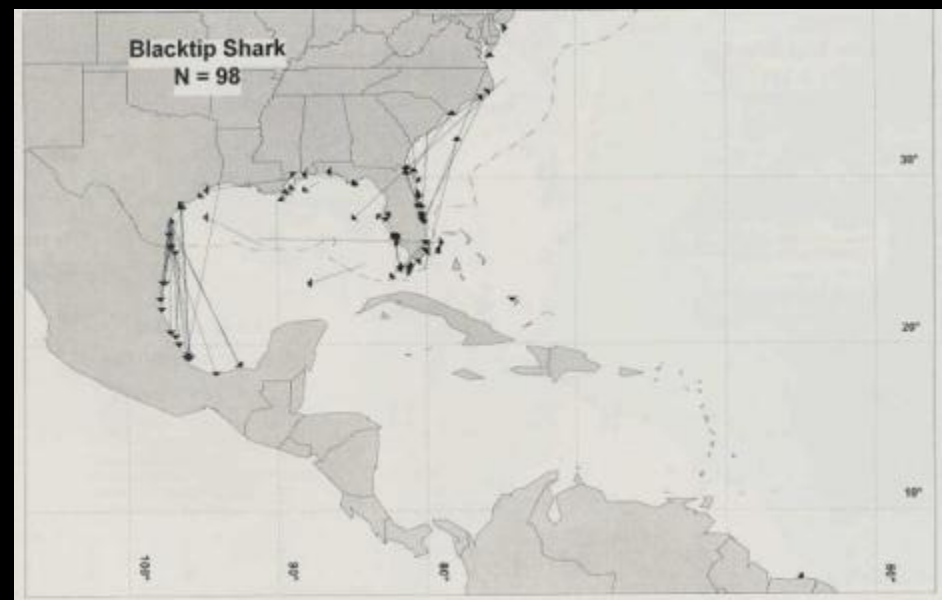
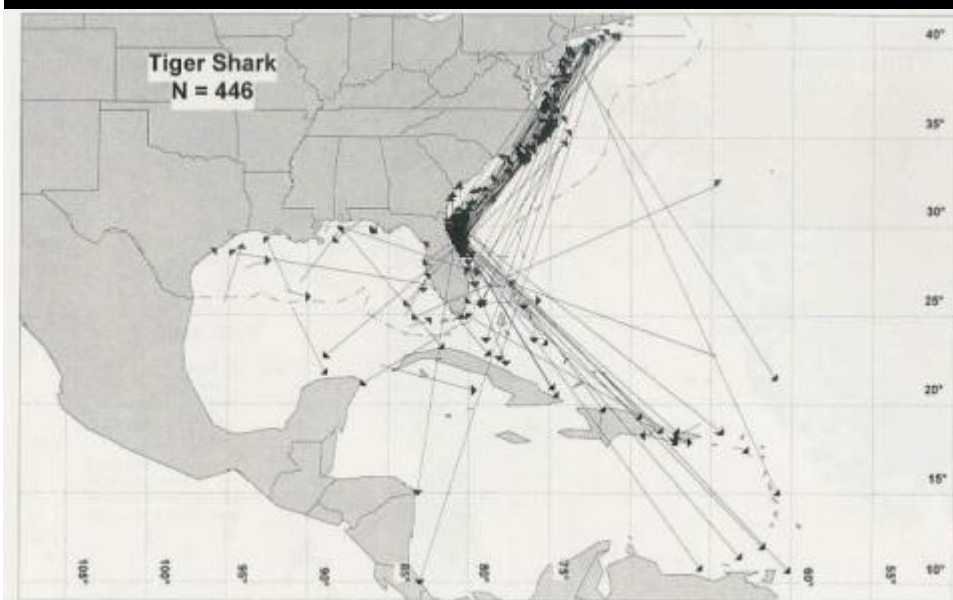
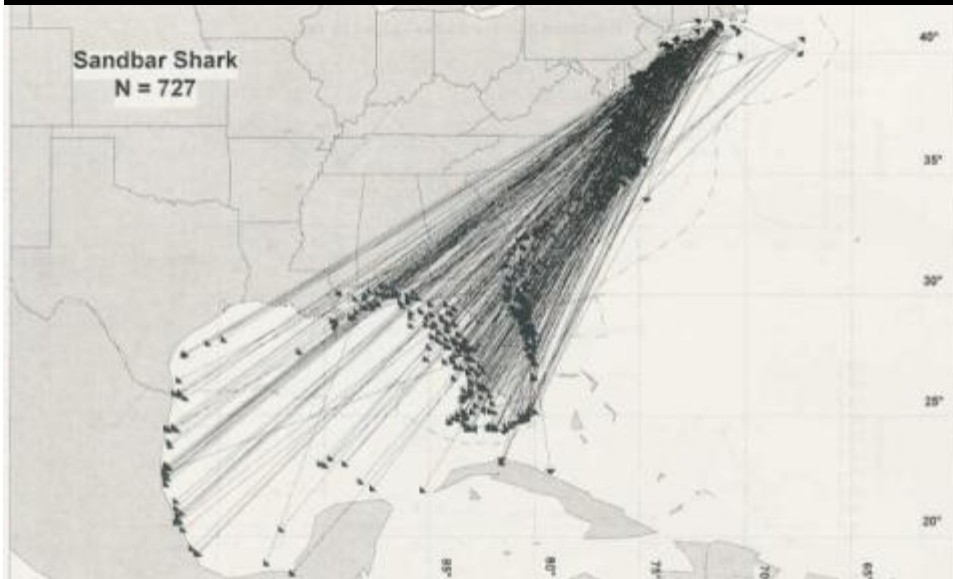




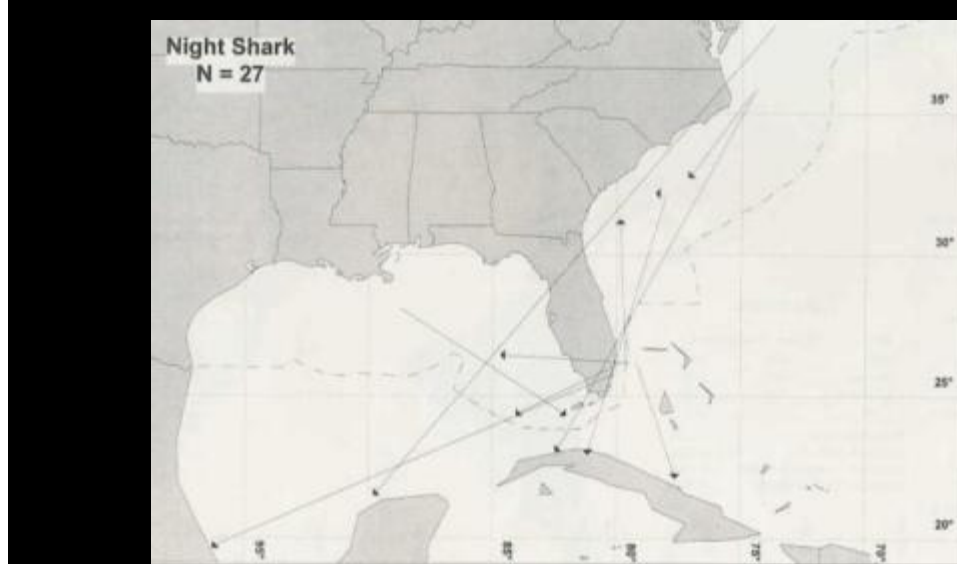
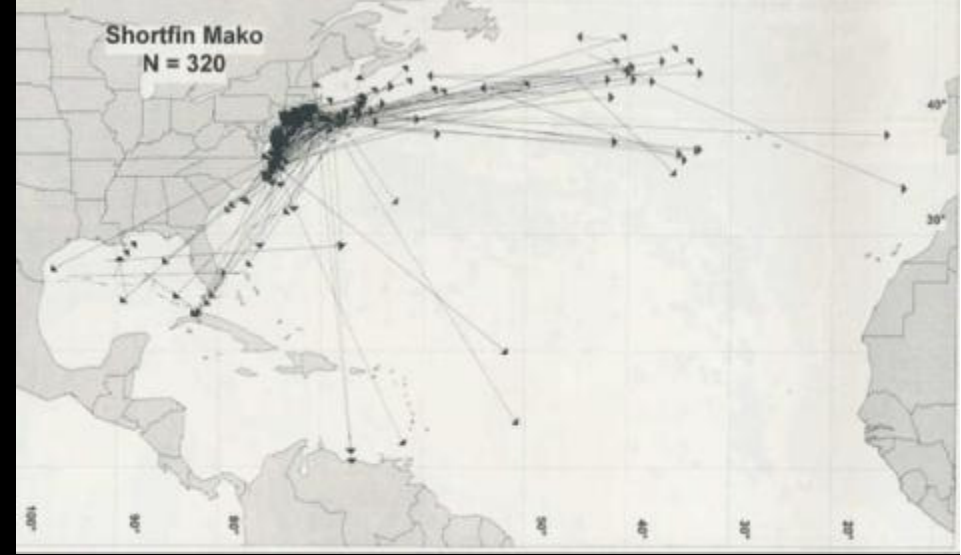
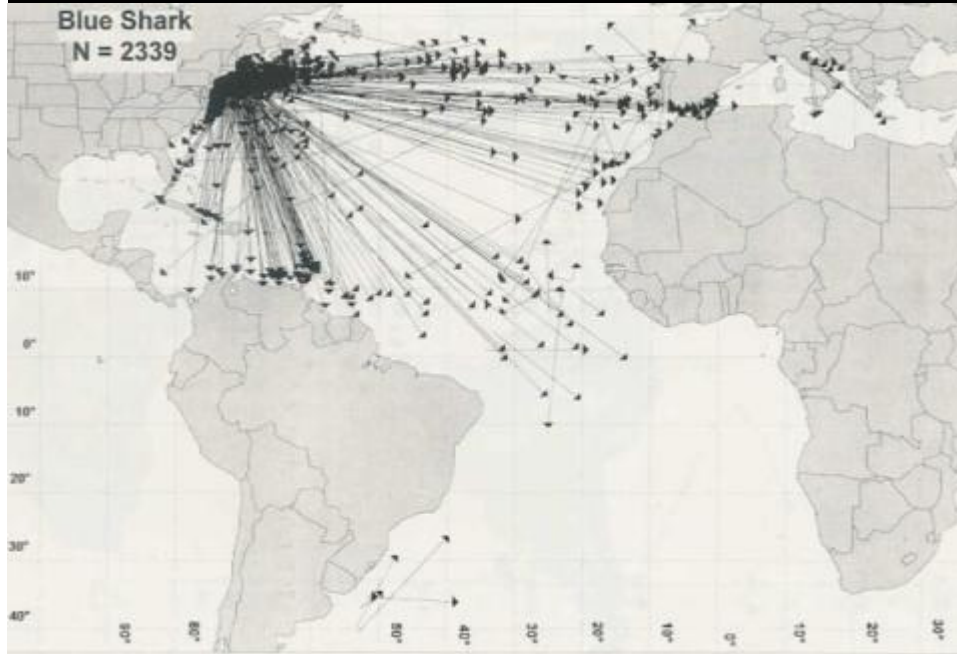




# U.S. National Marine Fisheries Service (NMFS) conventional tag returns from large coastal sharks



# U.S. National Marine Fisheries Service (NMFS) conventional tag returns from pelagic sharks



Kohler, Casey and Turner (1998) NMFS  
Cooperative Shark Tagging Program, 1962-93:  
An Atlas of Shark Tag and Recapture Data.  
*Marine Fisheries Review* 60(2)1-87.

# Conservation

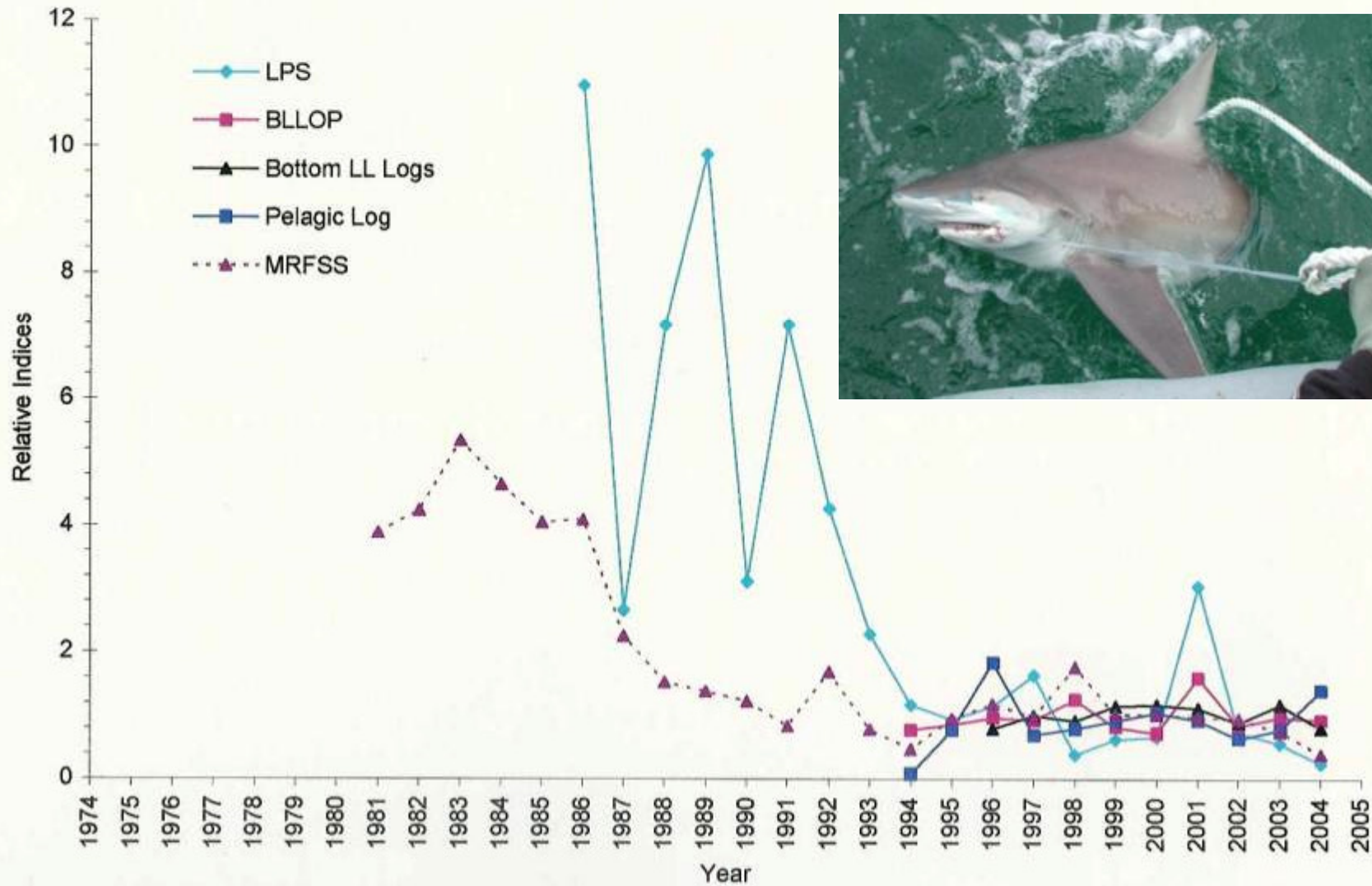




# U.S. SHARK FISHERIES

SEDAR 11 LCS Data Workshop Report

Sandbar - Fisheries Dependent



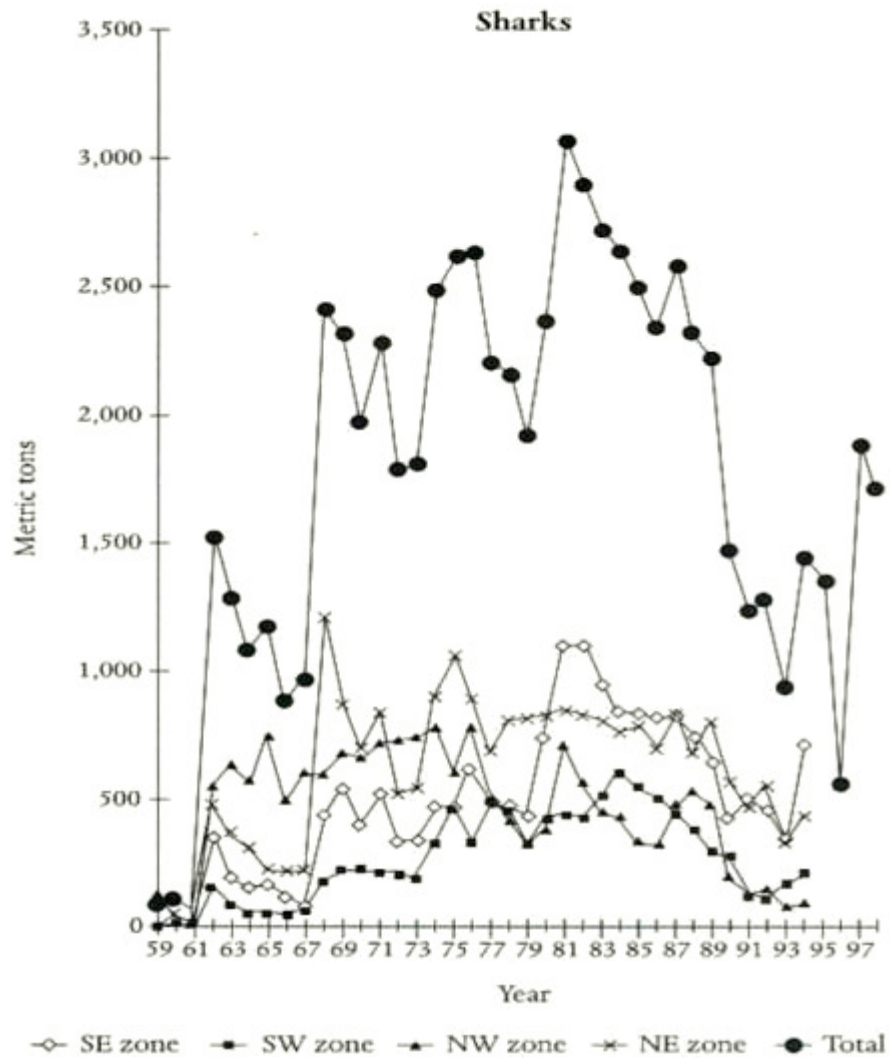


Fig. 8.22. Regional and total catches of sharks in Cuba, 1959–1998.

## CUBAN SHARK FISHERIES

**MEAN ANNUAL CATCH (in metric tons) and PROPORTION OF TOTAL FINFISH CATCH**

	1981-1985		1986-1990		1991-1995	
	mt	%	mt	%	mt	%
<b>Sharks</b>	<b>2,767.8</b>	<b>10.8</b>	<b>2,187.0</b>	<b>7.7</b>	<b>1,247.2</b>	<b>5.7</b>
<b>Rays</b>	<b>1,801.9</b>	<b>7.0</b>	<b>2,942.1</b>	<b>10.3</b>	<b>1,819.1</b>	<b>8.2</b>



Claro, Lindeman and Parenti, eds. (2001)  
*Ecology of the Marine Fishes of Cuba.*



# Mexican shark fisheries consistently rank in the top ten of all shark-fishing nations



# Collapse and Conservation of Shark Populations in the Northwest Atlantic

Julia K. Baum,\* Ransom A. Myers, Daniel G. Kehler, Boris Worm, Shelton J. Harlay, Penny A. Doherty

Overexploitation threatens the future of many large vertebrates. In the oceans and sea turtles are current conservation concerns because of this intense pressure. The status of most shark species, in contrast, remains uncertain. Using the largest data set in the Northwest Atlantic, we show rapid large declines in large coastal and oceanic shark populations. Scalloped hammerhead, white, thresher sharks are each estimated to have declined by over 75% in the 15 years. Coated-area models highlight priority areas for shark conservation and the need to consider effort, allocation and site selection if marine reserves are to benefit multiple threatened species.

Human exploitation has propagated across land, coastal areas, and the ocean, transforming ecosystems through the elimination of many species, particularly large vertebrates (1, 2). Only in the past half-century, as fishing fleets expanded rapidly in the open ocean, have large marine predators been subject to this intense exploitation. Many species, including tuna, billfishes (3), and sea turtles (4), are of immediate conservation concern as a result. Among the species impacted by these fisheries, sharks should be of particular concern. Despite their known vulnerability to overfishing (5, 6), sharks have been increasingly exploited in recent decades, both as bycatch in pelagic longline fisheries from the 1960s onward (7) and as targets in directed fisheries that expanded rapidly in the 1980s (8). The vast geographic scale of pelagic marine ecosystems constrains our ability to monitor shark populations adequately. Thus, the effect of exploitation on sharks has, for most populations, remained unknown (5). Shark management and conservation have been hindered by the lack of knowledge on their status, or even the direction of the population trends.

We present an analysis of logbook data for the U.S. pelagic longline fleet targeting swordfish and tunas in the Northwest Atlantic (Fig. 1). Pelagic longlines are the most widespread fishing gear used in the open ocean. The data set presented is the largest available for this region (2,4,234 sets between 1986 and 2000 with a mean of 550 hooks per longline set) and includes one of the longest time series for sharks. Six species or species groups were recorded from 1986 onward, and eight species from 1992 onward (Table 1).

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For most shark species examined, only data sets from which reliable trends can be estimated for the Atlantic (19). It is also one of the able sources worldwide from which the source of exploitation on sharks in the ocean can be investigated. However, credible unreporting may occur in data, and missing values cannot

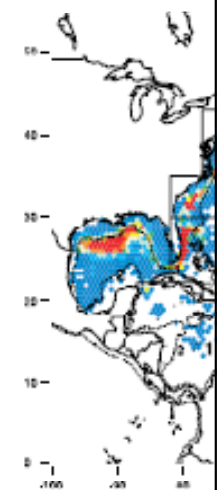


Fig. 1. Map of the Northwest Atlantic fishery between 1986 and 2000. Color-coded overlay shows the density of fishing effort. 1, Canada; 2, U.S. Gulf of Atlantic; 3, Northwest Coast; 4, Tuva North; 5, Tuva South; 6, Asia. We used the classification for longline fisheries.

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## REPORTS

guished from true zeros (11). To address this problem, we developed a method to model the positive catches using generalized linear models (GLMs) with a zero-inflated negative binomial distribution (12, 13). Our meth-

Ecology Letters (2004) 7, 135–145

doi: 10.1111/j.1461-0248.2003.00964.x

## REPORT

# Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico

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\*Correspondence: E-mail: baum@mathstat.dal.ca

## Abstract

Historical abundances of many large pelagic sharks in the Gulf of Mexico today. However, while pelagic shark populations in the northwest Atlantic in recent years, the natural abundances of these species. 1990s) stands alone catch rates of pelagic methods of exploitation between these that oceanic whitetip and silky shark species, have declined by over 99 and oceanic whitetip sharks in this ecosystem shifting baselines. Our analysis provides the Gulf of Mexico that is needed for the species.

## Keywords

Fisheries, generalized linear model, population, predator, restoration.

Ecology Letters (2004) 7, 135–145

## INTRODUCTION

Understanding the full extent and manner in which anthropogenic forces have impacted natural ecosystems requires knowledge of their unexploited state. Although human influences on terrestrial and coastal ecosystems are highly evident (MacIvor 1999; Jackson *et al.* 2001), the open ocean has been regarded as pristine until recently. Precipitous declines in many oceanic species and concomitant fisheries collapses are, however, clear demonstrations that these ecosystems have also been significantly impacted. In particular, large predators are known to sustain aquatic ecosystems, but that role may have changed dramatically because of large-scale declines. Estimates for whales, tunas, billfishes and large demersal fishes suggest that as in terrestrial and coastal ecosystems, the former natural abundances of large predators were enormous compared with recent observations (Myers & Worm 2003; Roman & Palumbi 2003). For many species, however, a historical perspective is obscured by a reliance on recent data in analyses. Without this knowledge our baseline of what was natural in the open ocean will continue to shift, and we risk becoming complacent about the rarity of species (Pauly 1995).

In the past few decades, the world's oceans have lost an estimated 90% of their large predators (Myers & Worm 2003). This loss has had a profound impact on the structure and function of marine ecosystems (Worm & Branch 2003). The loss of large predators has led to a shift in the baseline of what is considered 'normal' abundance for many species (Pauly 1995). This shift in the baseline has led to a decline in the abundance of many species, including sharks (Myers & Worm 2003). The loss of large predators has also led to a decline in the abundance of many other species, including tunas and billfishes (Worm & Branch 2003). The loss of large predators has led to a decline in the abundance of many other species, including tunas and billfishes (Worm & Branch 2003).

## letters to nature

# Rapid worldwide depletion of predatory fish communities

Ransom A. Myers & Boris Worm

Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1

Serious concerns have been raised about the ecological effects of industrialized fishing<sup>1–3</sup>, spurring a United Nations resolution on restoring fisheries and marine ecosystems to healthy levels<sup>4</sup>. However, a prerequisite for restoration is a general understanding of the composition and abundance of unexploited fish communities, relative to contemporary ones. We constructed trajectories of community biomass and composition of large predatory fishes in four continental shelf and nine oceanic systems, using all available data from the beginning of exploitation. Industrialized fisheries typically reduced community biomass by 80% within 15 years of exploitation. Compensatory increases in fast-growing species were observed, but often reversed within a decade. Using a meta-analytic approach, we estimate that large predatory fish biomass today is only about 10% of pre-industrial levels. We conclude that declines of large predators in coastal regions<sup>5</sup> have extended throughout the global ocean, with potentially serious consequences for ecosystems<sup>6,7</sup>. Our analysis suggests that management based on recent data alone may be misleading, and provides minimum estimates for unexploited communities, which could serve as the 'missing baseline'<sup>8</sup> needed for future restoration efforts.

Ecological communities on continental shelves and in the open ocean contribute almost half of the planet's primary production<sup>9</sup>, and sustain three-quarters of global fishery yields<sup>10</sup>. The widespread decline and collapse of major fish stocks has sparked concerns about the effects of overfishing on these communities. Historical data from coastal ecosystems suggest that losses of large predatory fishes,

as well as mammals and reptiles, were especially pronounced, and precipitated marked changes in coastal ecosystem structure and function<sup>11</sup>. Such baseline information is a scarce for shelf and oceanic ecosystems. Although there is an understanding of the magnitude of the decline in single stocks<sup>12</sup>, it is an open question how entire communities have responded to large-scale exploitation. In this paper, we examine the trajectories of entire communities, and estimate global rates of decline for large predatory fishes in shelf and oceanic ecosystems.

We attempted to compile all data from which relative biomass at the beginning of industrialized exploitation could be reliably estimated. For shelf ecosystems, we used standardized research trawl surveys in the northwest Atlantic Ocean, the Gulf of Thailand and the Antarctic Ocean off South Georgia, which were designed to estimate the biomass of large demersal fish such as codfishes (Gadidae), flatfishes (Pleuronectidae), skates and rays (Rajidae), among others (see Supplementary Information for detailed species information). In all other shelf areas for which we could obtain data, industrialized trawls occurred before research surveys took place. For oceanic ecosystems, we used Japanese pelagic longline data, which represent the complete catch-rate data for tuna (Thunnini), billfishes (Istiophoridae) and swordfish (Xiphiidae) aggregated in monthly intervals, from 1952 to 1999, across a global 3° × 5° grid. Pelagic longlines are the most widespread fishing gear, and the Japanese fleet the most widespread longline operation, covering all oceans except the circumpolar area. Longlines, which scramble long, limited trawlers, catch a wide range of species in a consistent way and over vast spatial scales. We had to restrict our analysis of longline data to the equatorial and southern ocean, because industrialized exploitation was already underway in much of the Northern Hemisphere before these data were recorded<sup>13,14</sup>. Longline data were separated into temperate, subtropical and tropical communities (see Methods).

For each shelf and oceanic community, *i*, we estimated

$$N_i(t) = N_i(0)(1 - A)^t e^{-Bt} + A \quad (1)$$

where  $N_i(t)$  is the biomass at time  $t$ ,  $N_i(0)$  is the initial biomass

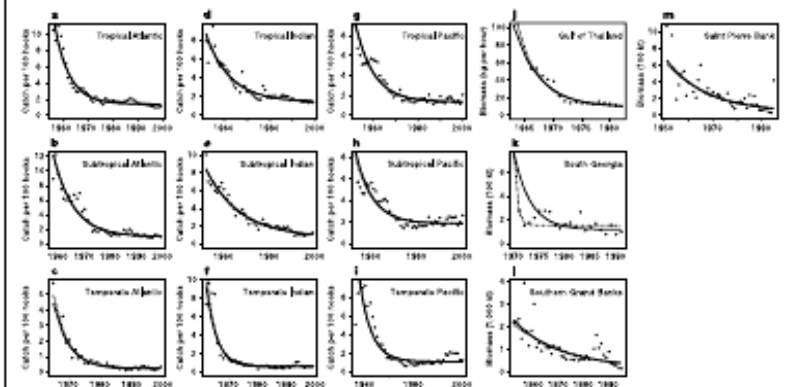


Figure 1. Time trends of community biomass in coastal (a–f) and shelf (g–l) ecosystems. Black dots are estimates from the beginning of industrialized fishing (solid points) as shown with supporting data on key individual estimates (solid lines). Solid lines are estimates from the beginning of industrialized fishing (solid lines) and unexploited baseline (dashed lines) from a generalized fit (eqn 1).

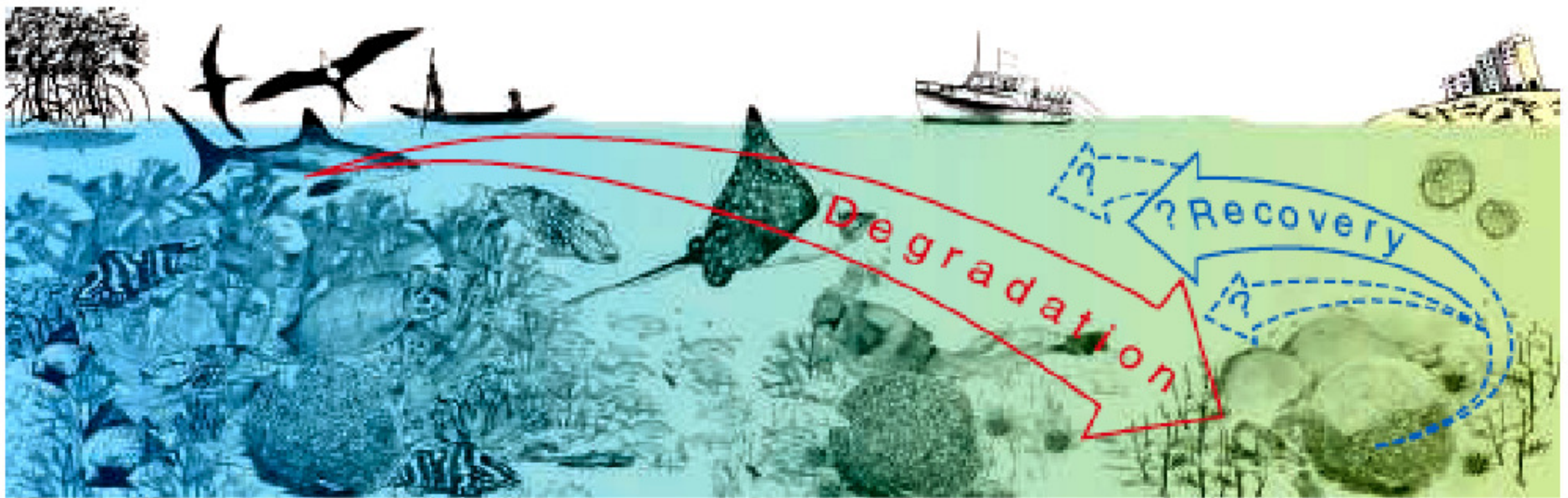


# Why care about shark conservation?

- **BIOLOGICAL RESEARCH & HUMAN HEALTH**
  - Classic vertebrate anatomy tool
  - Studies of advanced senses & reproduction
  - Anti-cancer properties
  - Source of therapeutic materials
- **COMMERCIAL & RECREATIONAL INDUSTRY**
  - Commercial & recreational fisheries
  - Diving & ecotourism
  - Aquariums
- **ECOLOGICAL**
  - Top predators → Ecological balance
  - Biological control of other species







The slippery slope of coral reef decline through time.

Pandolfi et al. (2005) Are U.S. coral reefs on the slippery slope to slime?  
*Science* 307:1725-1726.



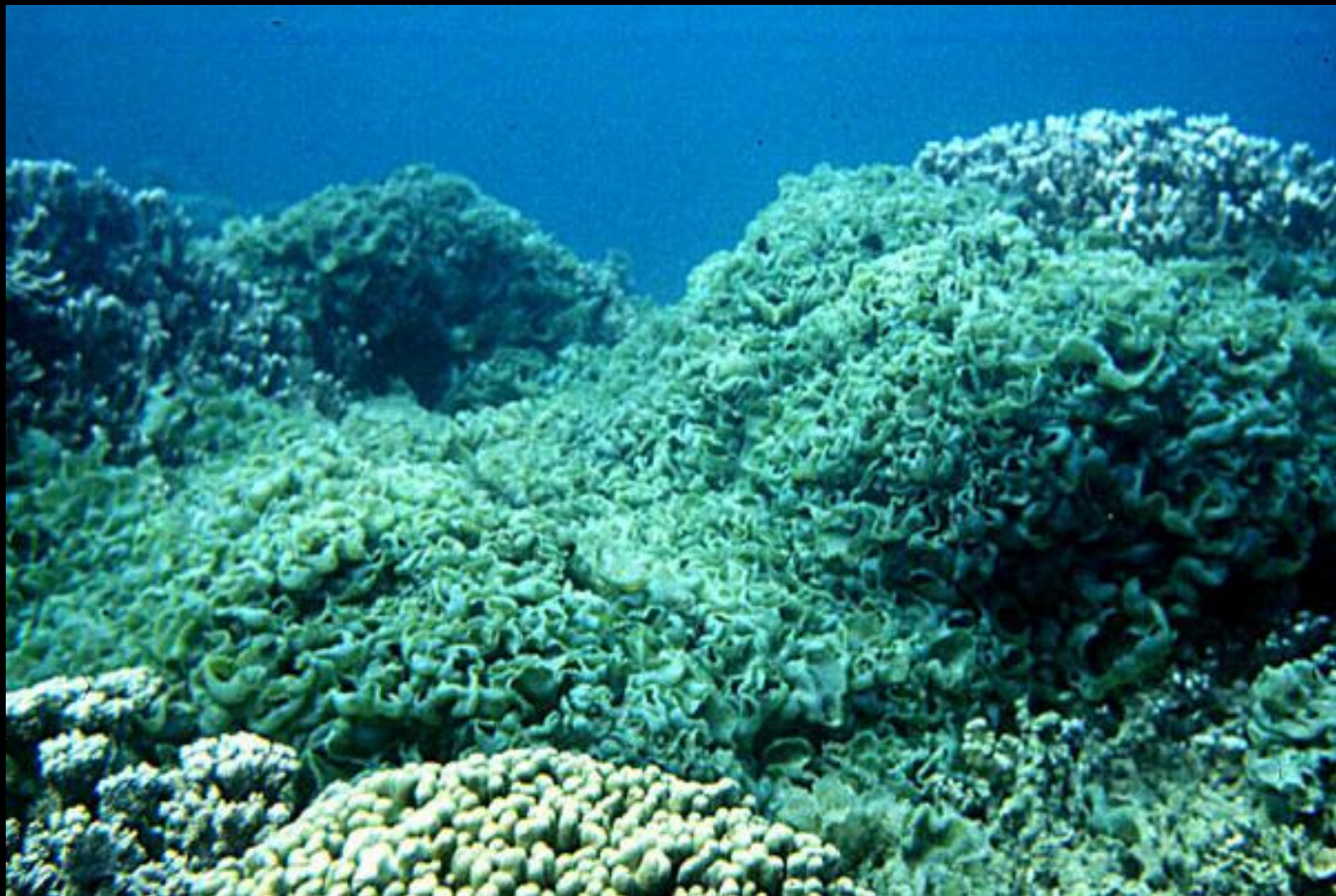












**"It appears that ecosystems such as Caribbean coral reefs need sharks to ensure the stability of the entire system."**

**Eric Sala, Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography**





***Muchas  
gracias!***

