Regional Workshop on Cownose Ray Issues Identifying Research and Extension Needs

Yorktown, VA
June 1-2, 2006

Sea Grant
Virginia

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VIMS Marine Resource Report 2009-6

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Virginia Sea Grant Program. The views expressed herein do not necessarily reflect the views of any of those organizations.

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Introduction

Robert Fisher
Fisheries Specialist
Virginia Sea Grant Marine Advisory Program
Virginia Institute of Marine Science
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Gloucester Point, VA 23062

The Virginia Sea Grant Marine Advisory Program (VASG MAP) first responded to industry concerns about cownose ray predation on shellfish in the Chesapeake Bay and the ray's impact on submerged aquatic vegetation (SAV) in the late 1980s. We have continued to address these needs through recent studies focusing on the marketing of various ray products and by obtaining ray biological assessment information. Demonstration projects have provided industry with valuable ray harvesting, processing, and marketing information. Current research continues to investigate various market potentials, but also provides needed biological and behavioral information on the cownose ray population in the Bay. This biological assessment information will have important fishery management implications.

Studies performed in the mid-1970s, and reported in the early 1980s, reported on ray social behavior, diet, and some methods to keep the rays off shellfish beds. Since the time of these studies, many things have changed, including the reported increase in the number of rays, shifts in the main prey species available to rays (soft clams were a primary prey species in the 1980s, but are no longer abundant), methods of predator control, and the continual loss of submerged aquatic vegetation (SAV).

A current project funded by the Fisheries Resource Grant (FRG) program (administered by VIMS MAP) is titled "Value of Cownose Ray: Population Size, Harvesting, Processing and Market Acceptance." In cooperation with VIMS Marine Advisory Services, this work is expanding on previous efforts to establish markets for the cownose ray as well as providing new information in the processing of ray for various markets. This project has also helped create a collaborative atmosphere among various Virginia fisheries (shellfish growers as well as pound-net and haul-seine fisheries) and between those fisheries and research and regulatory agencies. In addition, it has elicited information requests from other states regarding similar problems with cownose rays. For example, one of the largest clam aquaculture production sites in the U.S., out of Cedar Key, Florida, has recently experienced ray predation problems. Likewise, other Mid-Atlantic states have contacted VASG MAP for information and assistance with cownose ray predation problems. Ray predation on bay scallops is affecting scallop restoration efforts in North Carolina, and rays have been identified as severe predators on oysters and clams in commercial sites in Maryland and New Jersey. The cownose ray has become a regional issue, especially in areas where shellfish restoration efforts are being conducted.

The purpose of the Regional Workshop on Cownose Ray Issues was to provide research groups, regulatory agencies, and the fishing industry the opportunity to share information about the cownose ray issue in an attempt to consolidate future efforts. Historical and current information was presented about ray biology, predator control methods, ray impact on shellfish and SAV, ray harvesting and processing, and ray seafood product development. The potential to establish a responsible ray fishery was also addressed and research and extension needs for such a fishery were identified. Seafood marketing efforts for various ray products were highlighted with several ray products prepared by our collaborating culinary expert for sampling. The outcome of this regional workshop should be to provide a working reference for further research and extension efforts.

Workshop Agenda

Freight Shed, Yorktown, VA June 1-2, 2006
Hosted by Virginia Sea Grant Marine Advisory Program

June 1, 2006

12:00-12:30	Registration
12:30-12:40	Welcome, Purpose of Workshop *Bob Fisher, Virginia Sea Grant, VIMS*
12:40-1:10	A History of Cownose Ray Interactions in Virginia *Mike Oesterling, Virginia Sea Grant, VIMS*
1:10-1:40	Impact of Rays on Bay Scallops *Pete Peterson, UNC Institute of Marine Science*
1:40-2:10	North Carolina Ray Projects *Bob Hines, North Carolina Sea Grant*
2:10-2:30	Break
2:30-3:10	Virginia Ray Projects, Past and Present *Bob Fisher, Virginia Sea Grant, VIMS*
3:10-3:40	Ray Marketing Efforts in Virginia *Shirley Estes, Virginia Marine Products Board*
3:40-4:10	Ray Domestic Market Efforts *Chef John Maxwell, CEC, AAC, Culinary Instructor*
4:10-5:00	Social on Site (Ray Tasting)
5:00	Adjourn

June 2, 2006

8:30-8:45	Summary of Previous Days Discussions, *Bob Fisher*
8:45-9:15	Cownose Ray Life History *Dean Grubbs, VIMS*
9:15-9:45	Addressing Cownose Ray Predation in the North Carolina Bay Scallop Fishery Management Plan *Trish Murphy, North Carolina Division of Marine Fisheries*
9:45-10:10	Ray Interactions in Maryland *Don Webster, Univesrity of Maryland*
10:10-10:25	Break
10:25-10:45	Cownose Ray Threat to Aquaculture Development and Shellfish Restoration *Jim Wesson, Virginia Marine Resource Commission*
10:45-11:00	Alternative Oyster Reef Structures to Reduce Ray Predation Upon Oysters *Rom Lipcius, VIMS*
11:00-11:45	Panel: Commercial Shellfish Growers *Margaret Ransone (VA), Mike Peirson (VA), Steve Gordon (MD), Christopher Scales (NJ) (Moderator; Bob Fisher)*
11:45-12:45	Discussion: Development of a Ray Fishery? Research and Extension Needs? *Moderator; Bob Fisher*
12:45	Adjourn

A History of Cownose Ray Interactions in Virginia

Michael Oesterling
Fisheries/Aquaculture Specialist
Virginia Sea Grant Marine Advisory Program
Virginia Institute of Marine Science
PO Box 1346
Gloucester Point, VA 23062

Since the arrival of Captain John Smith and the Jamestown settlers in 1607, encounters with cownose rays (*Rhinoptera bonasus*) in Virginia have been documented. Captain Smith himself had a painful encounter near the mouth of the Rappahannock River, memorialized by the naming of the site Stingray Point.

For the next 350 years, cownose rays within Chesapeake Bay were periodically mentioned in various publications. However, it was not until the decade of the 1970s that scientific attention began to be focused on them as a potentially destructive force within Chesapeake Bay. In 1975, Orth highlighted the damage that schools of cownose rays inflicted upon submerged aquatic vegetation in the lower York River. Then, at the request of major Virginia oyster growers, VIMS scientists Merriner and Smith began a collaboration lasting several years investigating the impact of cownose rays on planted oyster grounds and evaluating the potential for a directed fishery for cownose rays to reduce their damage to shellfish stocks. The Merriner/Smith studies highlighted several points: 1) the apparent increase in the abundance of cownose rays in the early 1970s may have resulted from the decline of commercial haul-seine and pound-net fisheries; 2) Tropical Storm Agnes of 1972 depleted the cownose ray's preferred prey item (*Mya arenaria*, soft shell clams), causing them to redirect their predation onto oysters; 3) mechanical protection of extensive planting grounds would not be practical; and, 4) reducing the numbers of cownose rays would decrease the predation on commercially important shellfish. Simultaneously with these studies, public attention was focused on the cownose ray as a potential recreational angling species, with publications on catch, cleaning, and preparing the cownose ray being developed.

Also concurrent with the Merriner/Smith research, other VIMS scientists at the Wachapreague Laboratory were developing the methodology that would ultimately make Virginia the leader in the aquaculture production of the hard clam (*Mercenaria mercenaria*). In an unpublished 1979 manuscript, Castagna and Kraeuter documented almost total destruction of unprotected planted clams due to cownose rays and stated that without some protection from cownose rays, successful field culture would not be possible.

The woes of the oyster-planting industry continued into the 1980s, when in 1984 planters from the Rappahannock River once again approached VIMS to revisit the cownose ray situation. This continued to the late 1980s and early 1990s, when a better coordinated effort was begun to develop the exploitation of the cownose ray as a means to reduce their numbers. Speaking of numbers, in 1988, VIMS graduate student R. Blaylock photographed and documented a single school of rays within Chesapeake Bay covering over 1,100 acres and containing in excess of 5,000,000 individual rays!

All the efforts of the early 1990s served to develop baseline information that would be used in later projects. Since the late 1990s, efforts have been ongoing at VIMS leading, hopefully, to the full utilization of the cownose ray. Those efforts will be described by others.

Sea Grant
Virginia

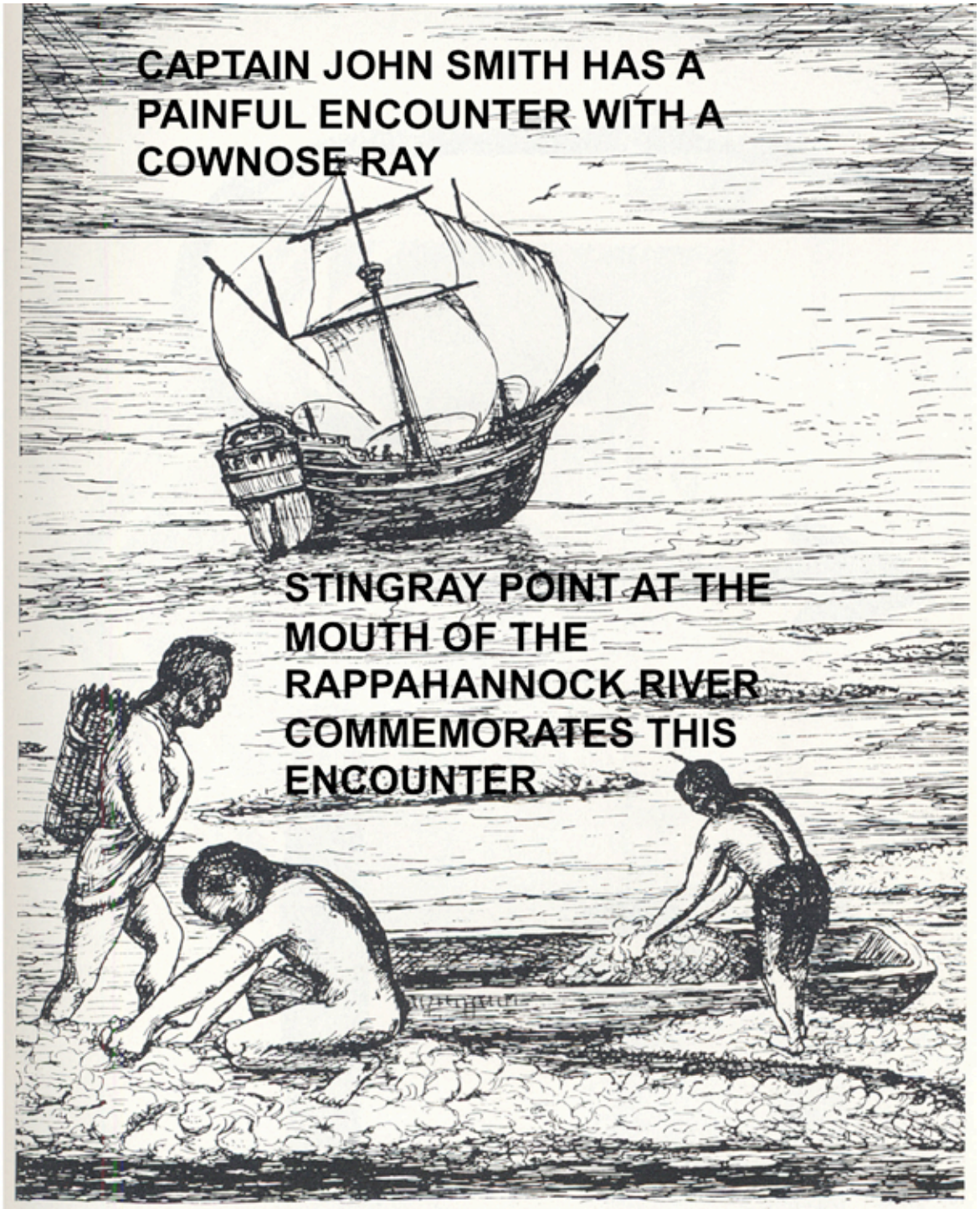
A HISTORY OF COWNOSE RAY INTERACTIONS IN VIRGINIA

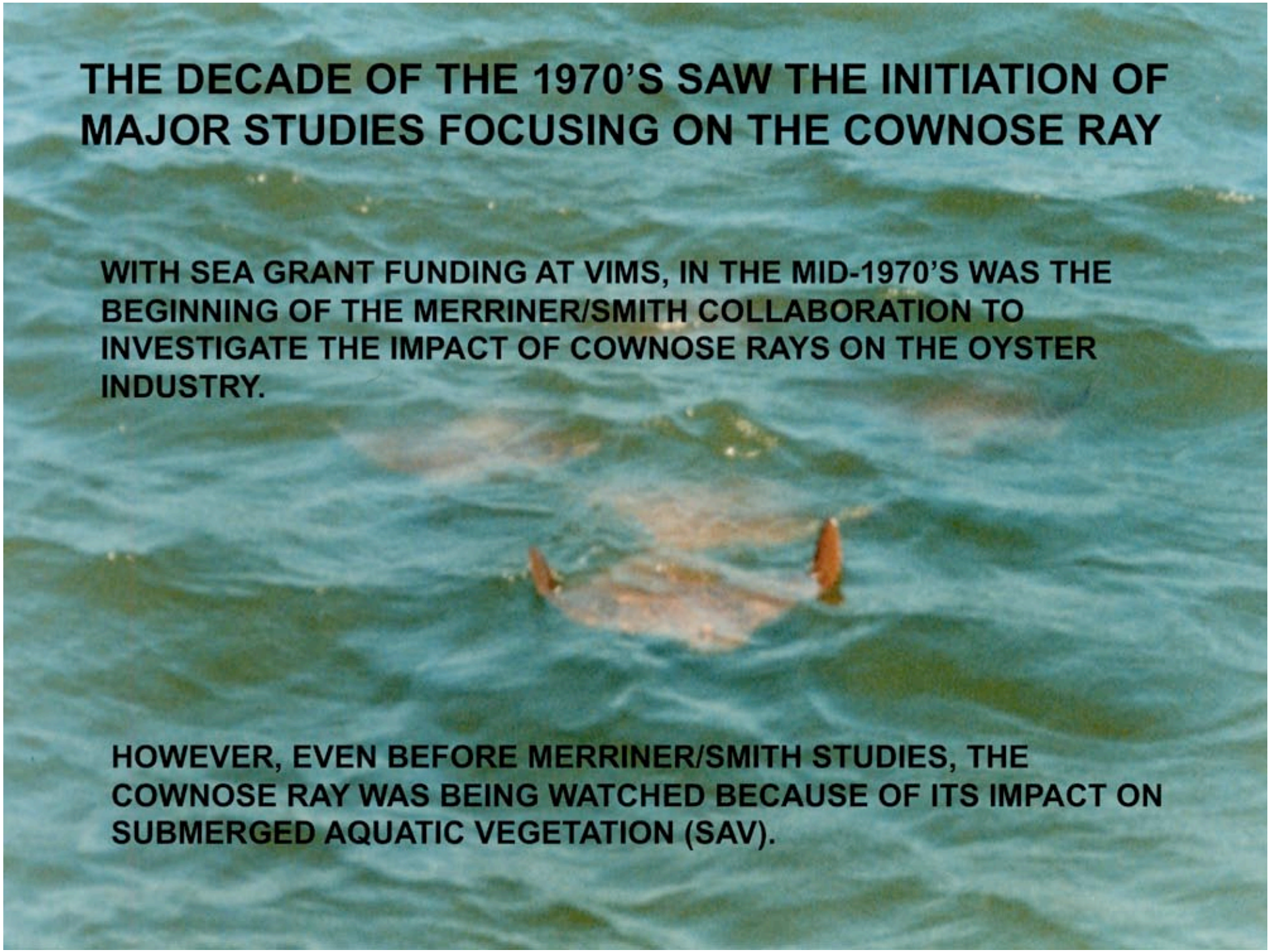
Michael J. Oesterling
Virginia Sea Grant
Virginia Institute of Marine Science

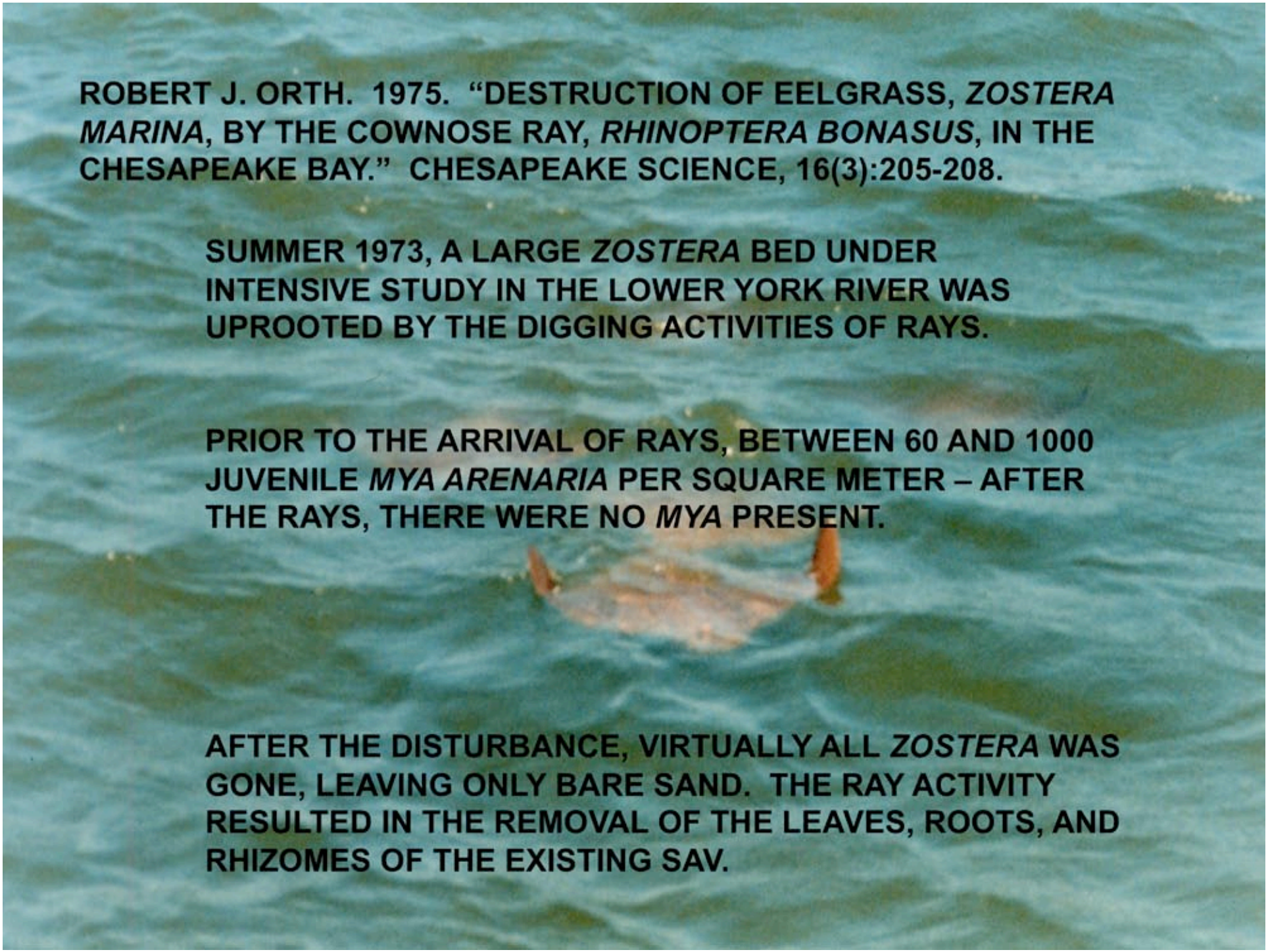
WILLIAM & MARY
VIMS
VIRGINIA INSTITUTE OF MARINE SCIENCE
SCHOOL OF MARINE SCIENCE

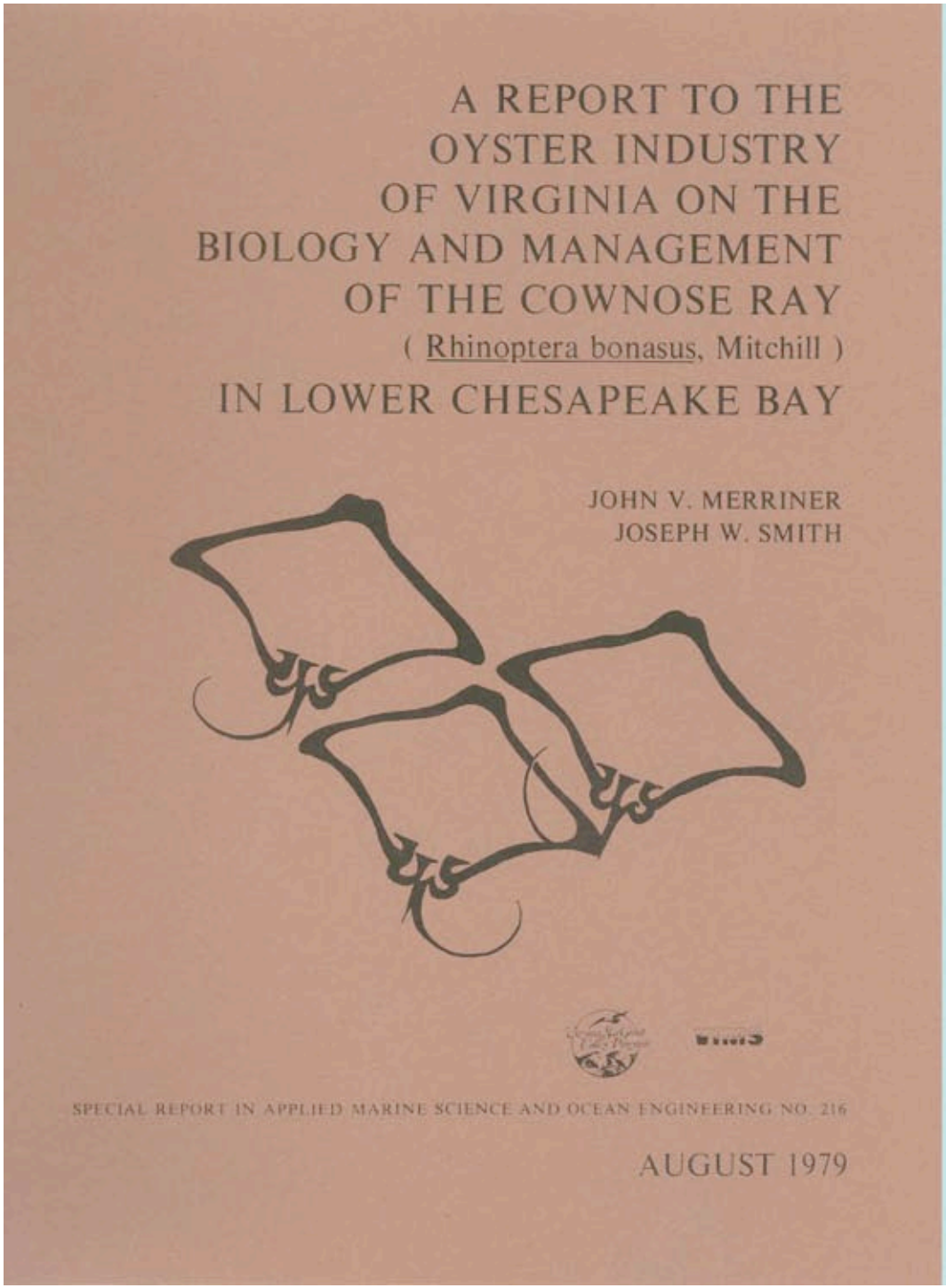
1608 – Chapter 5, "The Accidents that Happened in the Discovery of the Bay of Chisapeack"

"…being much of the fashion of a Thornback, but a long tayle like a ryding rodde, whereon the middest is a most poysoned sting, of two or three inches long, breaded like a saw on each side, which she strucke into the wrest of his arme neere an inche and a halfe: no blood nor wound was seene, but a little blew spot, but the torment was instantly so extreme, that in foure houres had so swollen his hand, arme, and shoulder, we all with much sorrow concluded his funerall, and prepared his grave in an Island by, as himselfe directed: yet it pleased God by a precious oyle Doctor Russell at the first applied to it when he sounded it with probe, (ere night) his tormenting paine was so well asswaged that he eate of the fish to his supper, which have no lesse joy and content to us then ease to himselfe."




THE DECADE OF THE 1970'S SAW THE INITIATION OF MAJOR STUDIES FOCUSING ON THE COWNOSE RAY
WITH SEA GRANT FUNDING AT VIMS, IN THE MID-1970'S WAS THE BEGINNING OF THE MERRINER/SMITH COLLABORATION TO INVESTIGATE THE IMPACT OF COWNOSE RAYS ON THE OYSTER INDUSTRY.
HOWEVER, EVEN BEFORE MERRINER/SMITH STUDIES, THE COWNOSE RAY WAS BEING WATCHED BECAUSE OF ITS IMPACT ON SUBMERGED AQUATIC VEGETATION (SAV).


ROBERT J. ORTH. 1975. "DESTRUCTION OF EELGRASS, *ZOSTERA MARINA*, BY THE COWNOSE RAY, *RHINOPTERA BONASUS*, IN THE CHESAPEAKE BAY." CHESAPEAKE SCIENCE, 16(3):205-208.
SUMMER 1973, A LARGE *ZOSTERA* BED UNDER INTENSIVE STUDY IN THE LOWER YORK RIVER WAS UPROOTED BY THE DIGGING ACTIVITIES OF RAYS.
PRIOR TO THE ARRIVAL OF RAYS, BETWEEN 60 AND 1000 JUVENILE *MYA ARENARIA* PER SQUARE METER – AFTER THE RAYS, THERE WERE NO *MYA* PRESENT.
AFTER THE DISTURBANCE, VIRTUALLY ALL *ZOSTERA* WAS GONE, LEAVING ONLY BARE SAND. THE RAY ACTIVITY RESULTED IN THE REMOVAL OF THE LEAVES, ROOTS, AND RHIZOMES OF THE EXISTING SAV.



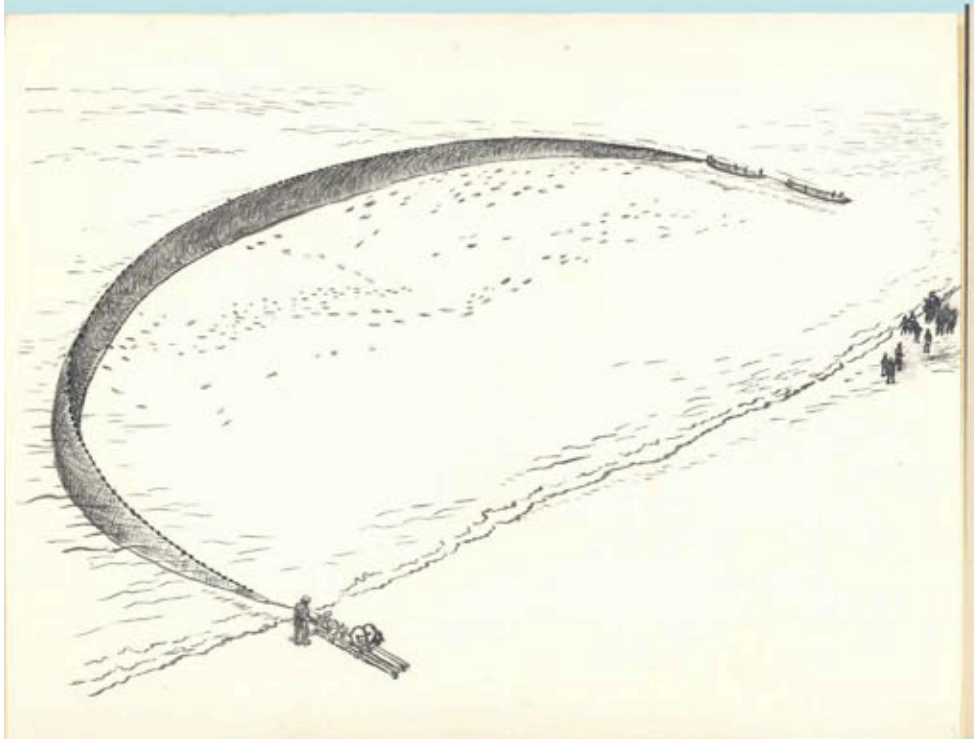
"IN SPRING 1975, EIGHT MAJOR VIRGINIA OYSTER GROWERS SOLICTED AID IN THE FORM OF CONTROL MEASURES TO REDUCE RAY PREDATION."

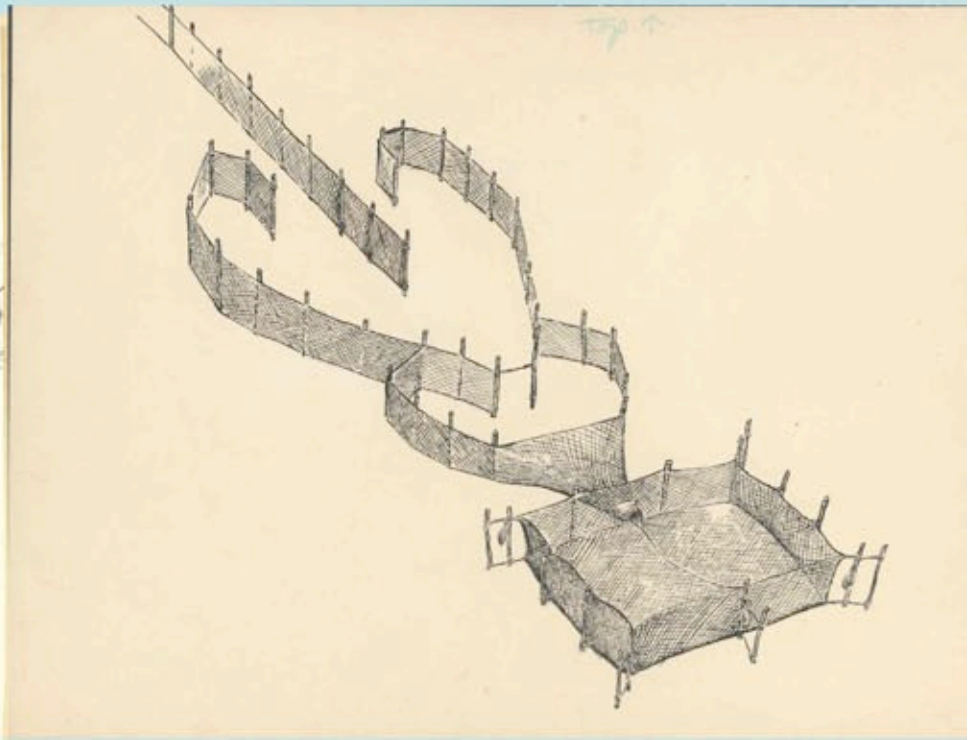
THIS REQUEST WAS DUE TO A PERCEIVED INCREASE IN RAY PREDATION BETWEEN 1972 AND 1973, ESPECIALLY IN THE RAPPAHANNOCK RIVER.

THUS BEGAN A 3-YEAR STUDY FROM 1975 TO 1977, FUNDED BY VIRGINIA SEA GRANT TO INVESTIGATE THE POTENTIAL "CONTROL" OF THE RAY POPULATION.

SIGNIFICANT OBSERVATIONS:

1. HYPOTHESIZED THAT THE RECENT APPARENT ABUNDANCE MAY BE DUE TO THE DECLINE IN THE NUMBERS OF COMMERCIAL HAUL SEINE AND POUND NET FISHERIES OVER THE PAST FIFTY YEARS.





COWNOSE RAYS IN A POUND NET IN THE RAPPAHANNOCK RIVER, MID-1980'S.

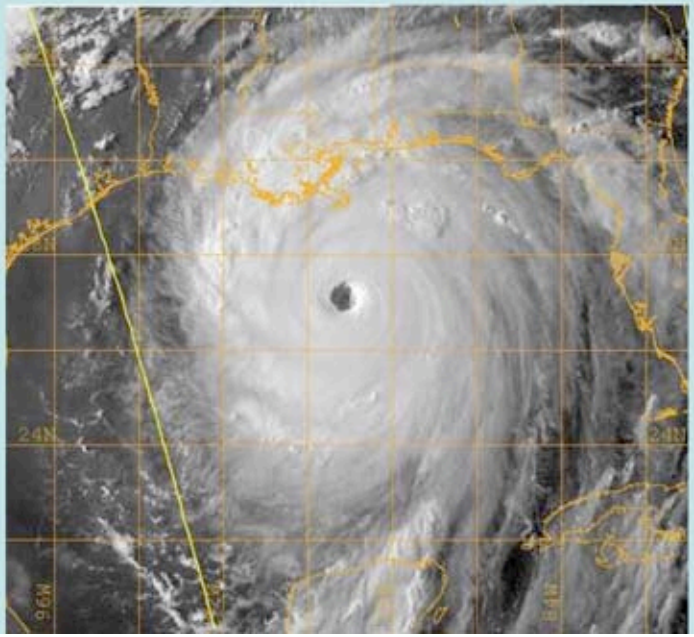
SMALL SCHOOL OF RAYS ABOUT TO ENCOUNTER THE HEDGING OF THE POUND NET AND BE DIRECTED INTO THE HEART TO BE TRAPPED.

SIGNIFICANT OBSERVATIONS:

1. HYPOTHESIZED THAT THE RECENT APPARENT ABUNDANCE MAY BE DUE TO THE DECLINE IN THE NUMBERS OF COMMERCIAL HAUL SEINE AND POUND NET FISHERIES OVER THE PAST FIFTY YEARS.

2. FOLLOWING THE PASSAGE OF TROPICAL STORM AGNES IN JUNE 1972, IT WAS ESTIMATED THAT 90% OF THE BAY'S *MYA* STOCKS PERISHED DUE TO THE COMBINED STRESS OF LOW SALINITIES AND HIGH WATER TEMPERATURES.

"THUS, DEPLETION OF THE RAY'S PREFERRED FOOD ITEM, *MYA*, MAY HAVE RESULTED IN INCREASED PREDATION ON AN ALREADY IMPACTED STOCK OF OYSTERS IN THE RAPPAHANNOCK RIVER."



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3. "IN CONCLUSION, THE WIDESPREAD APPLICATION OF ANY MECHANICAL DEVICE TO PROTECT CHESAPEAKE BAY OYSTER BEDS, SOME OF WHICH COVER SEVERAL THOUSAND ACRES AND ARE LOCATED IN UP TO 7.6 M (25 FT) OF WATER (HAVEN ET AL., 1978), WOULD BE IMPRACTICAL AND EXPENSIVE."

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4. "A REDUCTION OF COWNOSE RAY NUMBERS WOULD PROBABLY DECREASE PREDATION ON COMMERCIALLY IMPORTANT SHELLFISH. THUS, THE DEVELOPMENT OF A FISHERY FOR RAYS SEEMS HIGHLY DESIRABLE."

WHILE RECOMMENDING A FISHERY, THEY RECOGNIZED THE PROBLEMS WITH ELASMOBRANCH EXPLOITATION AND PROPOSED WAITING UNTIL AFTER THE BIRTHING PERIOD TO OPEN THE FISHERY – EXCEPT IN THE RAPPAHANNOCK RIVER, WHERE THERE WOULD BE NO CLOSED SEASON.

WHILE THEIR STUDIES WERE PROGRESSING, SMITH AND MERRINER INITIATED A PUBLIC INFORMATION PROGRAM TO HIGHLIGHT THE SITUATION REGARDING RAYS WITHIN THE BAY.

Marine Resource Advisory
A Sea Grant Advisory Service

ADVISORY NO. 14 SEPTEMBER 1977

RAYS IN THE CHESAPEAKE BAY

by Joseph W. Smith and J. V. Merriner, Ph.D.
Department of Ichtnyology

Pliny, the ancient Roman historian, describes a tree that withered from it.

Ulysses is said to have been slain by an arrow tipped with it.

Captain John Smith was its earliest recorded victim in the Chesapeake Bay.

What is this deadly thing, to be avoided at all cost by the wise and prudent? It's the sting of a ray, which is uncomfortable but far from deadly. About a dozen species of rays migrate to the Chesapeake Bay during warmer months.

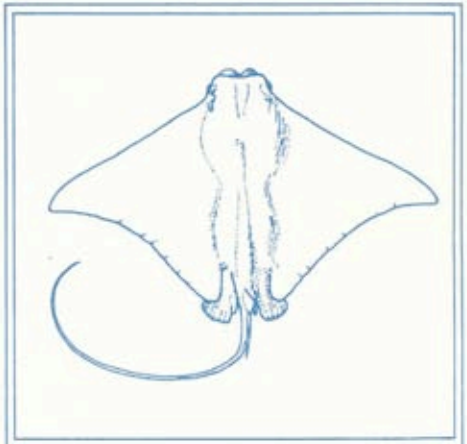
Stingray injuries frequently occur when a fisherman or beachcomber steps directly on a partially buried ray. The ray is pinned to the bottom and thus has the anchorage necessary to arch its tail and thrust the sting into an ankle or leg. A wader can reduce the chance of stepping squarely on a camouflaged ray and chase the ray from its hiding place by shuffling his feet along the bottom. A ray prefers a hastened retreat to undisturbed waters to an exhibition of aggressiveness towards humans.

When the sting strikes flesh, the pressure causes venom-producing cells to activate. Wounds are typically punctures and lacerations. The latter occurs when the sting is withdrawn and its serrated edges rip the surrounding tissue. Pieces of the stringray apparatus may remain in the wound as the sting is withdrawn.

Initial symptoms of stingray wounds are localized pain and swelling. The pain may spread rapidly, however. Numbness of the afflicted area, fainting, nausea, weakness, and muscle cramps are sometimes experienced.

RAY CHARACTERISTICS

Rays, along with sharks and skates, comprise a group of fish known as elasmobranchs. The skeleton of these fish is composed entirely of cartilage.



The cownose ray (Rhinoptera bonasus) *is one of the most abundant rays to enter the Bay. The species commonly occurs from May through October and is often seen in shallow water. Clams and oysters are its preferred food. An average adult measures 36 inches across and weighs 30 pounds.*

Rays may be thought of as sharks that are flattened top to bottom. The pectoral fins are longer, wider, and more fleshy in rays and serve as the primary means of locomotion, as opposed to the tail of sharks. The gill slits are positioned underneath rather than on the sides of the body as in sharks. The mouth is also positioned underneath.

Rays feed primarily on animals which live on or in the bottom muds and sands. Ray teeth are adapted to crush or grind food items. Their diet consists of worms, shrimps, bivalve mollusks,

Virginia Sea Grant College Program
VIMS
Marine Resource Advisory

NO. 18 VIRGINIA SEA GRANT MARINE ADVISORY SERVICES AT VIMS/WILLIAM & MARY Revised JULY 1985

Cleaning and Preparing the Cownose Ray

by John Merriner
and Joseph Smith

Available by the thousands in the Chesapeake Bay area in summer, the cownose ray offers sport and excellent eating to those willing to try it.

ANYTIME A COWNOSE ray is caught by a fisherman, commercial or sport, it usually ends up being mortally wounded and tossed back overboard. The sport fisherman vaguely suspects that "nothing that looks like that could be good for anything." The commercial operator knows the cownose damages clam and oyster beds and he doesn't have a ready market for it. So it gets clouted or pitchforked or stabbed, and back it goes, fodder for the crabs and eels (there is a market for them). And that's a pity, because this fish is good to eat, easy to clean and there's plenty of meat (enough to feed a crowd) on every ray. If you'd like to be enlightened, catch and clean a ray and prepare a seafood feast for your family and guests this summer.

Thousands of cownose rays move into Chesapeake Bay in early May, initially going northward and westward. They enter the major rivers later in the month. By mid-June, schools of 10-100 rays are often sighted in the middle reaches of the major rivers. Sandy shoal areas near the river mouths (stingray Point in Deltaville is an excellent example) and upriver sandy-muddy bars, rich beds of soft clams and natural or planted oyster beds are frequent haunts of the cownose ray. These fish move into shoal water with high tide, returning to deeper waters at low tide. The rays retreat to the ocean in later September, typically with decreasing water temperatures.

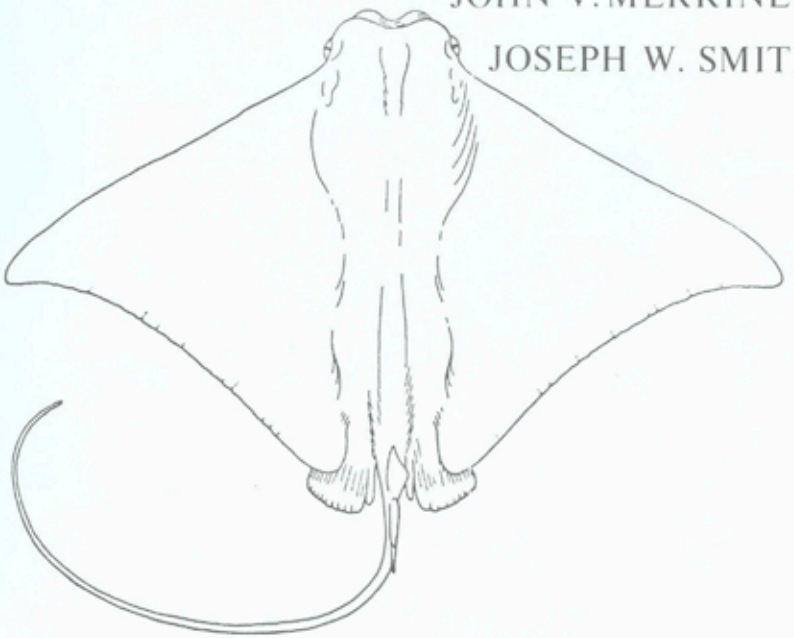
HOW TO CATCH THEM

Sight casting to a school of feeding rays is the most obvious means of capture by rod and reel fishermen. The only requirement is that your

MERRINER AND SMITH ALSO SUGGESTED THAT RECREATIONAL ANGLERS BE ENCOURAGED TO TARGET COWNOSE RAYS AS A MEANS TO REDUCE NUMBERS, EVEN PROPOSING COWNOSE RAY FISHING TOURNAMENTS.

GEAR FEASIBILITY STUDY FOR THE COWNOSE RAY, RHINOPTERA BONASUS

JOHN V. MERRINER
JOSEPH W. SMITH



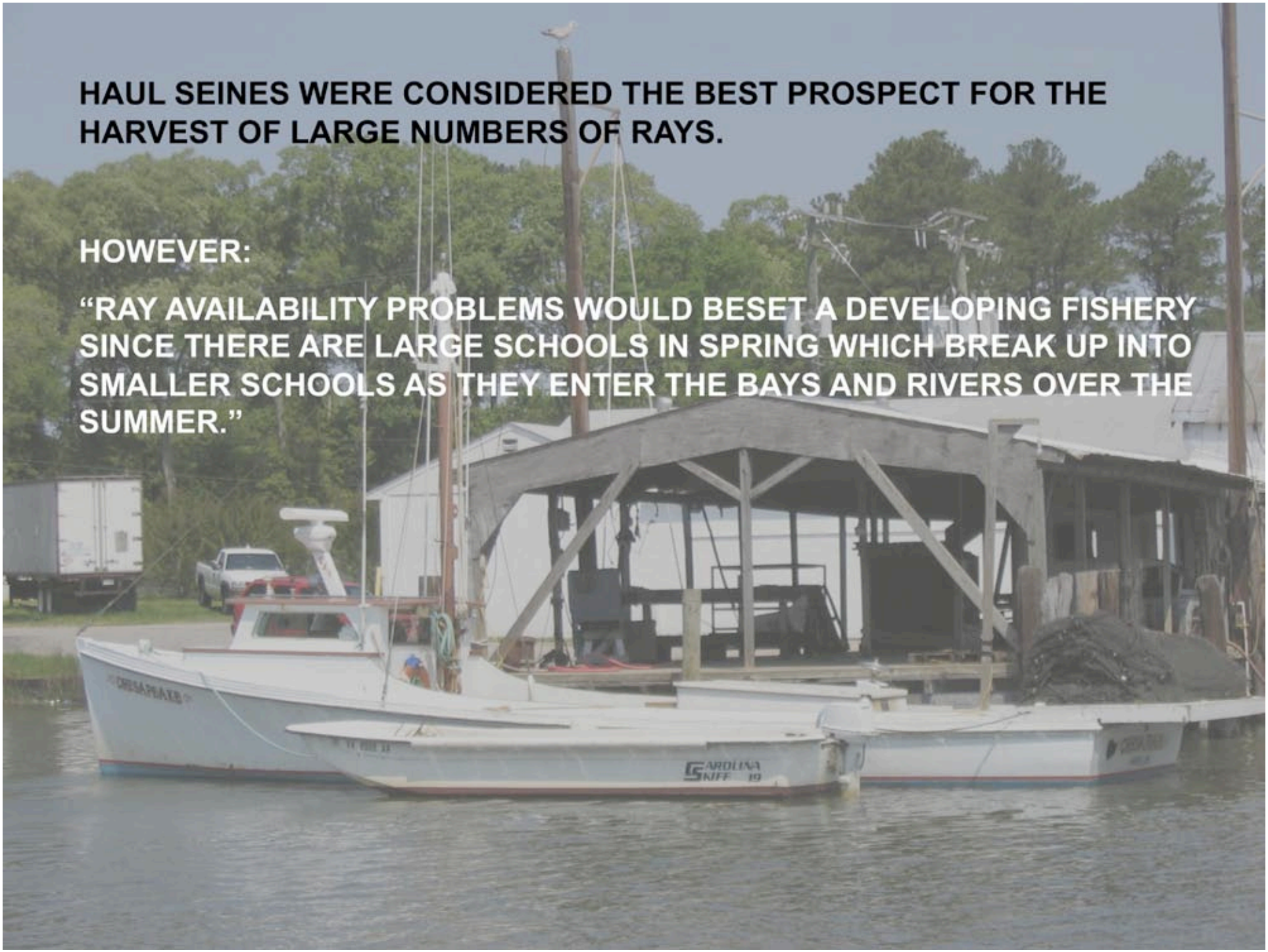
Special Report In Applied Marine Science and Ocean Engineering #227

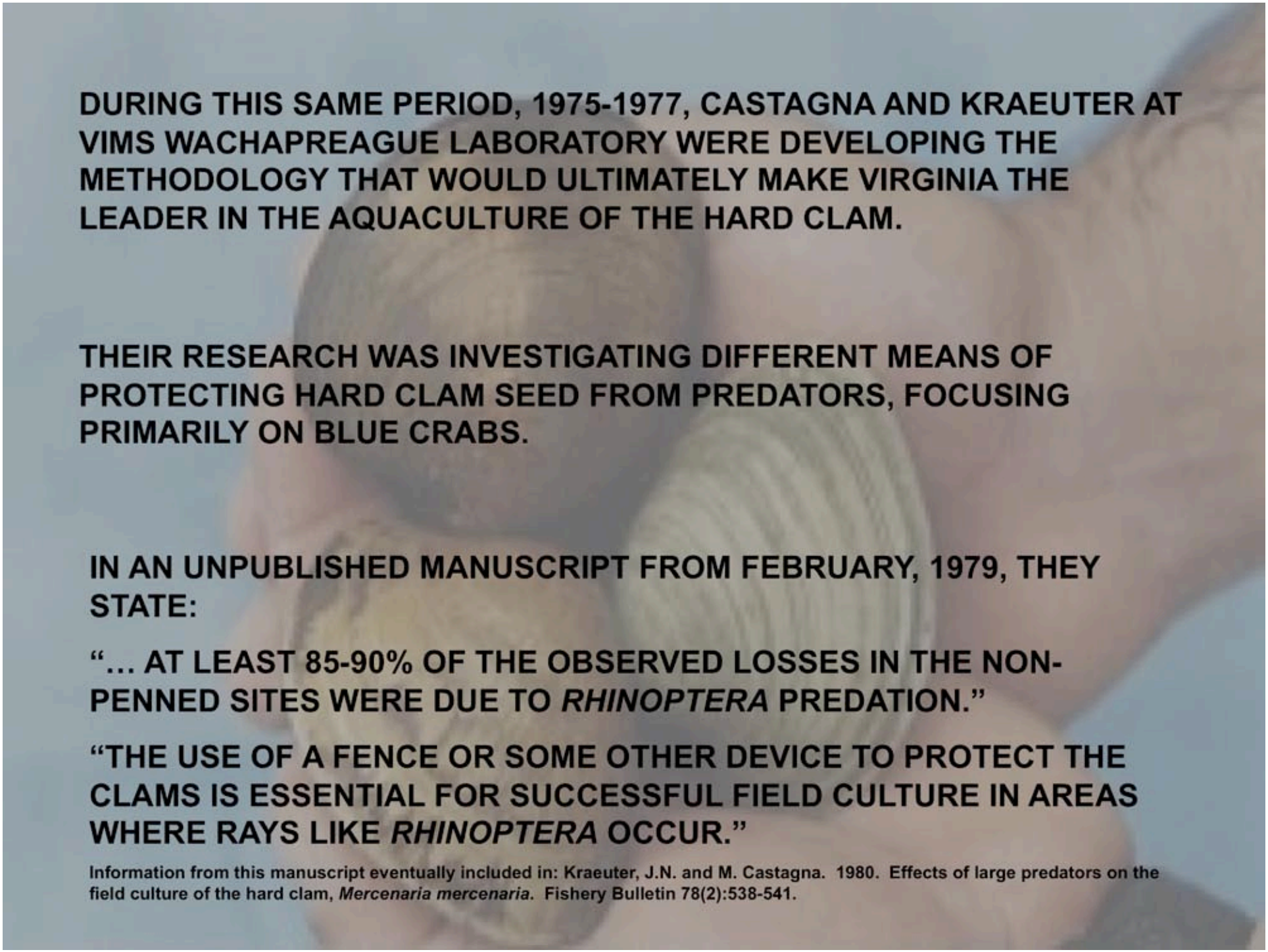
AUGUST 1979

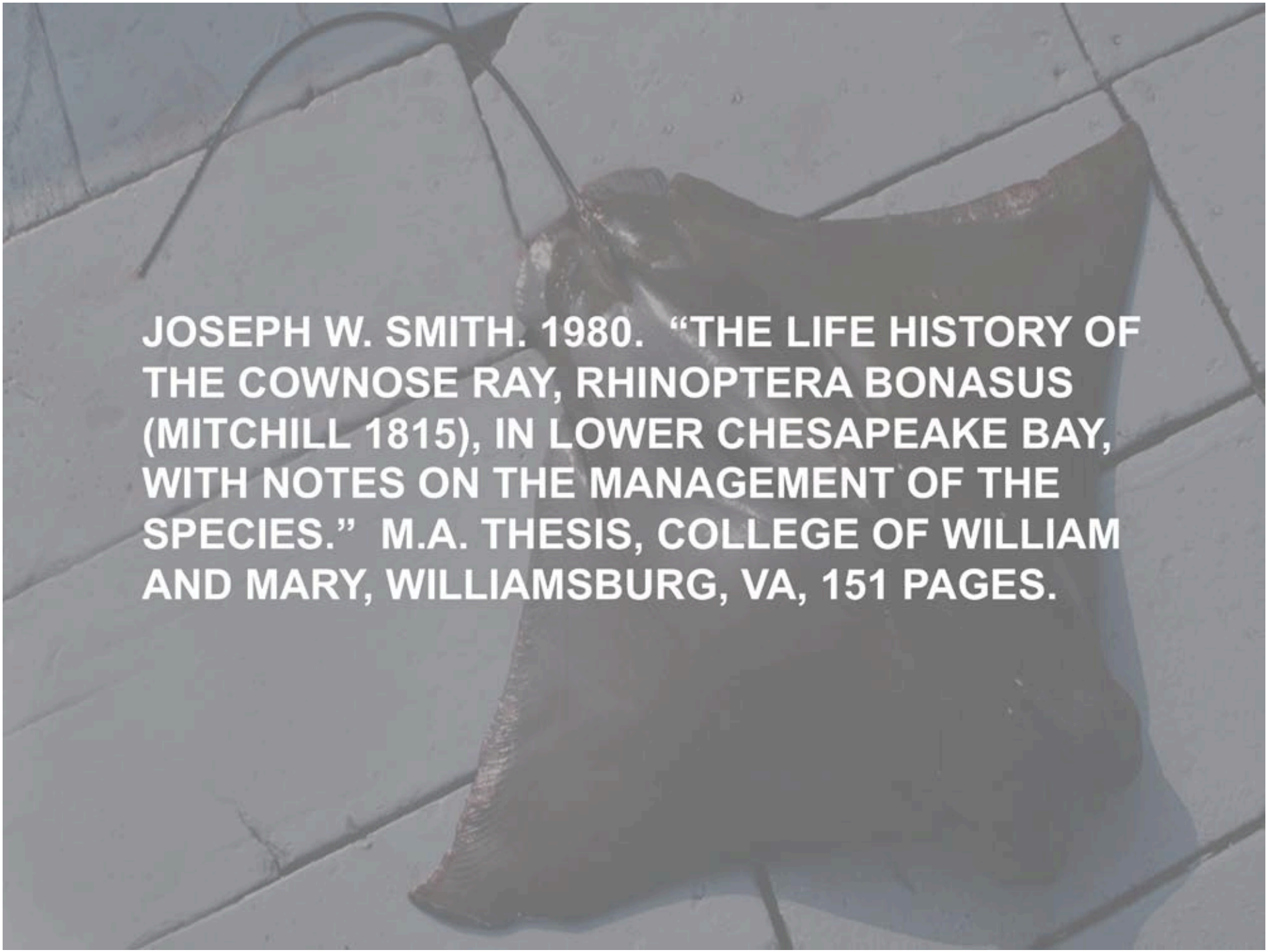
CONCURRENT WITH THEIR PREVIOUS STUDY, SMITH AND MERRINER ALSO CONSIDERED HARVESTING TECHNOLOGY TO ACCOMPANY THEIR PROPOSAL FOR A COMMERCIAL FISHERY.

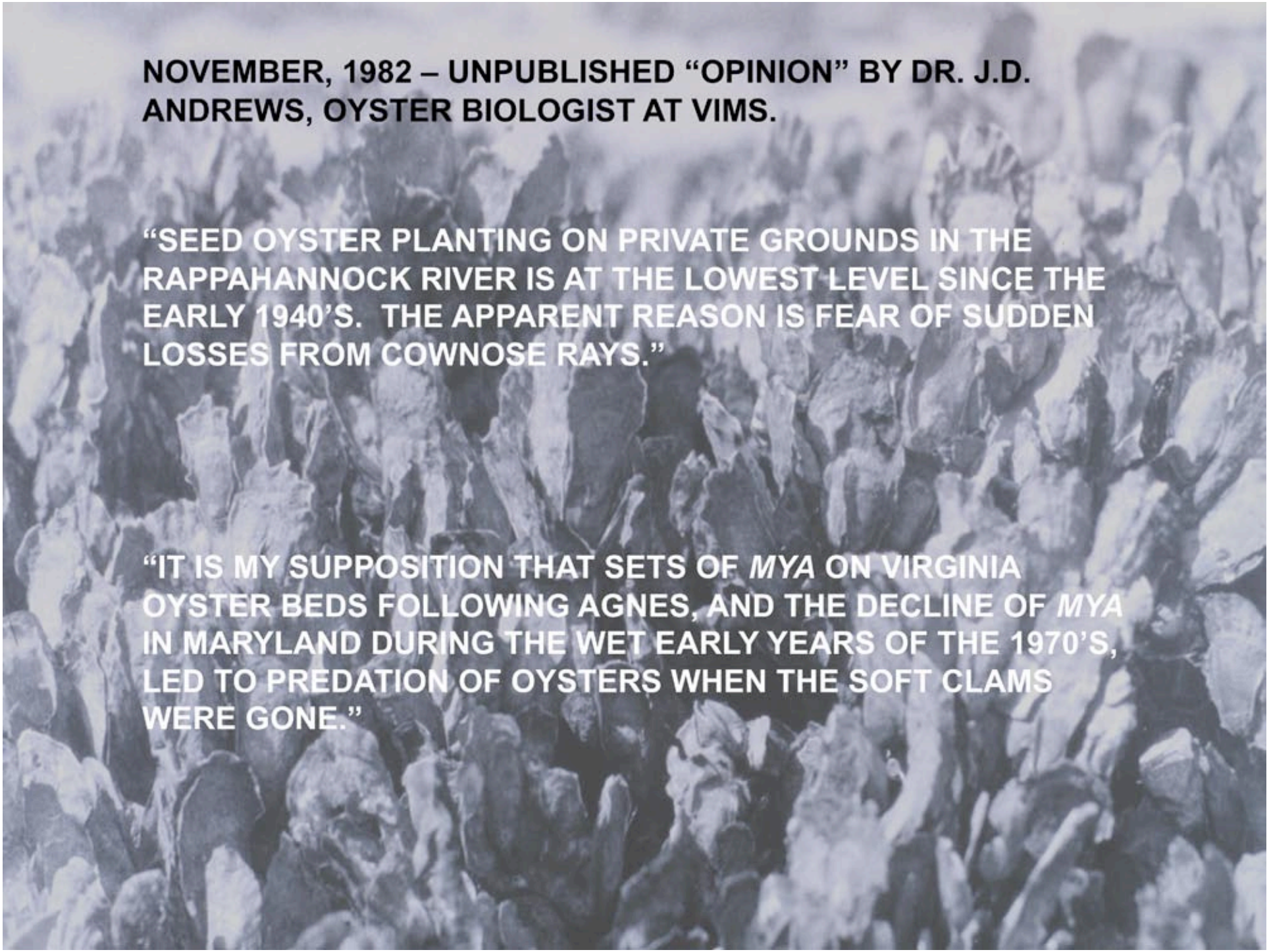
FUNDING PROVIDED BY THE GULF AND SOUTH ATLANTIC FISHERIES DEVELOPMENT FOUNDATION, INC.

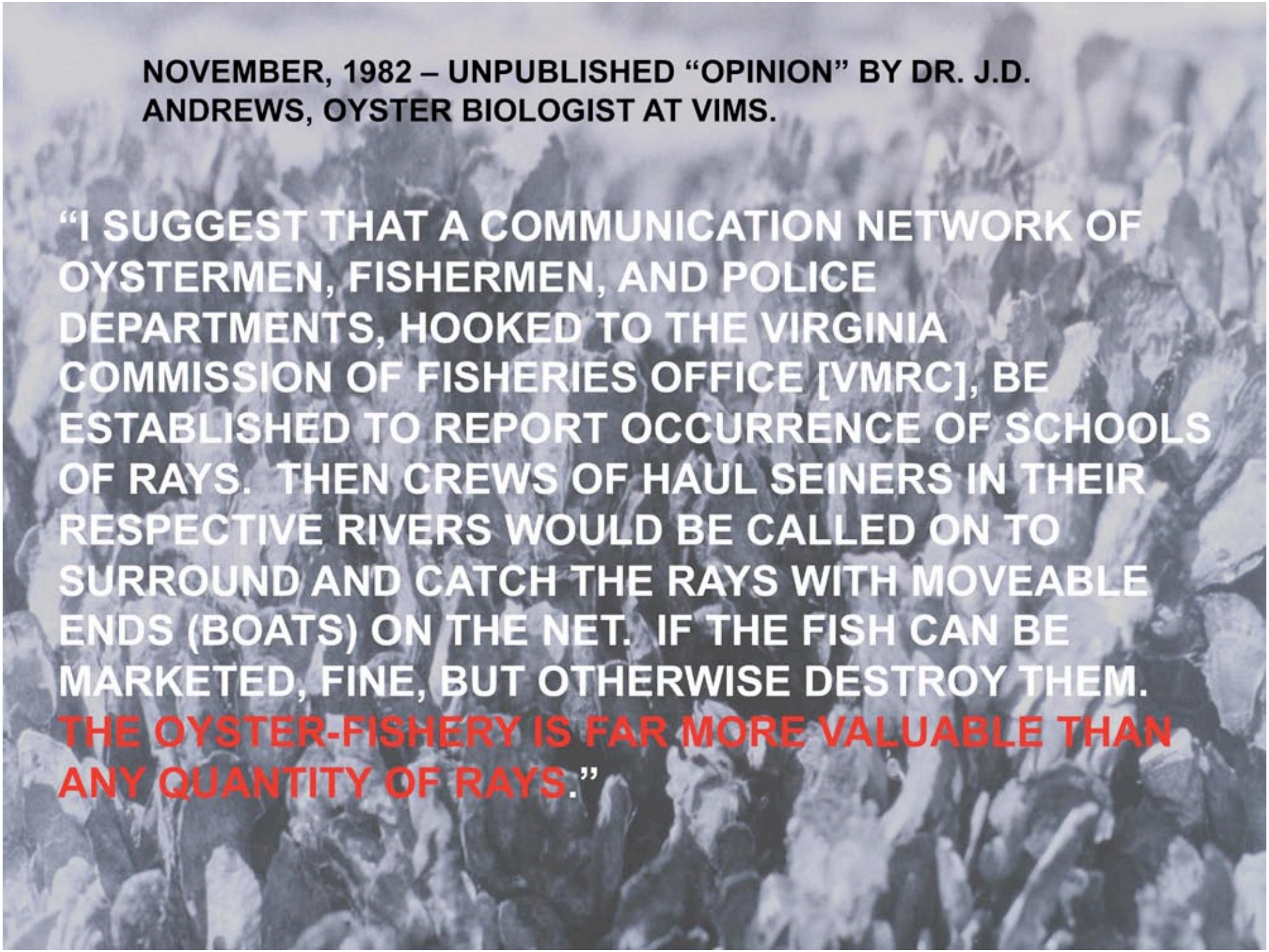
"RESEARCH CONDUCTED UNDER THE AUSPICES OF NOAA SEA GRANT PROGRAM LEAD TO THE RECOMMENDATION THAT REDUCTION OF THE RAY POPULATION THROUGH INCREASED FISHING MORTALITY WOULD BE THE BEST LONG-TERM METHOD TO DECREASE THE RAY DAMAGE ON COMMERCIALLY IMPORTANT SHELLFISH BEDS."

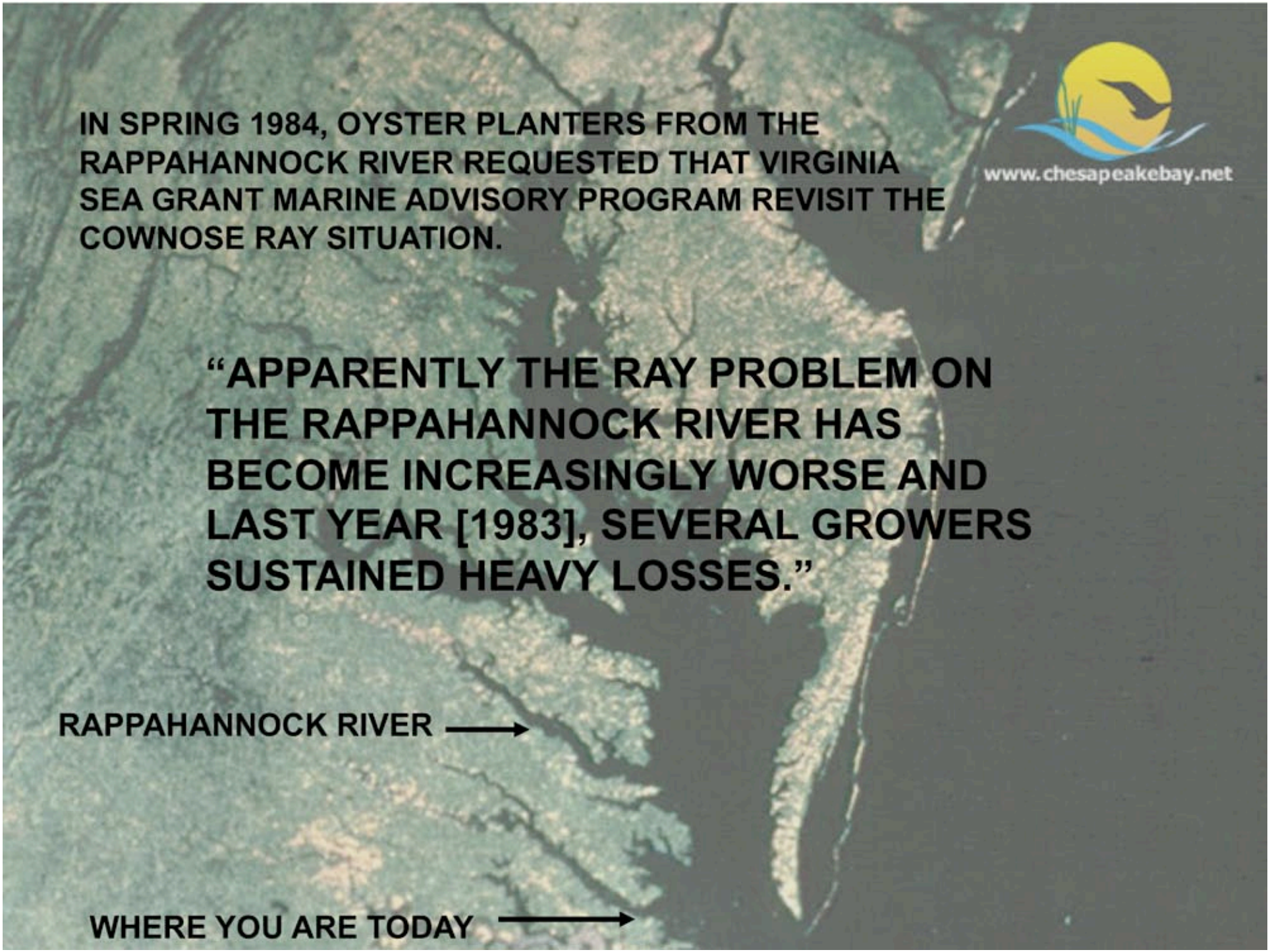

HAUL SEINES WERE CONSIDERED THE BEST PROSPECT FOR THE HARVEST OF LARGE NUMBERS OF RAYS.
HOWEVER:
"RAY AVAILABILITY PROBLEMS WOULD BESET A DEVELOPING FISHERY SINCE THERE ARE LARGE SCHOOLS IN SPRING WHICH BREAK UP INTO SMALLER SCHOOLS AS THEY ENTER THE BAYS AND RIVERS OVER THE SUMMER."


DURING THIS SAME PERIOD, 1975-1977, CASTAGNA AND KRAEUTER AT VIMS WACHAPREAGUE LABORATORY WERE DEVELOPING THE METHODOLOGY THAT WOULD ULTIMATELY MAKE VIRGINIA THE LEADER IN THE AQUACULTURE OF THE HARD CLAM.
THEIR RESEARCH WAS INVESTIGATING DIFFERENT MEANS OF PROTECTING HARD CLAM SEED FROM PREDATORS, FOCUSING PRIMARILY ON BLUE CRABS.
IN AN UNPUBLISHED MANUSCRIPT FROM FEBRUARY, 1979, THEY STATE:
"… AT LEAST 85-90% OF THE OBSERVED LOSSES IN THE NON-PENNED SITES WERE DUE TO *RHINOPTERA* PREDATION."
"THE USE OF A FENCE OR SOME OTHER DEVICE TO PROTECT THE CLAMS IS ESSENTIAL FOR SUCCESSFUL FIELD CULTURE IN AREAS WHERE RAYS LIKE *RHINOPTERA* OCCUR."
Information from this manuscript eventually included in: Kraeuter, J.N. and M. Castagna. 1980. Effects of large predators on the field culture of the hard clam, *Mercenaria mercenaria*. Fishery Bulletin 78(2):538-541.

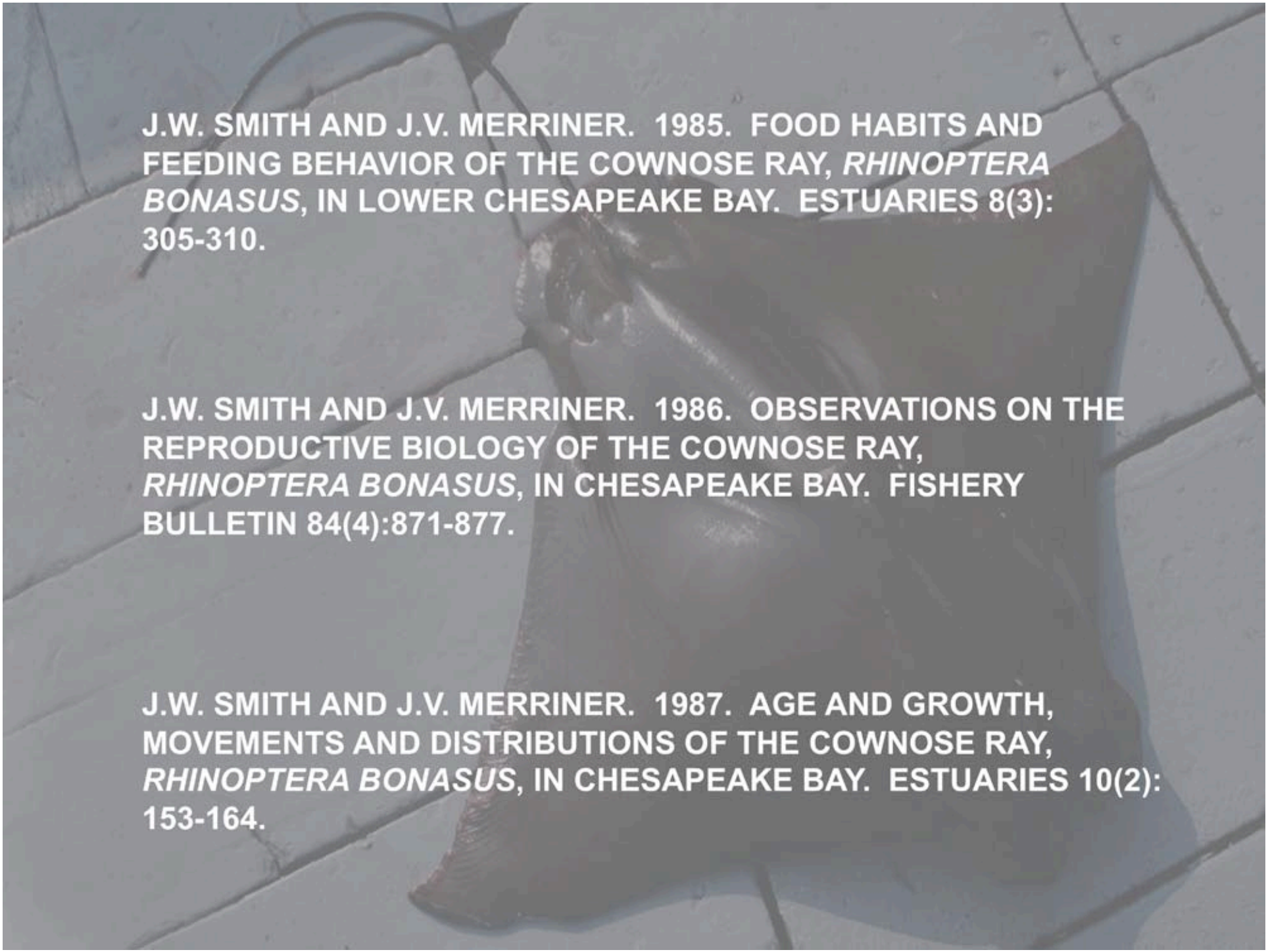

JOSEPH W. SMITH. 1980. "THE LIFE HISTORY OF THE COWNOSE RAY, RHINOPTERA BONASUS (MITCHILL 1815), IN LOWER CHESAPEAKE BAY, WITH NOTES ON THE MANAGEMENT OF THE SPECIES." M.A. THESIS, COLLEGE OF WILLIAM AND MARY, WILLIAMSBURG, VA, 151 PAGES.


NOVEMBER, 1982 – UNPUBLISHED "OPINION" BY DR. J.D. ANDREWS, OYSTER BIOLOGIST AT VIMS.
"SEED OYSTER PLANTING ON PRIVATE GROUNDS IN THE RAPPAHANNOCK RIVER IS AT THE LOWEST LEVEL SINCE THE EARLY 1940'S. THE APPARENT REASON IS FEAR OF SUDDEN LOSSES FROM COWNOSE RAYS."
"IT IS MY SUPPOSITION THAT SETS OF *MYA* ON VIRGINIA OYSTER BEDS FOLLOWING AGNES, AND THE DECLINE OF *MYA* IN MARYLAND DURING THE WET EARLY YEARS OF THE 1970'S, LED TO PREDATION OF OYSTERS WHEN THE SOFT CLAMS WERE GONE."


NOVEMBER, 1982 – UNPUBLISHED "OPINION" BY DR. J.D. ANDREWS, OYSTER BIOLOGIST AT VIMS.
"I SUGGEST THAT A COMMUNICATION NETWORK OF OYSTERMEN, FISHERMEN, AND POLICE DEPARTMENTS, HOOKED TO THE VIRGINIA COMMISSION OF FISHERIES OFFICE [VMRC], BE ESTABLISHED TO REPORT OCCURRENCE OF SCHOOLS OF RAYS. THEN CREWS OF HAUL SEINERS IN THEIR RESPECTIVE RIVERS WOULD BE CALLED ON TO SURROUND AND CATCH THE RAYS WITH MOVEABLE ENDS (BOATS) ON THE NET. IF THE FISH CAN BE MARKETED, FINE, BUT OTHERWISE DESTROY THEM. THE OYSTER-FISHERY IS FAR MORE VALUABLE THAN ANY QUANTITY OF RAYS."


IN SPRING 1984, OYSTER PLANTERS FROM THE RAPPAHANNOCK RIVER REQUESTED THAT VIRGINIA SEA GRANT MARINE ADVISORY PROGRAM REVISIT THE COWNOSE RAY SITUATION.
www.chesapeakebay.net
"APPARENTLY THE RAY PROBLEM ON THE RAPPAHANNOCK RIVER HAS BECOME INCREASINGLY WORSE AND LAST YEAR [1983], SEVERAL GROWERS SUSTAINED HEAVY LOSSES."
RAPPAHANNOCK RIVER
WHERE YOU ARE TODAY


MERRINER/SMITH MATERIALS REVIEWED AND OPTIONS DISCUSSED.
www.chesapeakebay.net
DR. STEVE OTWELL BROUGHT TO MEETING AT SEA GRANT EXPENSE TO DISCUSS HIS EFFORTS IN NORTH CAROLINA.
AN INDUSTRY COMMITTEE WAS TO BE FORMED IN ORDER TO DEVELOP A MORE ORGANIZED APPROACH TO THE COWNOSE RAY SITUATION.
UNFORTUNATELY, THIS COMMITTEE DID NOT MATERIALIZE IMMEDIATELY.



J.W. SMITH AND J.V. MERRINER. 1985. FOOD HABITS AND FEEDING BEHAVIOR OF THE COWNOSE RAY, *RHINOPTERA BONASUS*, IN LOWER CHESAPEAKE BAY. ESTUARIES 8(3): 305-310.

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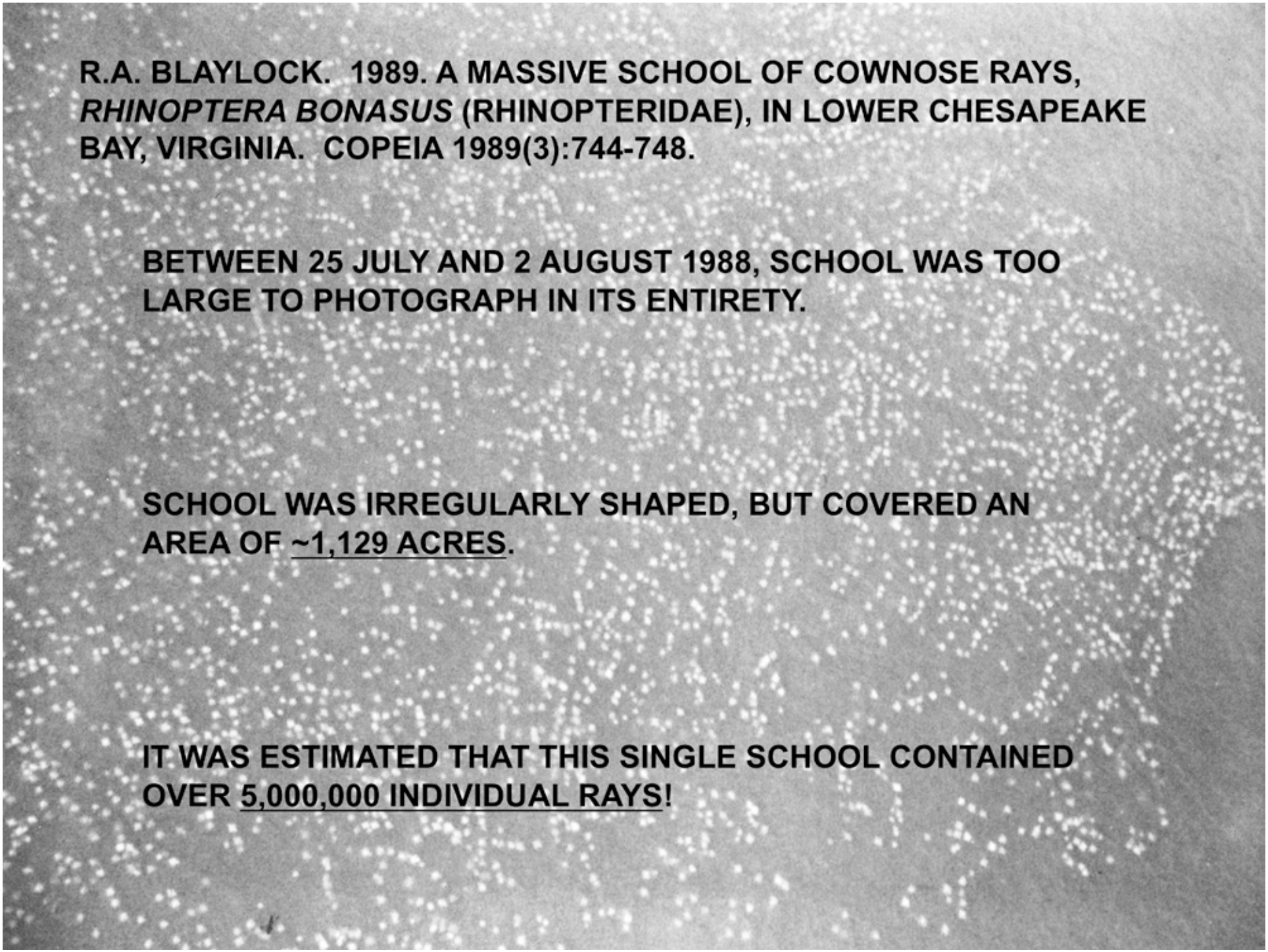
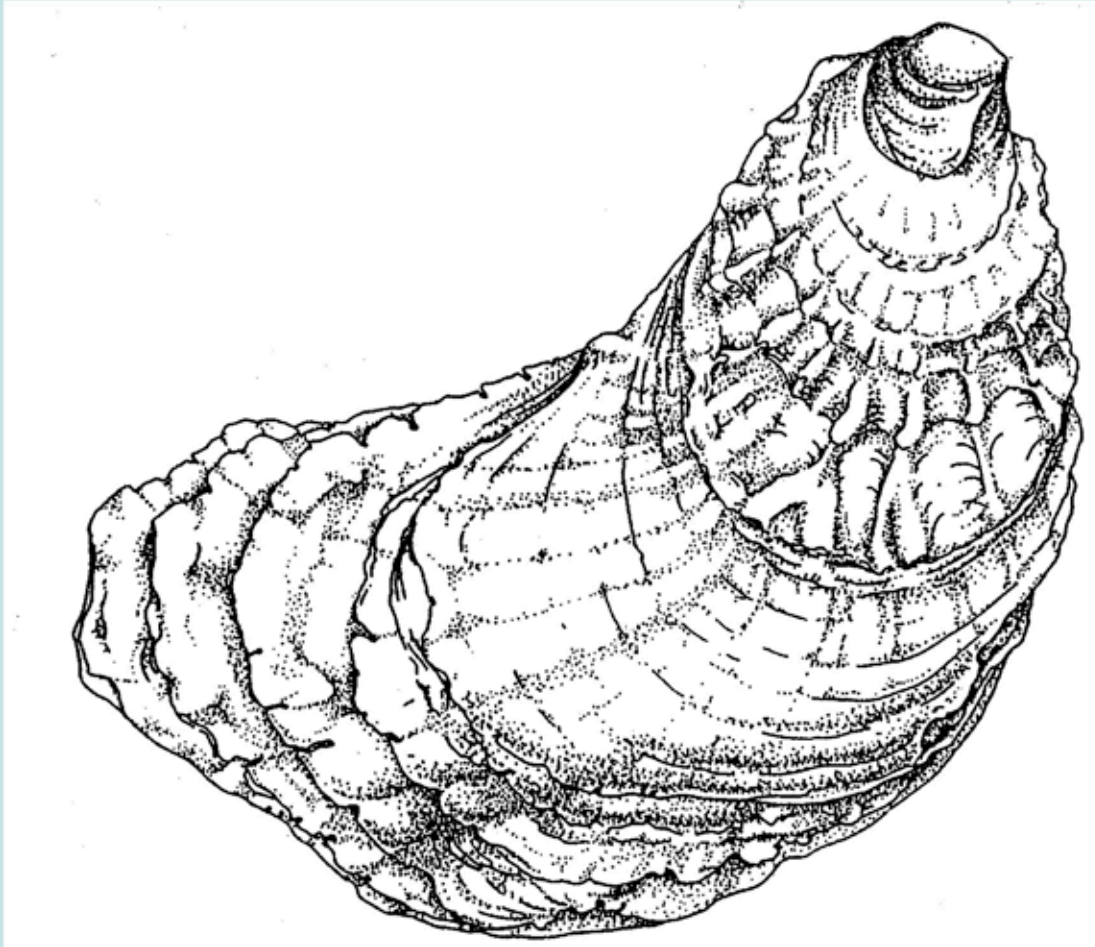
J.W. SMITH AND J.V. MERRINER. 1987. AGE AND GROWTH, MOVEMENTS AND DISTRIBUTIONS OF THE COWNOSE RAY, *RHINOPTERA BONASUS*, IN CHESAPEAKE BAY. ESTUARIES 10(2): 153-164.


R.A. BLAYLOCK. 1989. A MASSIVE SCHOOL OF COWNOSE RAYS, *RHINOPTERA BONASUS* (RHINOPTERIDAE), IN LOWER CHESAPEAKE BAY, VIRGINIA. COPEIA 1989(3):744-748.
BETWEEN 25 JULY AND 2 AUGUST 1988, SCHOOL WAS TOO LARGE TO PHOTOGRAPH IN ITS ENTIRETY.
SCHOOL WAS IRREGULARLY SHAPED, BUT COVERED AN AREA OF ~1,129 ACRES.
IT WAS ESTIMATED THAT THIS SINGLE SCHOOL CONTAINED OVER 5,000,000 INDIVIDUAL RAYS!

IN THE FALL OF 1989, AT THE URGINGS OF THE OYSTER INDUSTRY, CONGRESSMAN HERBERT BATEMAN REQUESTS THAT VIMS SEA GRANT MARINE ADVISORY PROGRAM RE-FOCUS ATTENTION ON THE COWNOSE RAY SITUATION.

THUS BEGAN A MORE "COORDINATED" EFFORT TO ADDRESS THE COWNOSE RAY SITUATION.



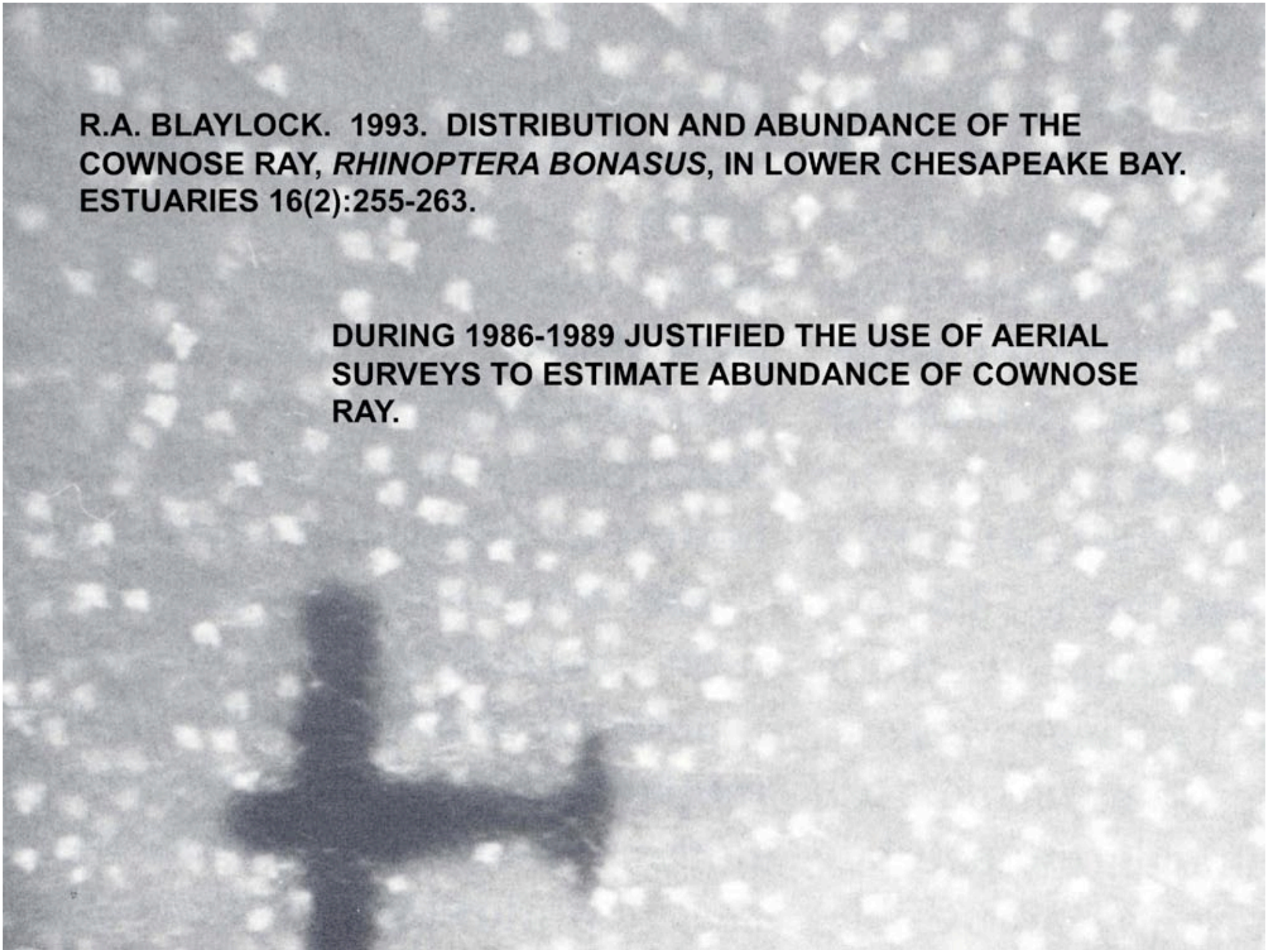
DECEMBER 14, 1989 – ORGANIZATIONAL MEETING OF THE "COWNOSE RAY WORKING GROUP," WITH DR. BILL DUPAUL, VIMS SEA GRANT MARINE ADVISORY PROGRAM SERVING AS OVERALL COORDINATOR.

FORMATION OF DIFFERENT TOPIC GROUPS:

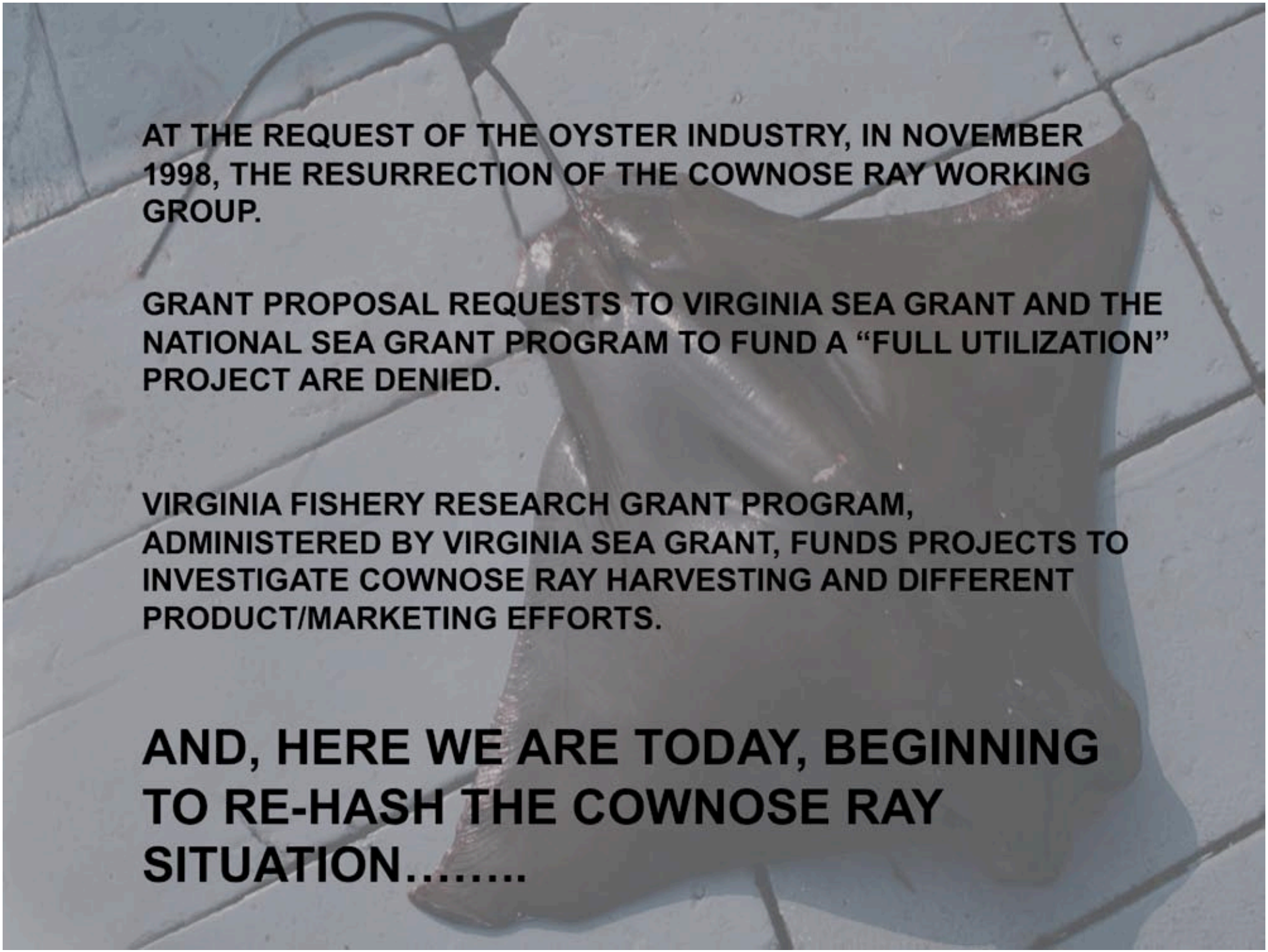
- **BIOLOGICAL ASSESSMENT**
- **HARVESTING**
- **PROCESSING/PRODUCT DEVELOPMENT**
- **WASTE DISPOSAL/RECOVERY**
- **MARKETING**
- **FUNDING**

DURING 1990-1991 A HUGE AMOUNT OF EFFORT, REPORTS GENERATED, AND MANY MEETINGS HELD FOR INFORMATION EXCHANGE.

ALL THIS WORK SERVED TO DEVELOP BASELINE INFORMATION THAT WOULD BE USED IN LATER PROJECTS.


R.A. BLAYLOCK. 1993. DISTRIBUTION AND ABUNDANCE OF THE COWNOSE RAY, *RHINOPTERA BONASUS*, IN LOWER CHESAPEAKE BAY. ESTUARIES 16(2):255-263.
DURING 1986-1989 JUSTIFIED THE USE OF AERIAL SURVEYS TO ESTIMATE ABUNDANCE OF COWNOSE RAY.


G.M. SILBERHORN, S. DEWING, AND P.A. MASON. 1996. PRODUCTION OF REPRODUCTIVE SHOOTS, VEGETATIVE SHOOTS, AND SEEDS IN POPULATIONS OF *RUPPIA MARITIMA* L. FROM THE CHESAPEAKE BAY, VIRGINIA. WETLANDS 16(2):232-239.
COWNOSE RAY ACTIVITY IN THE CORROTOMAN RIVER (TRIBUTARY OF THE RAPPAHANNOCK RIVER) LOWERED THE MEAN REPRODUCTIVE SHOOT PRODUCTION IN 1989.


AT THE REQUEST OF THE OYSTER INDUSTRY, IN NOVEMBER 1998, THE RESURRECTION OF THE COWNOSE RAY WORKING GROUP.
GRANT PROPOSAL REQUESTS TO VIRGINIA SEA GRANT AND THE NATIONAL SEA GRANT PROGRAM TO FUND A "FULL UTILIZATION" PROJECT ARE DENIED.
VIRGINIA FISHERY RESEARCH GRANT PROGRAM, ADMINISTERED BY VIRGINIA SEA GRANT, FUNDS PROJECTS TO INVESTIGATE COWNOSE RAY HARVESTING AND DIFFERENT PRODUCT/MARKETING EFFORTS.
AND, HERE WE ARE TODAY, BEGINNING TO RE-HASH THE COWNOSE RAY SITUATION……..


HOPEFULLY, THE BEGINNING OF A BRAND NEW DAY IN THE REALM OF COWNOSE RAY RESEARCH.

Conservation of Trophic Cascades in Marine Ecosystems: From Monsters to Morsels

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UNC-CH Institute of Marine Sciences
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Morehead City, NC 28557

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Killam Chair of Ocean Studies
Dalhousie University
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David H. Smith Conservation Research Fellow
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University of California, San Diego
9500 Gilman Drive
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Travis D. Shepherd
Department of Biological Sciences
Dalhousie University
1355 Oxford Street
Halifax, NS, Canada B3H 4J1

Over the past 30 years, cownose rays have increased along the Atlantic coast by approximately 6% annually. This increase in abundance has coincided with a range expansion, with summertime ray distribution now extending north of Delaware Bay to at least Long Island. Quantitative evaluation in both 1983 and 1984 of whether cownose rays substantially reduced bay scallop abundances during fall migration in prime scallop grounds of North Carolina sounds revealed little evidence of ray predation controls of adult bay scallop abundances (Peterson et al. 1989). In contrast, identical quantitative assessments, confirmed by implementation of experimental ray-exclusion stockades, revealed that from 1996 to 2003 cownose ray predation during fall migration has increased to the degree that bay scallops in all scallop beds of the state are now depleted to levels below one or two per m^2 by October each year (Peterson et al. 2001, Myers et al. 2006). Ray predation was sufficient by 2004 to cause an ongoing functional extinction of the century-old bay scallop fishery in North Carolina. The best explanation for the ascendancy of cownose rays and the consequent crash of their bay scallop prey is the operation of a powerful trophic cascade initiated by overfishing of the great sharks along the Atlantic coast. A coast-wide meta-analysis of up to five independent data surveys, plus analysis of the single best long-term time series on great sharks, taken since 1972 by UNC-IMS off Cape Lookout, demonstrates dramatic declines over the past 30 years in both abundance and length of all great sharks, including the bull shark and hammerheads, per-

haps the only natural effective predators on cownose rays (Myers et al. 2006). All the elasmobranch meso-predators, smaller sharks and rays, have increased dramatically over this same period of time. In addition to the bay scallop, other bivalve mollusks like soft-shell clams, hard clams, and oysters, all prey of rays and small sharks, have generally suffered dramatic declines during this same 30 years, probably accentuated by increased cownose ray predation. This study provides the first documented example of a trophic cascade beginning with the apex pelagic predators of the sea, the great sharks, and terminating after multiple links with the functional extinction of a fishery (bay scallops) and likely suppression of others. Because the densities to which bay scallops are now reduced in North Carolina during fall passage of cownose rays prior to scallop spawning are below what seems required to establish a fishable cohort of new scallop recruits (Peterson and Summerson 1992, Peterson et al. 1996), bay scallops now suffer jointly from direct predation by rays and also consequent Allee effects of density limitation on spawning and fertilization success. Now that more readily targeted epibiotic bay scallops are depleted by migrating cownose rays, it is reasonable to expect future dramatic expansion of their foraging for infaunal bivalves in seagrass beds and consequent SAV destruction (Orth 1975). Thus, like the classic consequences of overfishing sea otters on the West Coast, the overfishing of coastal pelagic sharks on the East Coast carries huge risks of ecosystem transformation and degradation, with negative effects of many fisheries dependent on SAV habitat. Evidence of similar ray explosions and bivalve shellfish crashes in Japan indicate that this trophic cascade from great sharks to meso-predators to bivalves is a widespread feature of ocean ecosystem organization, critical to ecosystem-based mismanagement of marine fisheries (Yamaguchi et al. 2005).

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Orth RJ (1975). Destruction of eelgrass, Zostera marina, by the cownose ray, Rhinoptera bonasus, in the Chesapeake Bay. Ches Sci 16:205-208.

Peterson CH, Summerson HC (1992). Basin-scale coherence of population dynamics on an exploited marine invertebrate, the bay scallop: implications of recruitment limitation. Mar Ecol Prog Ser 90:257-272

Peterson CH, Summerson HC, Fegley, SR, Prescott RC (1989). Timing, intensity and sources of autumn mortality of adult bay scallops Argopecten irrandians concentricus Say. J Exp Mar Ecol Biol 127:121-140.

Peterson CH, Summerson HC, Luettich RA Jr (1996). Response of bay scallops to spawner transplants: a test of recruitment limitation. Mar Ecol Prog Ser 132:93-107.

Peterson CH, Fodrie FJ, Summerson HC, Powers SP (2001) Site-specific and density-dependent extinction of prey by schooling rays: generation of a population sink in top-quality habitat for bay scallops. Oecologia 129:349-356.

Yamaguchi A, Kawahara I, Ito S (2005). Occurrence, growth and food of longheaded eagle ray, Aetobatus flagellum, in Ariake Sound, Japan. Env Biol Fish 74:229-238

Conservation of trophic cascades in marine ecosystems: from monsters to morsels

CH Peterson (UNC), RA Myers (Dal),
SP Powers (DISL), J Baum (Dal),
TD Shepherd (Dal)

J. Exp. Mar. Biol. Ecol., 1989, Vol. 127, pp. 121–140
Elsevier

JEM 01233

Timing, intensity and sources of autumn mortality of adult bay scallops *Argopecten irradians concentricus* Say

Charles H. Peterson, Henry C. Summerson, Stephen R. Fegley and R. Christopher Prescott

University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, North Carolina, U.S.A.

(Received 1 September 1988; revision received 31 January 1989; accepted 4 February 1989)

Abstract: Intensive sampling for the bay scallop *Argopecten irradians concentricus* Say at five sites in sounds around Cape Lookout, North Carolina, in 1983–84 demonstrated little change in density of adult (>4 cm in shell height) scallops from August to October in either year but several significant declines from October to December 1983. Because the first sampling interval brackets the period of autumn migration through the North Carolina sounds of the molluscivorous cownose ray *Rhinoptera bonasus* (Mitchill), a reputed scallop predator, these sampling results imply that cownose rays have little effect on adult bay scallop densities during autumn in North Carolina. Furthermore, eight young-of-the-year cownose rays failed to consume any adult bay scallops when confined for 6 days with 104 tethered adult scallops in a 48-m^2 field enclosure. Mortality of tethered scallops within the enclosure, probably caused by predation from whelks *Busycon* spp., was significantly greater on unvegetated bottom than inside a seagrass meadow, yet did not vary with the presence or absence of epibiotic cover on the scallop's top valve. The October–December declines in density of adult scallops preceded the commercial harvest but coincided with the arrival of large numbers of overwintering herring gulls *Larus argentatus* and ring-billed gulls *Larus delawarensis*. Field experiments revealed extremely rapid predation by these gulls on adult scallops aerially exposed on intertidal flats and negligible losses for scallops covered by as little as 1–3 cm of water. Gull predation did not vary with epibiotic cover on the scallops. Because adult bay scallops can be shown to emigrate more rapidly from sandflats than from seagrass beds, which are deep enough to avoid aerial exposure on all but the most extreme low tides, it is unclear whether gull predation can explain the full magnitude of observed October–December declines in scallop density. Storms may be necessary to transport enough scallops onto intertidal flats where vulnerability to gulls is enhanced to enable gulls to exert substantial mortality.

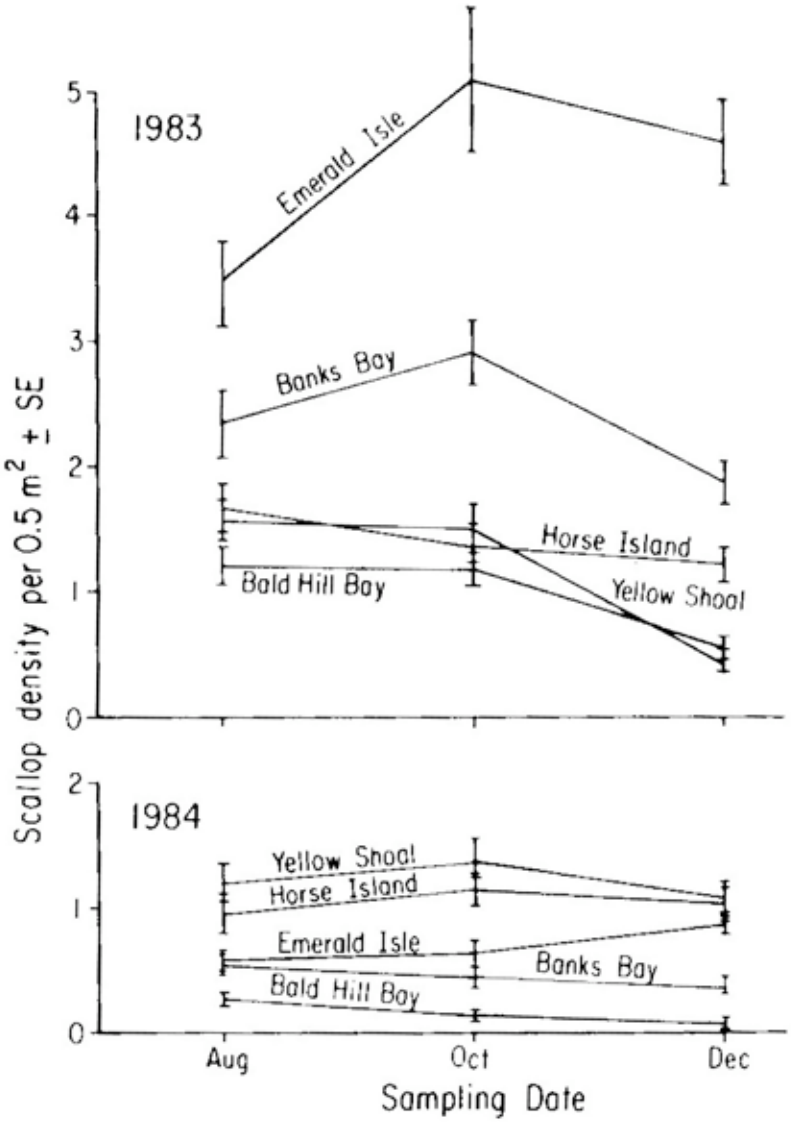


Fig. 3. Average (± SE) densities of large (> 4 cm) bay scallops over a 4-month period in each of 2 yr at each of five sampling sites.

Oecologia (2001) 129:349–356
DOI 10.1007/s004420100742

Charles H. Peterson · F. Joel Fodrie
Henry C. Summerson · Sean P. Powers

Site-specific and density-dependent extinction of prey by schooling rays: generation of a population sink in top-quality habitat for bay scallops

Received: 3 July 2000 / Accepted: 10 May 2001 / Published online: 4 July 2001

Abstract Bay scallops (*Argopecten irradians concentricus*) are patchily distributed on two dominant spatial scales: (1) geographically restricted to highly saline marine lagoons, and (2) locally abundant within such lagoons only in relatively discrete beds of seagrass habitat. In the Cape Lookout lagoonal system of North Carolina, adult bay scallop abundance in the most densely occupied seagrass bed (Oscar Shoal) exhibits repeatable declines from up to 70 m^{-2} to near zero in a 2- to 4-week period during late summer. This crash is completed before fall spawning can be initiated, thereby creating a population sink in what is the singly most productive patch of habitat. Field experiments conducted in the summers of 1996 and 1998 demonstrated that the seasonal extinction of bay scallops on Oscar Shoal can be prevented by the erection of 1-m^2 stockades, made of 50-cm-high vertical poles, spaced every 25 cm, which inhibit access by cownose rays. Because these stockades were porous to emigration and physical transport, and open to access by all other predators of adult scallops, predation by migrating cownose rays is the only viable explanation for the crash. Consequently, the natural predation process in this system achieves the reproductive extinction of prey in the habitat patch of highest productivity. Over 7 years of observation, the mortality rate in this patch increased with summer density, reaching the asymptote of 100% at 10 m^{-2}. The site-specific habitat selection by schools of rays may be based on prey density, which could render this example representative of a widespread generator of population sinks in habitat patches of high quality. The virtual extinction of scallops within Oscar Shoal despite nearby patches with relatively high density may be related to the highly efficient feeding behavior of schools and the high vulnerability of bay scallops in a context of multiple alternative prey types.

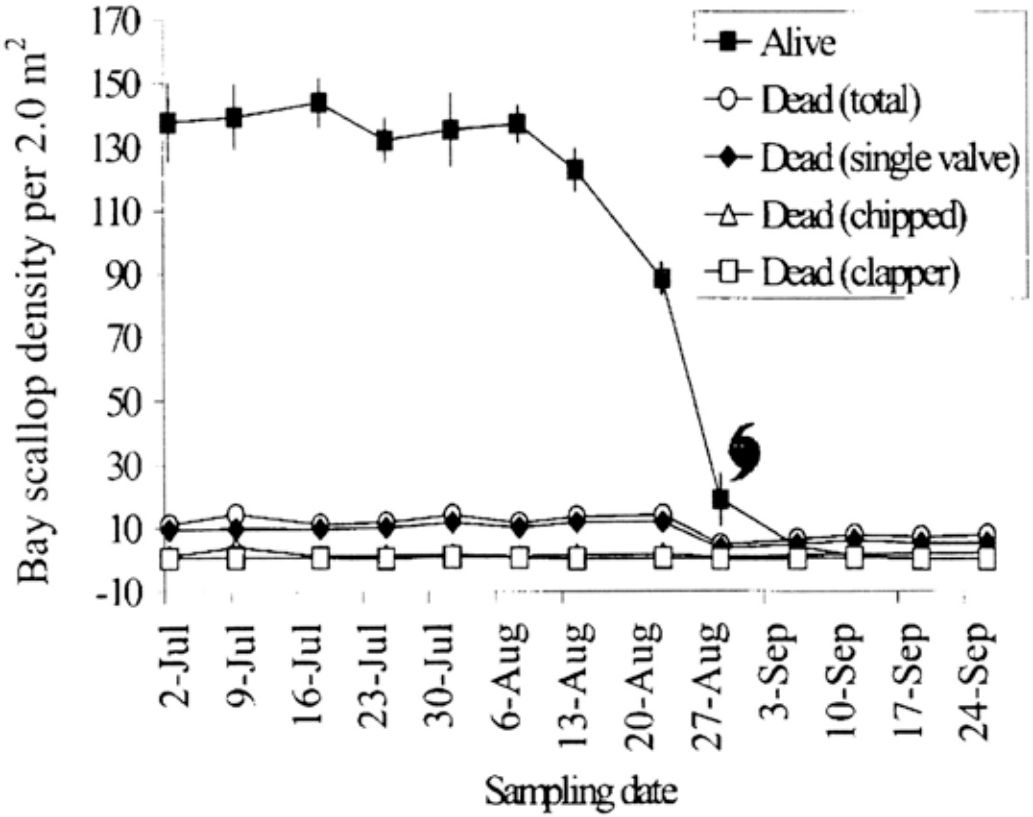


Fig. 1 Bay scallop densities on Oscar Shoal in 1998. *Error bars* indicate SE (n=twenty 2-m^2 quadrats). The *hurricane icon* indicates the timing of passage of hurricane Bonnie just after sampling on 27 August (*Aug*). *Jul* July, *Sep* September

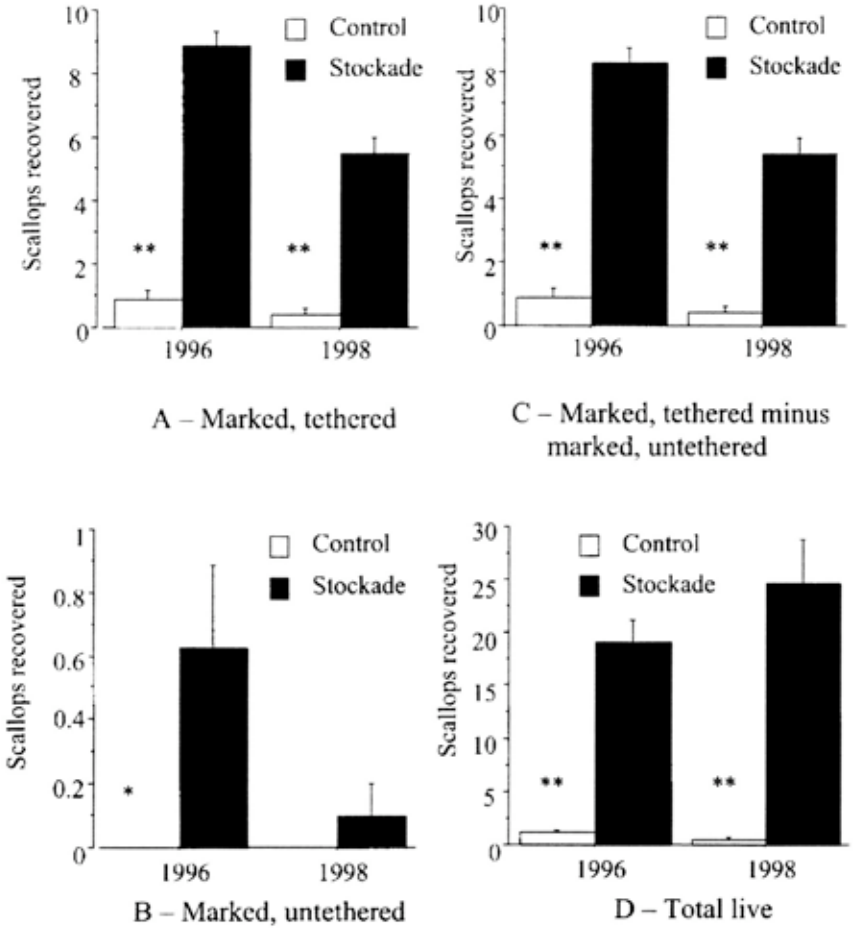
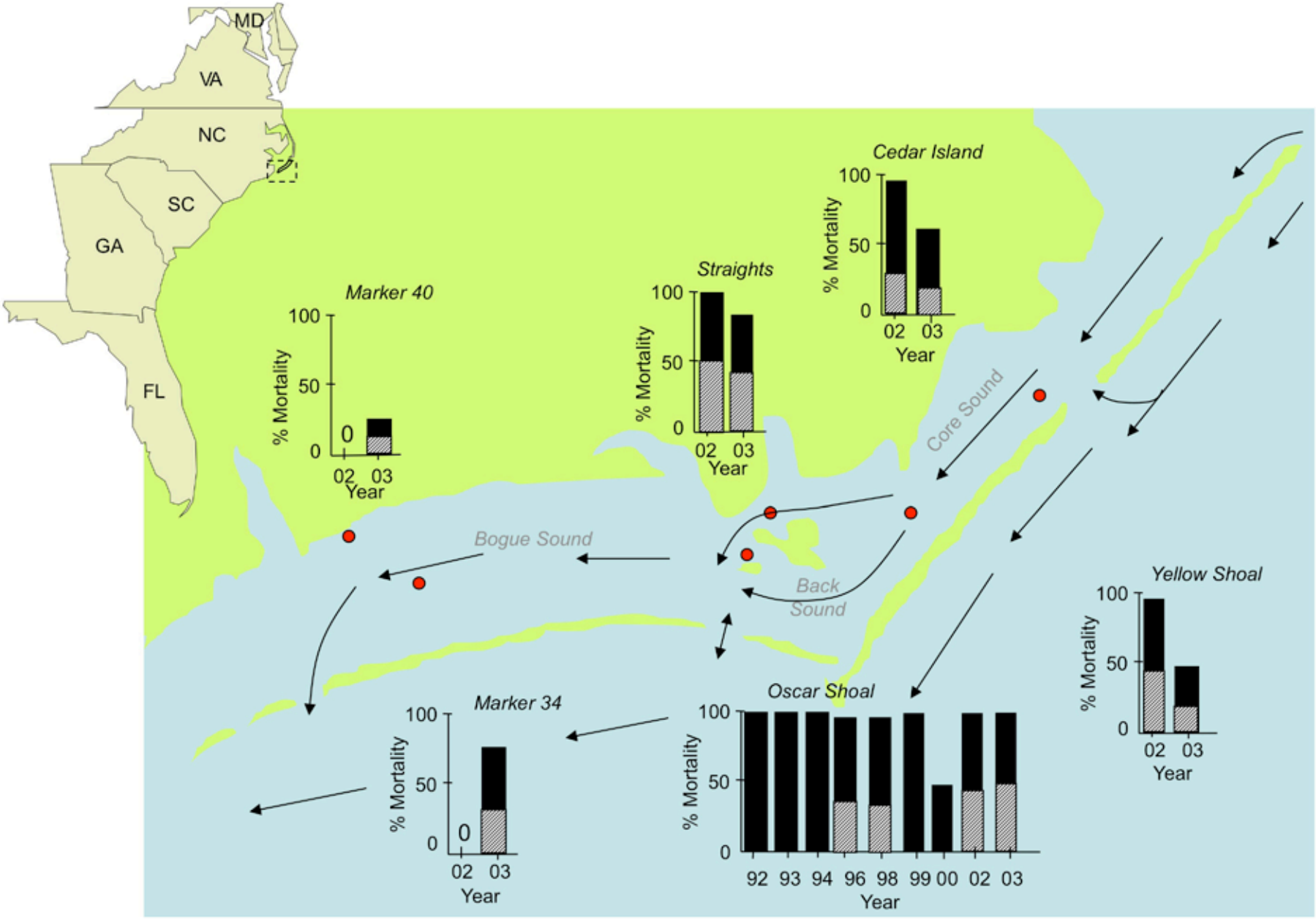
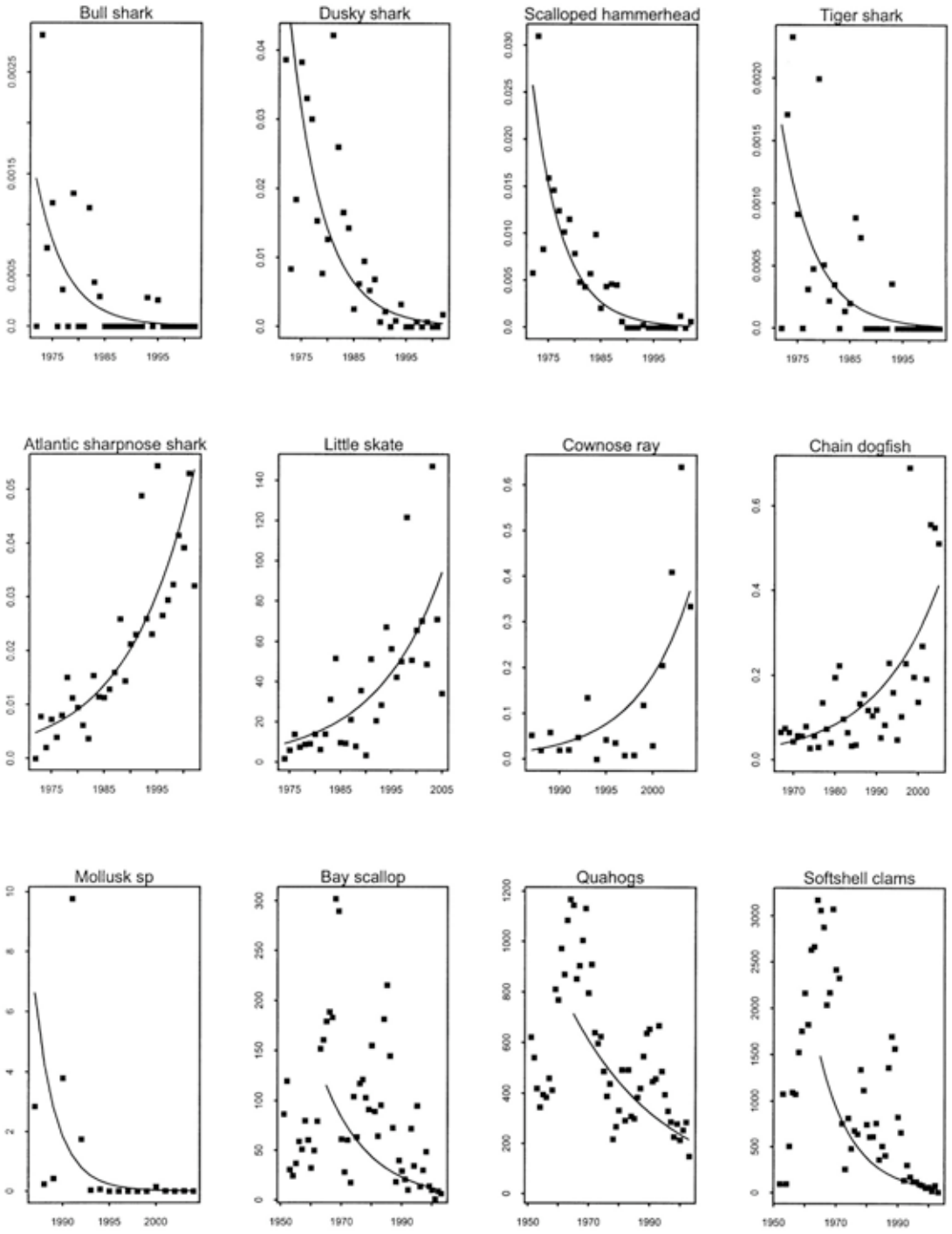
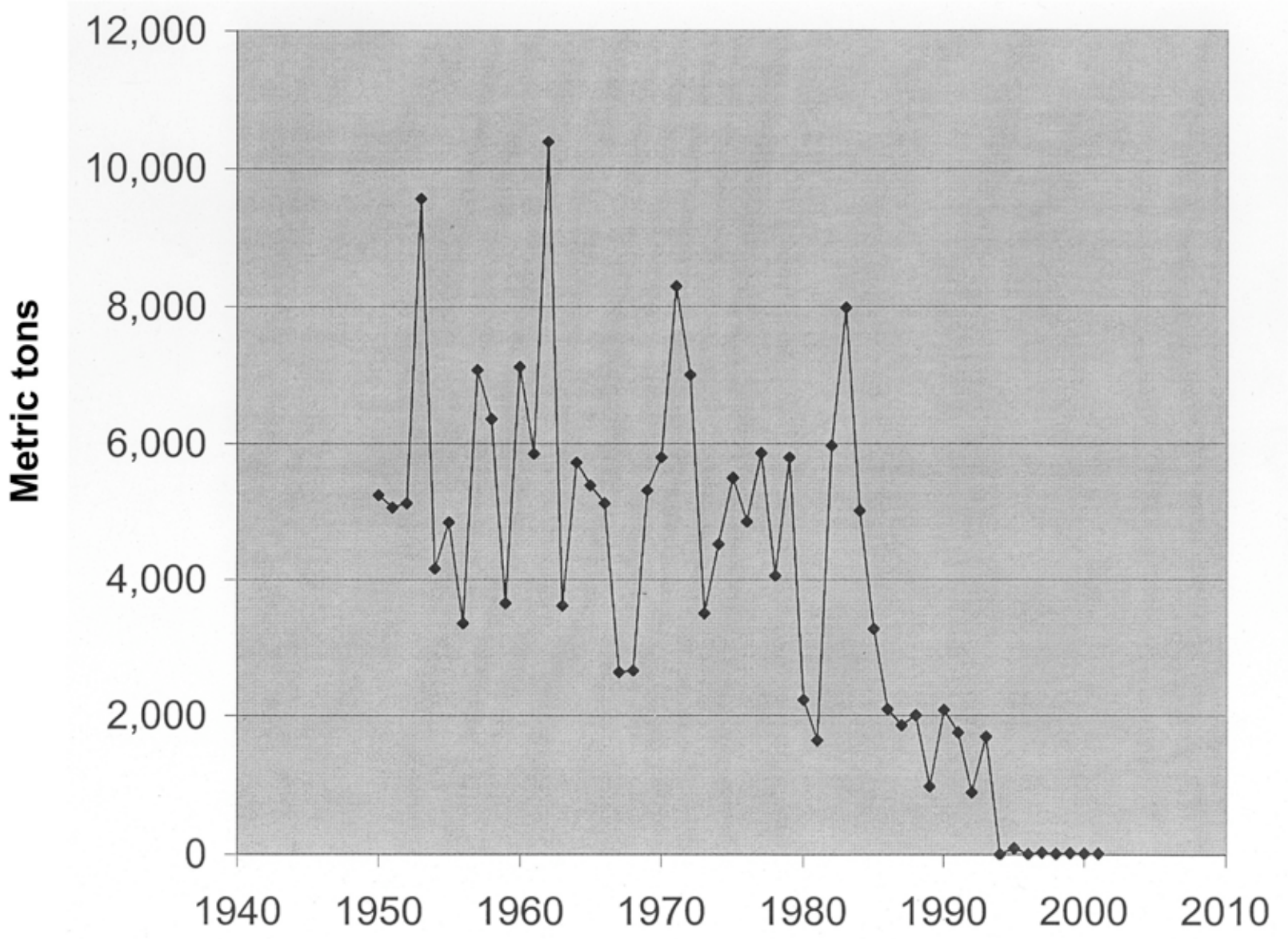


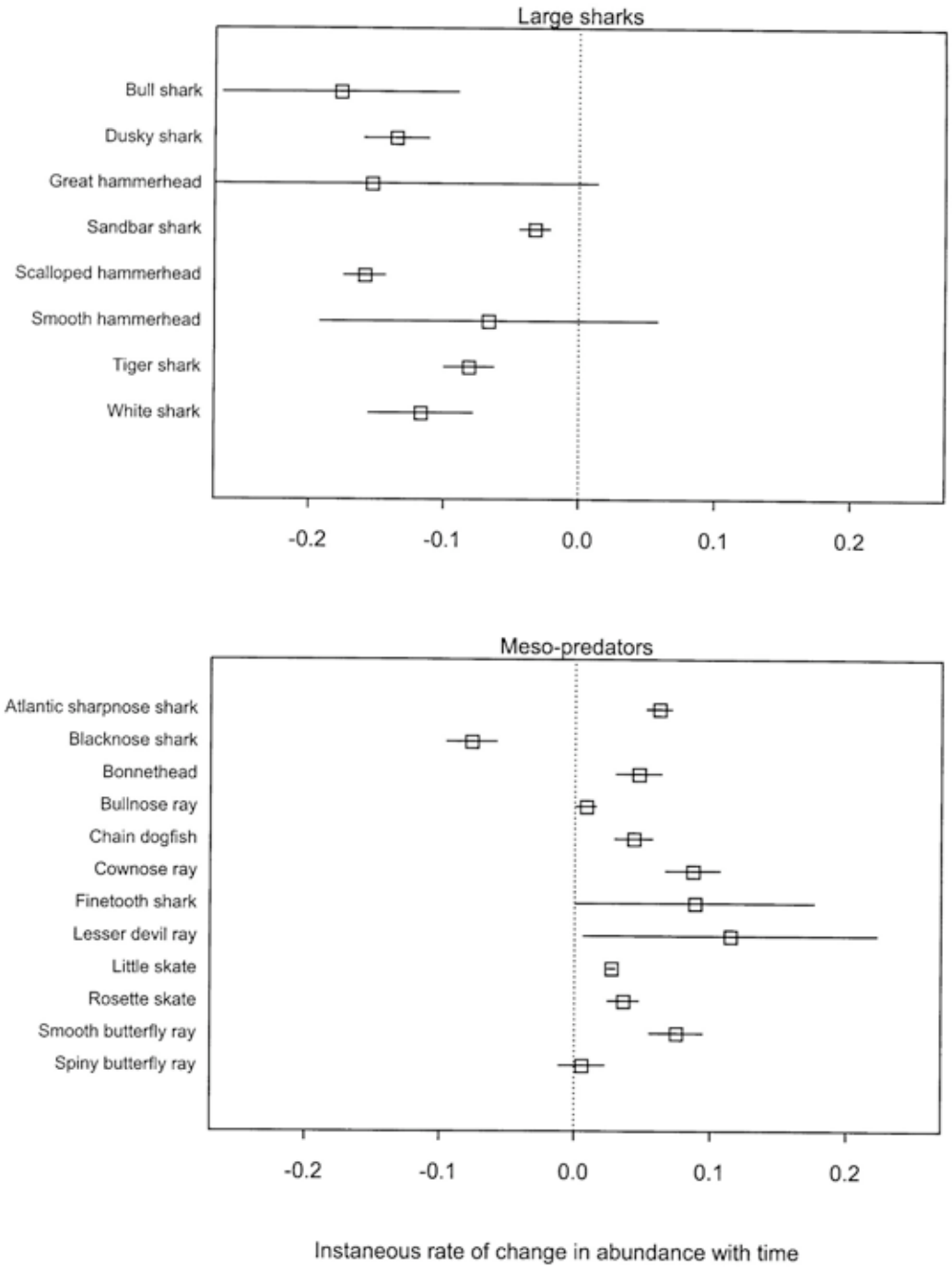
Fig. 4A–D Recoveries of living bay scallops from field experiment on Oscar Shoal. Data for **A–C** represent means out of ten marked, tethered and ten marked, untethered scallops +SE per replicate 1-m^2 plot (n=4 in 1996, n=5 in 1998). Data in **D** include marked scallops introduced for our experiment as well as unmarked scallops that were also present in the plots and were free to move into and out of plots. Significance levels in t-tests are indicated by *P<0.05 or **P<0.01: lack of symbol implies not significant (P>0.05)


MD
VA
NC
SC
GA
FL
Marker 40
Straights
Cedar Island
Core Sound
Bogue Sound
Back Sound
Yellow Shoal
Marker 34
Oscar Shoal
% Mortality
Year
100
50
0
02 03
92 93 94 96 98 99 00 02 03


Bull shark
Dusky shark
Scalloped hammerhead
Tiger shark
Atlantic sharpnose shark
Little skate
Cownose ray
Chain dogfish
Mollusk sp
Bay scallop
Quahogs
Softshell clams

FAO statistics on U.S. bay scallop catches in the U.S.A. north of 35° latitude




Large sharks
Bull shark
Dusky shark
Great hammerhead
Sandbar shark
Scalloped hammerhead
Smooth hammerhead
Tiger shark
White shark
-0.2
-0.1
0.0
0.1
0.2
Meso-predators
Atlantic sharpnose shark
Blacknose shark
Bonnethead
Bullnose ray
Chain dogfish
Cownose ray
Finetooth shark
Lesser devil ray
Little skate
Rosette skate
Smooth butterfly ray
Spiny butterfly ray
-0.2
-0.1
0.0
0.1
0.2
Instaneous rate of change in abundance with time

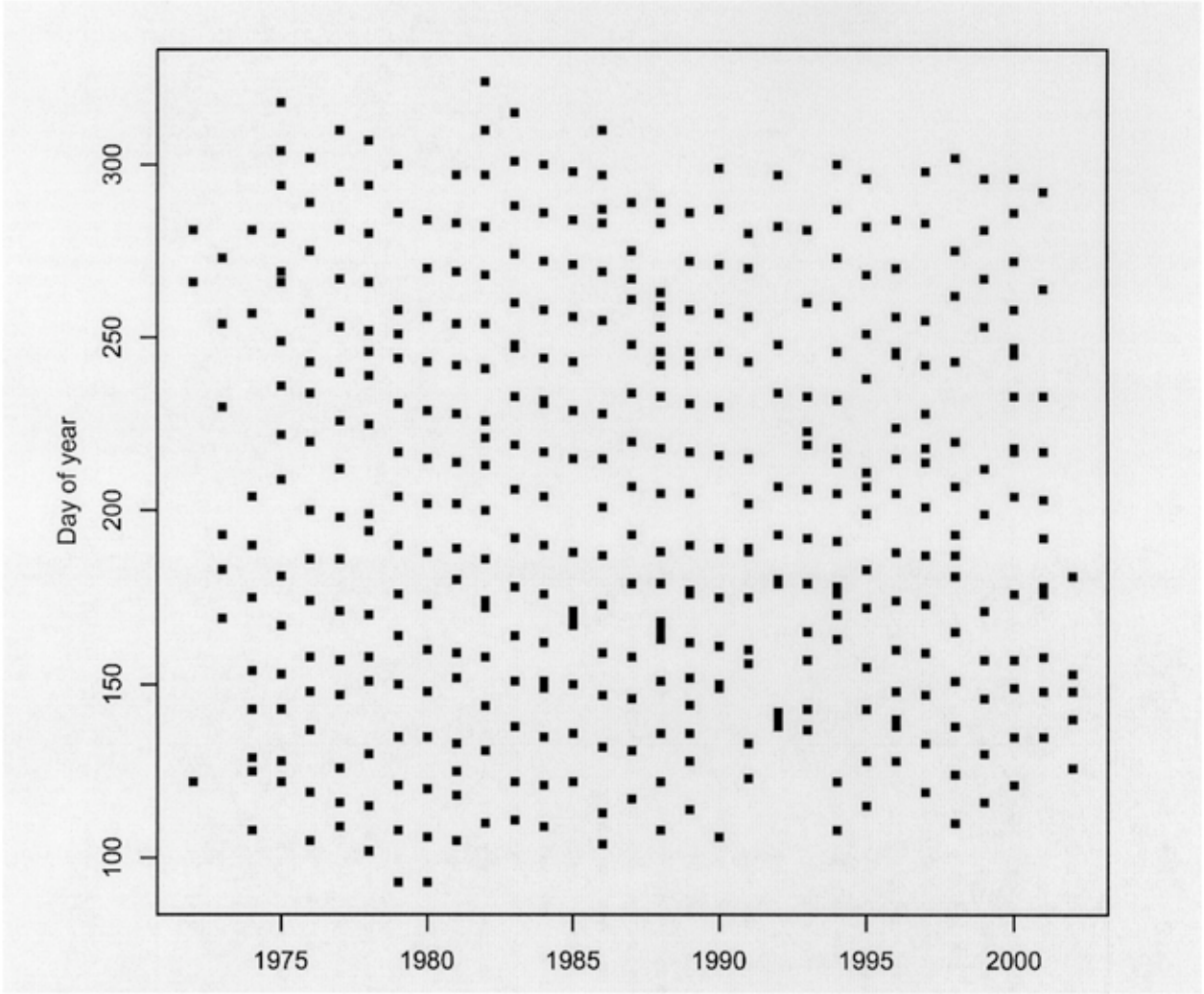
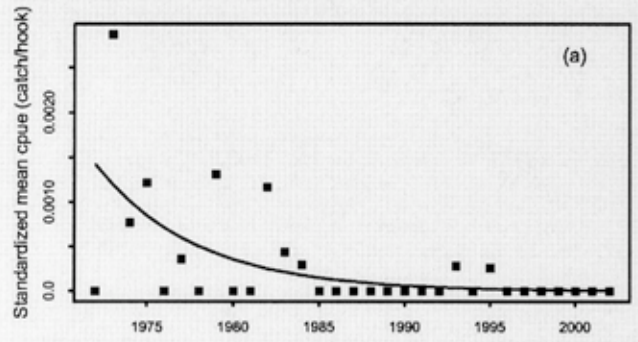
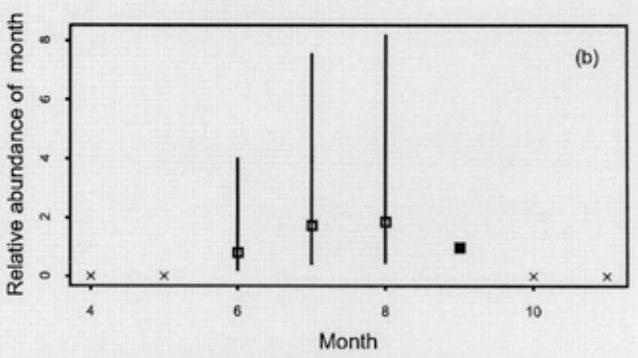
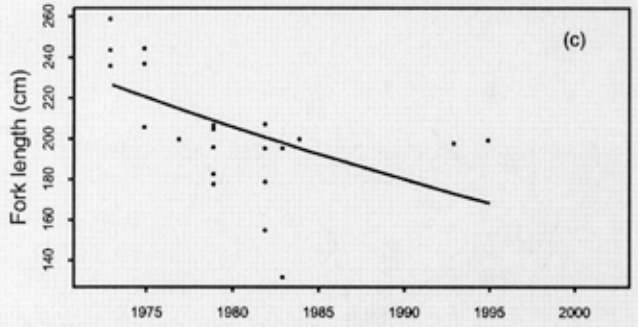


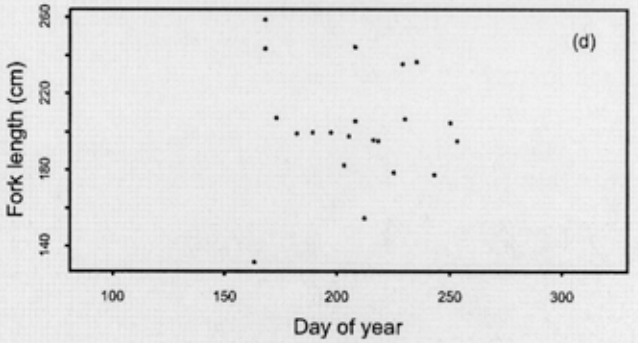
Figure 2. Monthly distribution of samples from the North Carolina, fishery-independent longline shark survey (1972-2002).

Bull shark



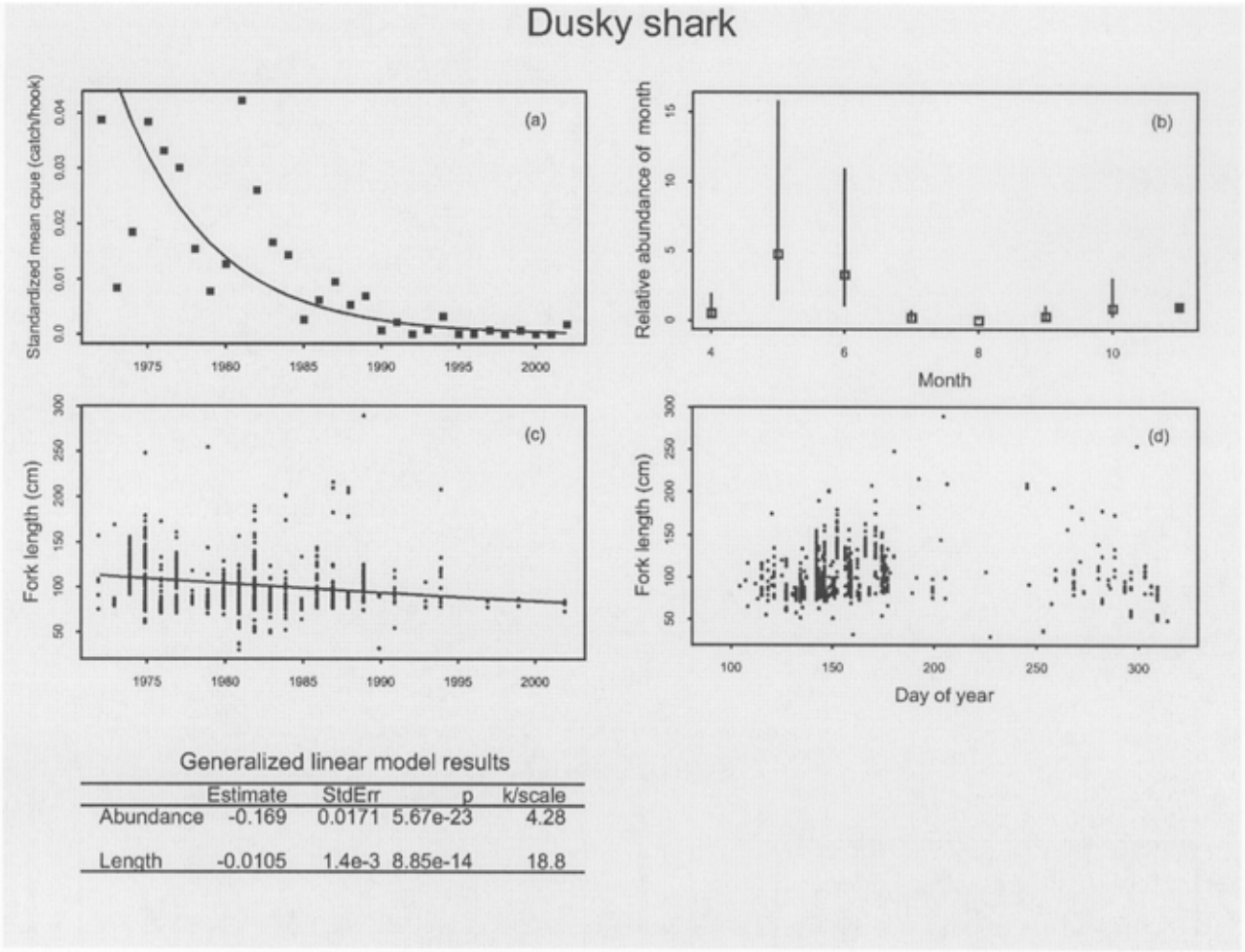






Generalized linear model results

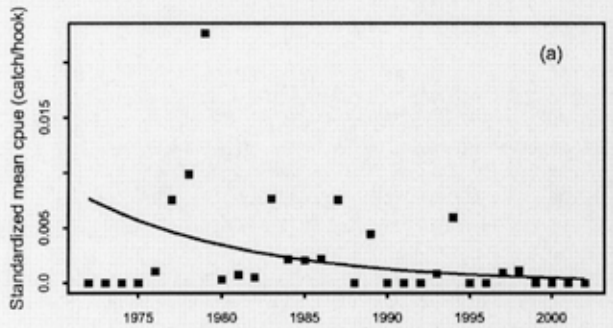
	Estimate	StdErr	p	k/scale
Abundance	-0.172	0.0443	9.99e-5	4.28
Length	-0.0136	5.e-3	6.69e-3	63.2

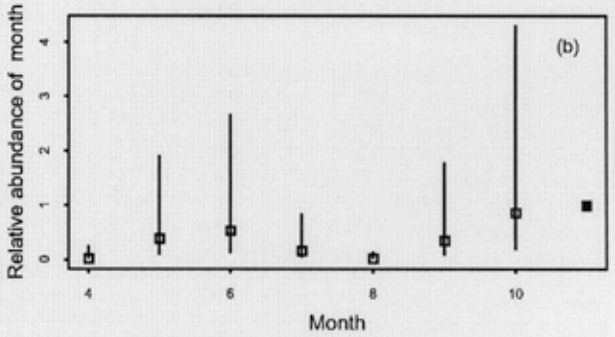


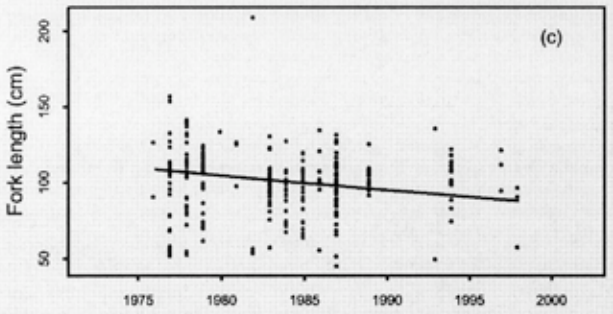
Generalized linear model results

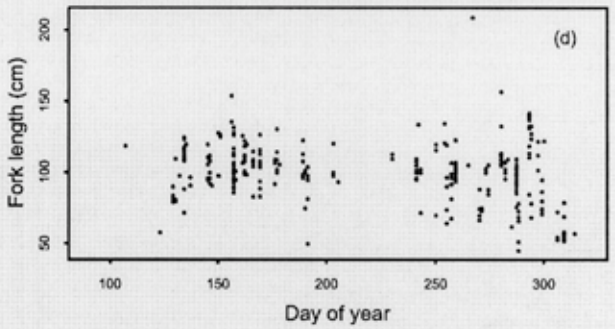
	Estimate	StdErr	p	k/scale
Abundance	-0.169	0.0171	5.67e-23	4.28
Length	-0.0105	1.4e-3	8.85e-14	18.8

Sandbar shark





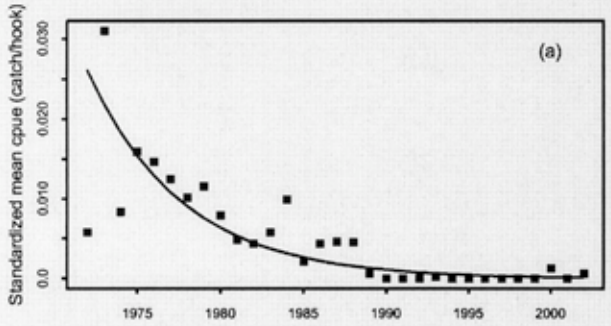


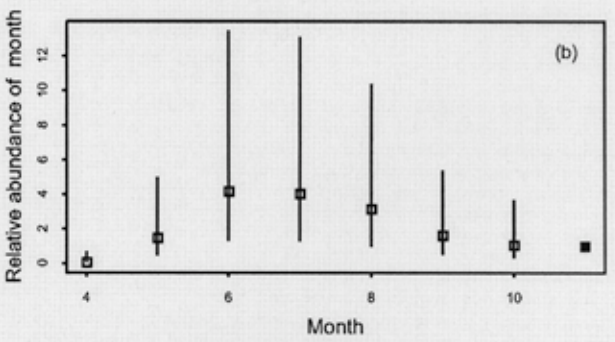


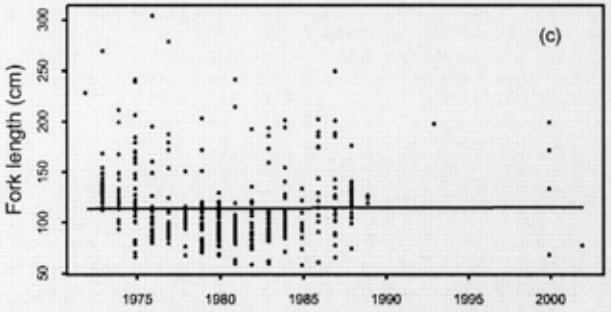
Generalized linear model results

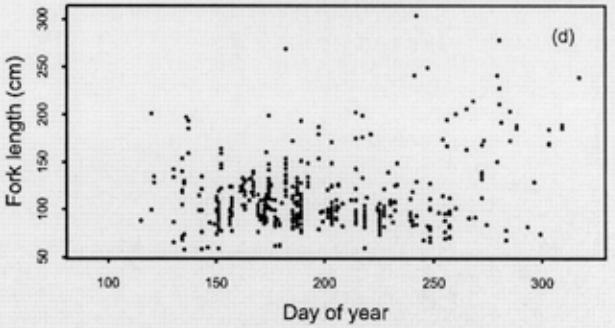
	Estimate	StdErr	p	k/scale
Abundance	-0.0992	0.0228	1.32e-5	8.5
Length	-9.59e-3	2.26e-3	2.14e-5	30.6

Scalloped hammerhead



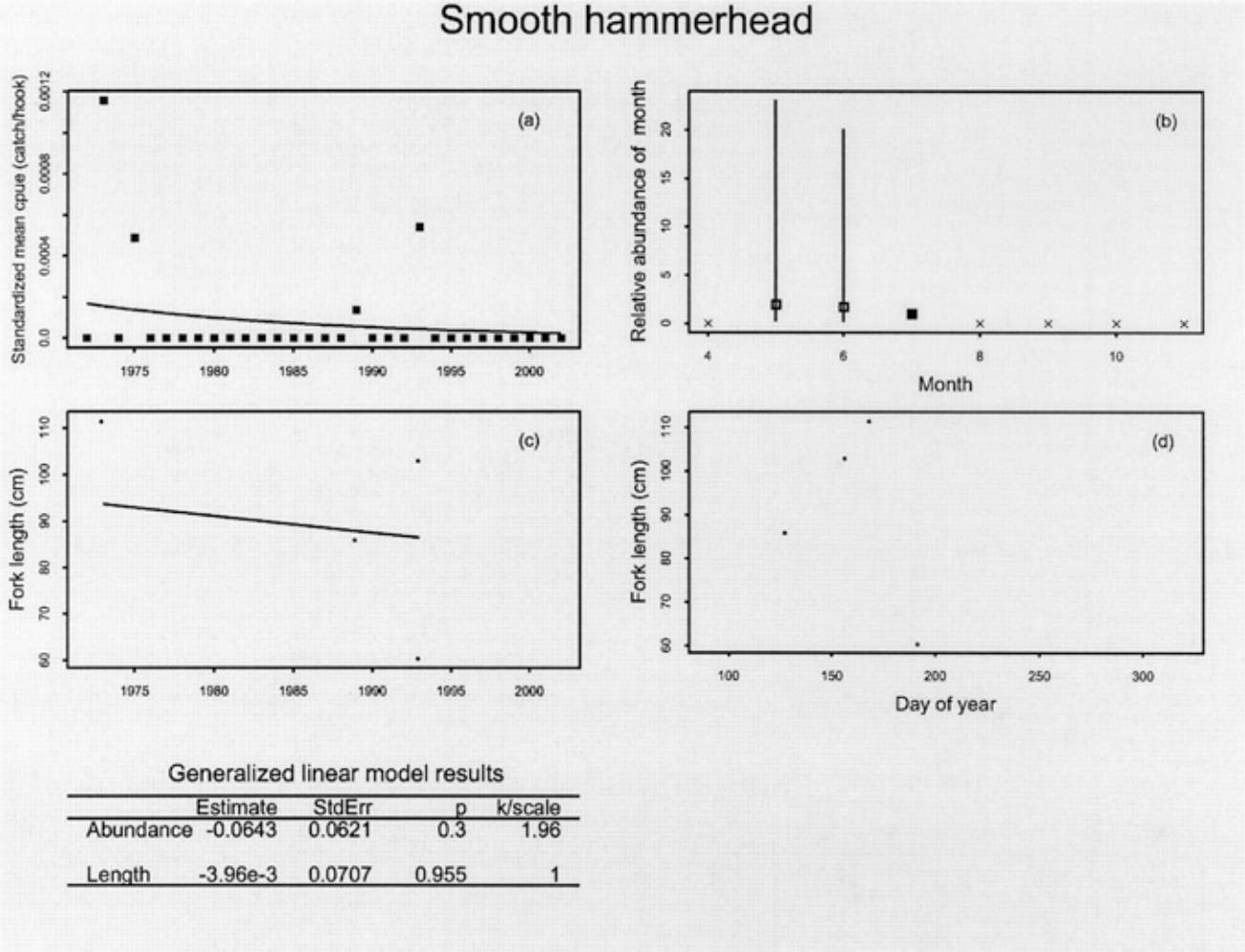






Generalized linear model results

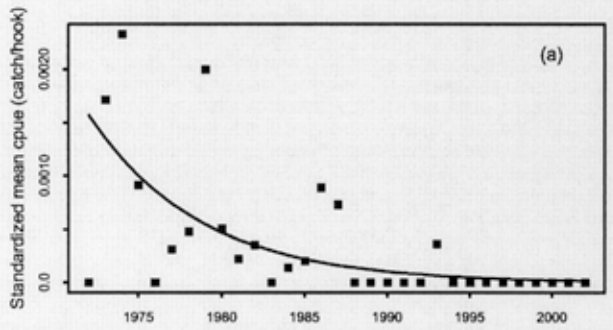
	Estimate	StdErr	p	k/scale
Abundance	-0.177	0.0145	6.16e-34	1.96
Length	3.6e-4	2.44e-3	0.883	14.7

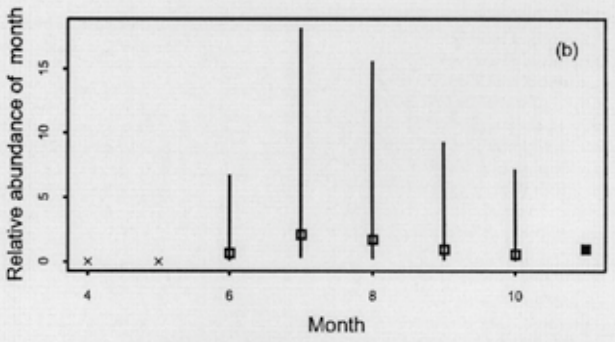


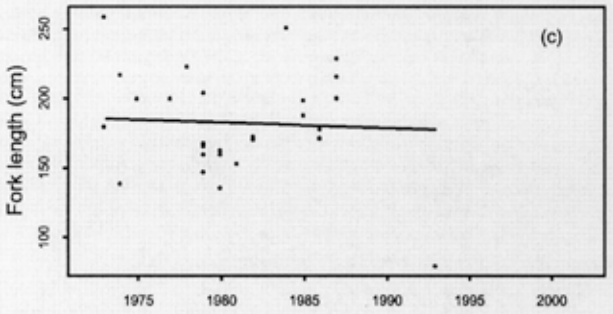
Generalized linear model results

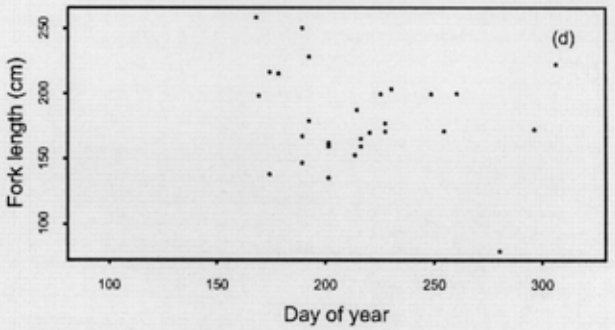
	Estimate	StdErr	p	k/scale
Abundance	-0.0643	0.0621	0.3	1.96
Length	-3.96e-3	0.0707	0.955	1

Tiger shark









Generalized linear model results

	Estimate	StdErr	p	k/scale
Abundance	-0.151	0.0345	1.22e-5	1.06
Length	-2.11e-3	7.56e-3	0.78	31.2

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Response of bay scallops to spawner transplants: a test of recruitment limitation

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University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, North Carolina 28557, USA

ABSTRACT: Adult bay scallops *Argopecten irradians concentricus* Say were transplanted prior to spawning in summer 1992 (135000), 1993 (100000), and 1994 (150000) from a donor site where scallops were abundant to receiver sites in western Bogue Sound, North Carolina, USA, an estuarine water basin where scallops had not initiated recovery since their virtual elimination by a red tide outbreak in 1987–1988. Transplantation enhanced local adult density in receiver sites from <1 in 1992 and 1993 and 3 in 1994 to 15 m^{-2}. These transplants were intended as a test of the hypothesis that bay scallop populations are recruitment-limited on a basin scale within sounds, which is consistent with the limited physical transport of their short-lived pelagic larvae. This intervention also represents an empirical test of a process-based restoration option (spawner transplantation) with broad significance to managers of shellfish resources. Both mortality and emigration were negligible from August to December for transplanted scallops at each of the 4 receiver sites in western Bogue Sound. On average, recruitment of scallops at 2 study sites in western Bogue Sound following the transplants in 1992, 1993, and 1994 was 568% greater than in 1988 and 1989 when no transplantation had occurred. At 2 control sites in Back and Core Sounds, North Carolina, USA, the average change in recruitment was a non-significant 34% increase over this same period. Adult density in Bogue Sound increased by 258% following spawner transplantation as compared to a non-significant change of 8% in control sounds. The absolute magnitude of the temporal increase in recruitment of bay scallops to natural seagrass beds was significantly larger in western Bogue Sound than in the control sounds, demonstrating a positive effect of the transplants on bay scallop restoration. Larval settlement onto spat collectors at 3 of those same study sites did not correlate well with recruitment data and failed to reveal enhancement in western Bogue Sound following transplantation. Thus, spat collector data cannot confirm that the transplants succeeded through the mechanism of enhancing larval abundances. Nevertheless, settlement of scallop spat onto collectors deployed along a transect in the channel revealed a pattern of decreasing settlement with distance from Bogue Inlet, which is consistent with the hypothesis that scallop larvae become depleted with distance from their source and thus limit population size in this system. Furthermore, larval settlement onto collectors and recruitment to natural seagrass beds were negligible at a site in central Bogue Sound that lies outside the influence of tidal forcing from Bogue Inlet and is disconnected hydrographically from the source of competent larvae in western Bogue Sound. Thus, recruitment appears to limit population size of bay scallops in this system, implying that larval subsidy from transplantation is the likely although unconfirmed mechanism of successful enhancement of recruitment following spawner transplantation.

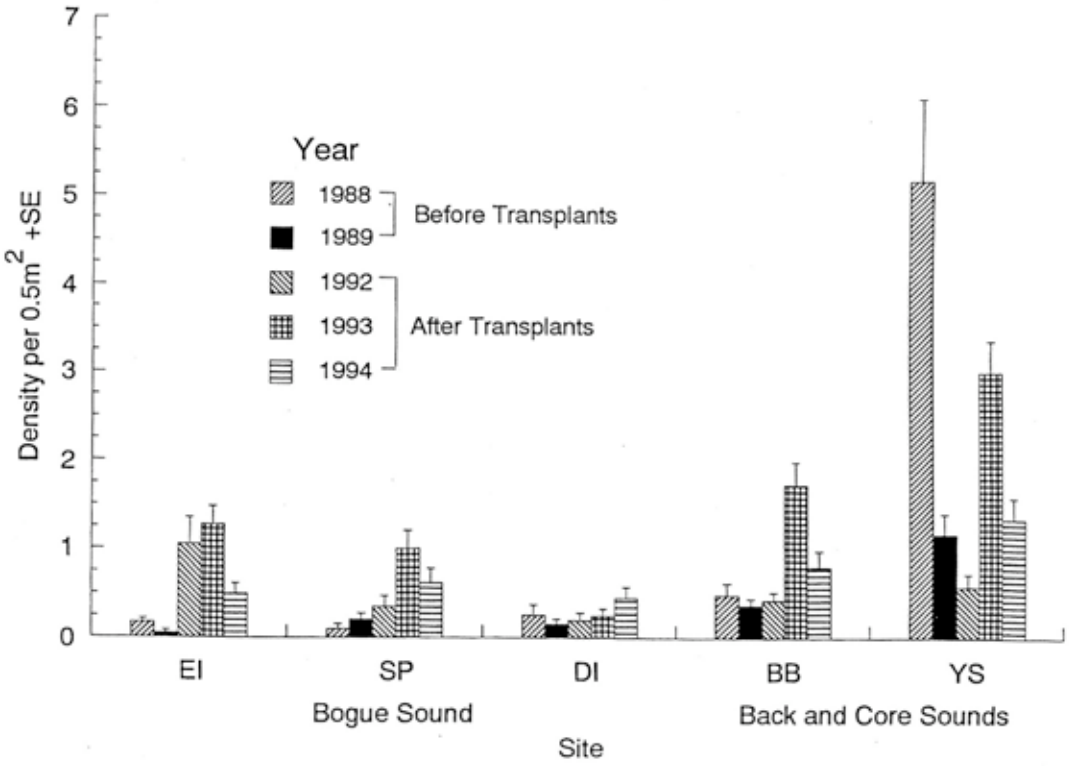

Fig. 7. *Argopecten irradians concentricus* Say. Average (+SE; n = 35 to 61) density of newly recruited bay scallops in natural seagrass beds as measured in early December after cessation of recruitment in each of 2 yr before (without) transplants and in each of 3 yr after (with) transplants in 2 treatment locations in western Bogue Sound (EI: Emerald Island and SP: Salter Path), in 2 control locations in other sounds where no transplantation occurred (BB: Banks Bay and YS: Yellow Shoal), and in 1 location in central Bogue Sound outside the influence of tidal forcing from Bogue Inlet (DI: Dog Island)

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Occurrence, growth and food of longheaded eagle ray, *Aetobatus flagellum*, in Ariake Sound, Kyushu, Japan

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Key words: elasmobranch, Myliobatidae, life history, bivalve predation

Synopsis

The longheaded eagle ray, *Aetobatus flagellum*, has recently increased significantly in numbers in Ariake Sound. It is assumed that it feeds on bivalves and so, to prevent predation by eagle rays on bivalves, a 'predator control program' aimed at reducing the ray population has been in place since 2001. We examined their occurrence, age, growth and food in Ariake Sound to obtain data on the ecology of the eagle ray and provide basic information on their potential impact on bivalve stocks in Ariake Bay. The eagle ray is a seasonal visitor to Ariake Sound, increasing in numbers from April, and peaking during the summer. None were captured during surveys in December and February. Their movement pattern around the bay differed according to sex. Pregnant females were caught in the estuary during August and September. Females grew to a larger size than males and apparently lived longer. The maximum ages were 19 years for females and 9 years for males. Growth until two years was similar in both sexes, but after 2 years females grew larger. The eagle ray fed only on bivalves, especially *Ruditapes philippinarum* and *Atrina pectinata*, very important fishery species farmed in Ariake Bay.

North Carolina Ray Projects

Bob Hines
North Carolina Sea Grant
(Has since Retired)

Presenter did not provide abstract. Page intentionally left blank.

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North Carolina Sea Grant

"The more things change, the more they remain the same."

Utilization of N.C. Skates & Rays

Objectives

- Locate and characterize foreign markets for N.C. skates and rays
- Determine product characteristics of N.C. skates and rays as they apply to market demands
- Initiate development of a skate and ray fishery in N.C.

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Objective I - Assessment of Foreign Markets

- 1977 and 1978 – TELEX machine was predominant means of communicating with foreign markets (buyers).
- Project had no telex machines so surveys were done via literature reviews, direct communication though mail, indirect communication through brokers in the U.S.

Market Size

- > 30 million lbs. of skate wings marketed in England, France, and Belgium in 1973.

Table 1. Landings and import levels of skates wings England, France and Belgium in 1973. Figures cited are in millions of pounds of wings.

	Domestic Landings	Imports	Total Wings Marketed	% Imported
England	15.5	5.0	20.5	24%
France	4.5	3.0	7.5	40%
Belgium	1.7	0.5	2.2	23%
	21.7	8.5	30.2	

*Figures extracted from Department of Commerce Project Report No. 4-36731.

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- Volume of potential imports (in Europe) would depend on the amount of European domestic harvest, quality of imports, and institutional barriers to trade such as: import duties, turnover taxes, and health inspections.

Species Marketed

Table 2. Species of skate which are commonly marketed in Europe.*

Species	Size (max. length)	Commercial Value	Comments
Raja batis, Blue or Grey skate	170-190 cm	excellent	most common skate in Europe
Raja clavata, Roker (thornbach skate)	80-90 cm	considerable	abundant inshore
Raja naevus, Cuckoo ray	65-75 cm	considerable	common
Raja radiata, starry ray	70-80 cm	considerable	trawl harvest in northern England
Raja alba, bottlenosed on Bondened skate	150-180 cm	minimal	rare
Raja oxyriuchus, long-nosed skate	110-130 cm	minimal	

*Tabulated data was extracted from Wheeler (1969).

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Product Form (Wings)

- IQF
- Blast frozen in shatter pack

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Table 3. Composite analysis of important market attributes for skate and ray, as outlined in letters from European fish firms**.

	Wing Six Categories	Desired Color	Marketed Species (Genus Raja)
England	.75-1.25#* 1-3# 1.25-2.50# 3.5# 2.5-4.00# 5-7#	not specified	not specified
France	- -	not specified	not specified
Belgium	150-200 g, smalls mediums 3-4 kg, larges	white	R. batis, ? lava radiata and montagni???
Italy	Min. 500 g Max. 4-5 kg	not specified	R. erinace?, fyllae garmani, radiata, and senta
Spain	100-400 g 400-800g 800g	pink	R. batis and clavata
* Size categories vary in England depending on dealer. # implies pounds.			
**Table extracted from Otwell and Crow (1977).			

- Rays such as common stingray (Dasyatis partinacea); rough tail stingray (D. centroura); eagle ray (Myliobatis aquila), and the devil ray (Mobula mobular) have no economic importance in Europe due to infrequent occurrence there.

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Letter Correspondence

- 12 European seafood firms
- 50% response (6)
- Interest in exchange of samples (skate)
- Skeptical of ability and desire of U.S. industry to supply quality product
- Samples sent to Holland and Germany but no results from market were received

Objective II - CNR Samples Trails

- Core Sound
- Sent to Blackpool, England to coincide with annual Seafood Exhibition.
- These samples then distributed to France, Sweden, Germany, Italy

Responses were disappointing

- European firms unfamiliar with blood (red muscle) in samples
- Brokerage firm used was unfamiliar with marketing of skate. They introduced the product as skate when it was, in fact, ray. Foreign firms anticipated white meat, as in skate. This was misleading.

- Commercially, skates and rays were referred to as skates in the market
- There are distinct differences, however
- Dealers should understand the differences and communicate in specific terms which identify the particular species
- Marketable yields of skate and ray similar – CNR – 42% -- Clearnose Skate 35%
- Differ in skin color, meat color, and size
- Meat low in fat, high in protein
- ?? Area content less than most sharks
- Chemical composition was stable during one month of frozen storage at -29°C
- Taste panel preferred larger fried CNR to broiled and to smaller rays
- Texture and flavor of CNR are distinctly different from Canadian skate Raja batis.

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Objective III – Develop N.C. Skate & Ray Fishery

- Interest from fishermen and processors, particularly from Harkers Island
- Potential additional income and help reduce ray predation on shellfish
- Long haul seine was effective in catching CNR
- Processors could use existing method to package wings
- Most processors did not want to deal directly with foreign seafood firms – preferred using brokers
- Public demonstration of CNR preparation at Harkers Island, N.C., Aquarium, Division of Marine Fisheries, indicate strong potential for public acceptance.

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Follow-Up Studies

- Maryland Department of Economic and Community Development, Office of Seafood Marketing submitted samples of CNR to NMFS labs for orgavoleptic and echnological evaluation.
- NMFS made "some progress" adapting a mechanical skinning device.
- Gulf and South Atlantic Fishery Development Foundation funded marketing study in spring of 1979
- Marketing study was done by Seafood Lab of NCSU – results of this study follow

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North Carolina

"Utilization of N.C. Skates & Rays"

Sam Thomas
NCSU Seafood Lab
1979

- Goal: Locate and Identify a market(s) for rays
- TELEX Communications with European buyers
- Inform buyers of project and determine interest in receiving samples of CNR

Foreign Contacts

Nippon Suisan Kaisha, Tokyo, Japan

Sealand Trading Co., Hong Kong, China

International Federation of Fishmongers, Surrey, England

Nolting Gebruder, Hamburg, Germany

Messrs. Cofrapech, Imexco, and Donald, France (Names received in another cable, along with TELEX numbers; no complete addresses)

Arne Liljemark, Swedish Food Institute, Goteborg, Sweden

Danish Ministry of Fisheries, Lyngby, Denmark

Mr. Saykers, Morubel, Ostende, Belgium

Mr. Depreter, Seafood, Zebrugge, Belgium

Simon and Derru, Ostende, Belgium

Federal Research Centre of Fisheries, Hamburg, Germany

Der Bundesminister fur Ernahrung, Landwirtschaft und Forsten, Germany

R.J. Nachenius, University of Cape Town, South Africa

Irvin Johnson, Melbourne, Australia

Craig Mostyn, Sydney, Australia

Kerville Co., Victoria, Australia

Henning Anderson, Belgium

Ittirusso S.R.I., Naples, Italy

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North Carolina

Foreign Contacts continued.....

Decostes and Lapierre, Boulogne-sur-Mer, France

Japan Fisheries Agency, Tokyo, Japan

James Johnson, Fisheries Attache, Tokyo, Japan

Claudio Foy, Giolfi and Cagnano, Genor, Italy

Richard Stock, Industries del Atlantico, La Coruna, Spain

D. Alberto Martin Varela, Frigorificos de Berbes, Vigo Spain

J.N. Keay, Torry Research Station, Aberdeen, Scotland

F. Donaldson, Intel, Aberdeen, Scotland

D. James, FAO, Rome, Italy

Luis Metles Torres, Ministerio da Agricultura e Pescas, Lisbon, Portugal

Allan Bremner, Tasmanian Regional Lab, Hobart, Tasmania

Norman Pease, Fisheries Attache, Copenhagen, Denmark

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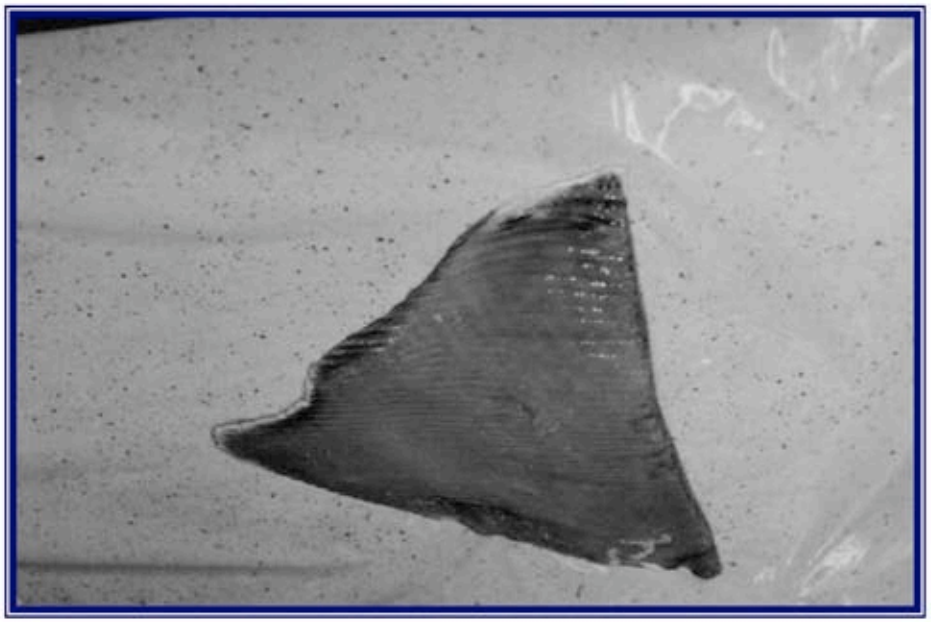
- 5 replies with interest in samples
- Samples sent
- Evaluation of samples was very strong and negative

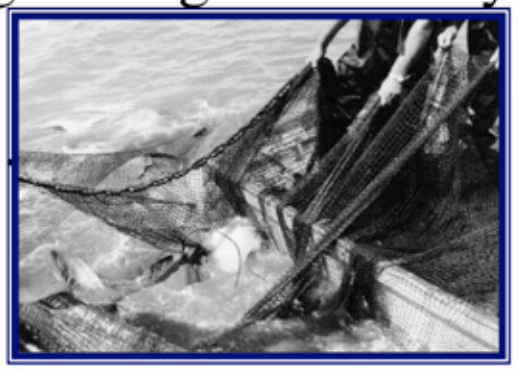


Domestic Markets

- U.S. Exporters
  -George Washington – Whitestone, VA – Nigeria
  -Gene Raffield – Florida
- Seafood Brokers - ??
- Supermarket chains – one indicated a cheap product would sell in large cities. Would require packaging and product development

Product Development

- Name - CNR - "Whipparee"
- Products
  - Ray cakes – blended meat, breading, spices packed in scallop or clam shells. Above average ratings in sensory evaluations
  - Ray Creole – packed in boil-in-bags. Rated above average
  - Sweet and Sour Ray
  - Canned Ray – vegetable oil, olive oil, brine, tomato sauce
  - Samples sent to promoters and industry representatives



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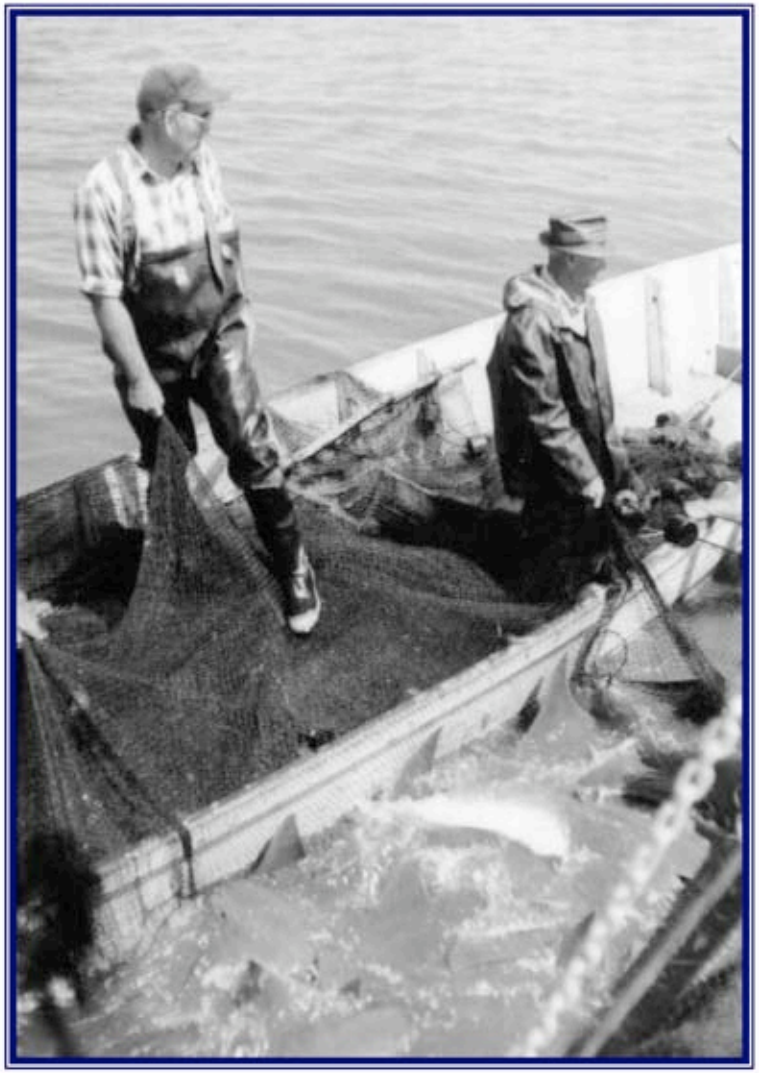
- Demos given to civic groups, clubs, general public, professional gatherings
- Hampton Mariner's Museum
  - 3,000 people
  - 500 ? tasted fried CNR and most liked it. 60% said they would buy and serve it



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North Carolina

Cownose Ray Projects in Virginia

Robert Fisher
Fisheries Specialist
Virginia Sea Grant Marine Advisory Program
Virginia Institute of Marine Science
PO Box 1346
Gloucester Point, VA 23062

Since the 1970s, concerns about ray predation on commercial shellfish in the Chesapeake Bay have prompted various research efforts at the Virginia Institute of Marine Science. Early work by Smith and Merriner (1985, 1986, and 1987) looked at ray feeding habits, biology, and distribution. Utilization of the ray for various markets was initiated in the 1990s and continues today. Harvesting rays was not a concern since rays readily interact with traditional fisheries throughout the bay (pound net and haul seine). Processing rays for human consumption markets was first evaluated in 1990 through collaborative research between VIMS and Virginia Tech. A commercial processing operation for cownose ray was evaluated with product yield and processing cost estimates established (Fisher and Lacey, 1991). Though this effort provided a feasible product for local watermen to fish, as well as favorable exposure to consumers (public tastings of "Chesapeake Ray"), industry interest in developing a ray fishery was very low, resulting in no subsequent participation. Interest in developing a ray market remained low until larger oyster restoration efforts began in 1999. Even at that time, research proposed for the full utilization of ray products including muscle/flesh for human consumption, cartilage, liver oil, bait, and silage from remaining waste (Proposal: Technology development for the Full Utilization of the Cownose Ray, Fisher 1999) was denied funding. Not until ray predation was frequently observed impacting oyster restoration efforts was funding to support development of a ray fishery re-established. From 1990 to the present, Virginia Sea Grant Marine Advisory Program has maintained ray product development efforts within their scope of work. Efforts to develop products included markets for human consumption (fillets, steaks, fried strips, BBQ, and mixed with beef for burgers) and for bait.

Largely due to industry pressure (as a result of rays' impediment to shellfish restoration efforts) funding from various state agencies was made available to evaluate the potential for a ray market. With the newly created Fishery Resource Grant (FRG) program in Virginia, funds were allocated for collaborative efforts between watermen and academics. In 2001, FRG funds supported testing of a portable anchor net to allow watermen to remove rays from shellfish growing areas. As part of this project, bait markets were explored for ray use. With no success in previous attempts to market the flesh for human consumption, attempts to market the ray were relegated to bait markets. Whole rays were cut into fishery-specific-sized pieces (to be compatible with existing gear) and tested within various fisheries (FRG project 2001). Feedback from the stone crab trap fishery and grouper ling-line fishery in Florida was favorable, with ray competing well with current baits (pig feet and mullet frames). However, to compete in that market, the cost had to be $.19-$.25/lb FOB Miami, which was not possible given cost of harvesting, processing, freezing, and shipping rays (fishermen alone demanded $.17/lb to harvest the ray). In addition, cut ray was tested as an alternative to horseshoe crab as bait in the Virginia whelk (conch) trap fishery (Virginia Marine Resource Commission (VMRC) funded project 1999-current). Ray worked the best (0.59 catch rate) of all alternative baits tested, but did not warrant large-volume use. In 2003 FRG funds were granted for a larger scale project

(Value of Cownose Ray: Population Size, Harvesting, Processing and Marketing Acceptance). This project has been extended into 2006. Marketing efforts at VIMS have recently combined with the Virginia Marine Products Board to expand market potential. To date, most interest in the ray has been from the Korean market. Current research at VIMS, supported by Virginia Sea Grant, FRG, and the Virginia Marine Resource Commission (VMRC), has fostered collaboration with industry and various state agencies, and has evolved as a two-pronged approach to the cownose ray issue: development of markets for ray products, and collection of ray biological information to assess the ray population.

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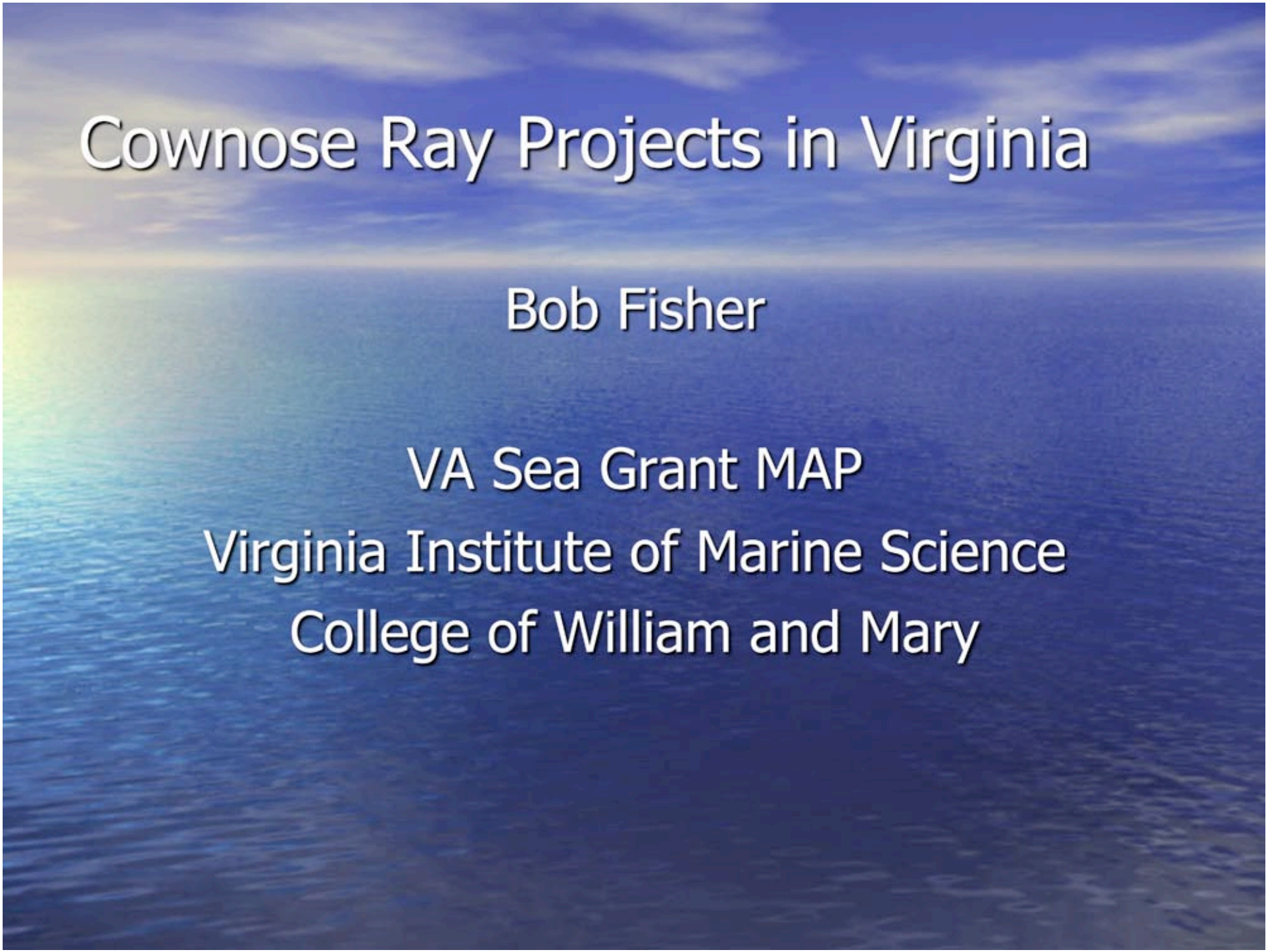
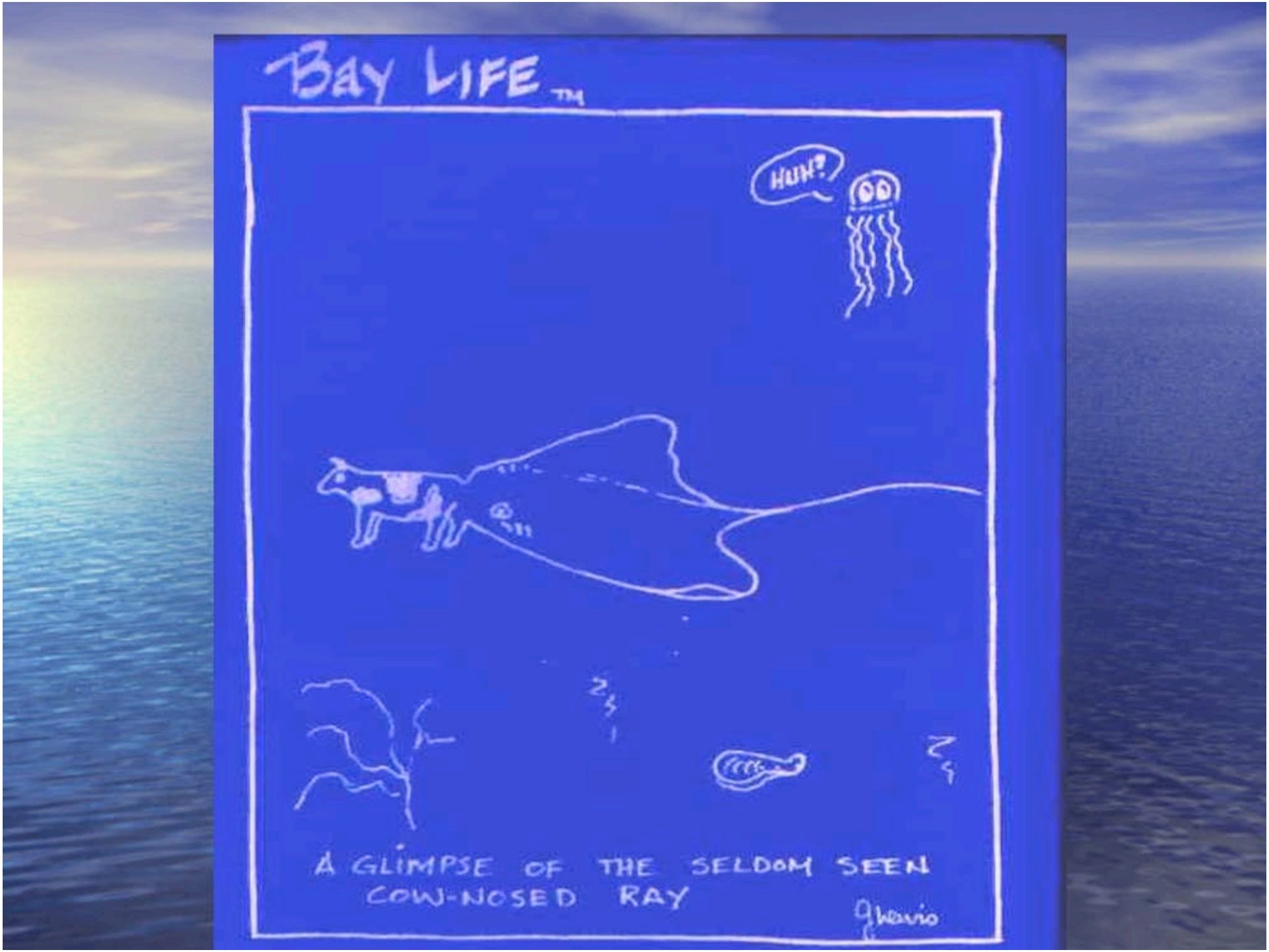
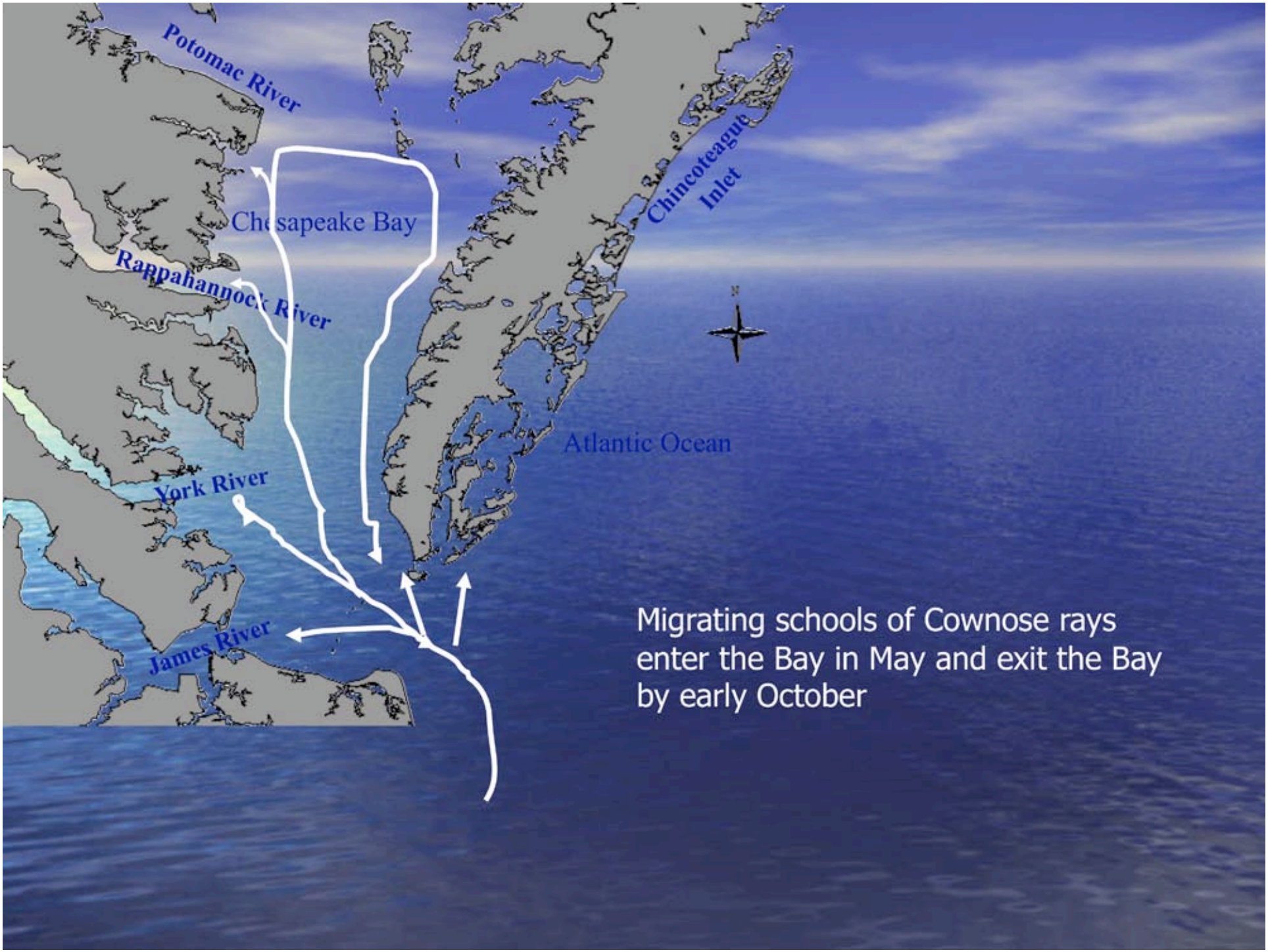

Cownose Ray Projects in Virginia
Bob Fisher
VA Sea Grant MAP
Virginia Institute of Marine Science
College of William and Mary


BAY LIFE ™
HUH?
A GLIMPSE OF THE SELDOM SEEN
COW-NOSED RAY
Gwavio


Potomac River
Chesapeake Bay
Rappahannock River
York River
James River
Chincoteague Inlet
Atlantic Ocean
Migrating schools of Cownose rays enter the Bay in May and exit the Bay by early October

Research Attempts at VIMS, VA Sea Grant

- 1990-2005 CNR Committees: VIMS-VA Sea Grant, VA TECH, VMPB, VSC, VMRC, VA Dept. of Ag, VA Watermen's Association, Working Watermen's Association, Cowards Seafood, Huff and Puff Pet Foods, Zapata Haynie Corp., B&G Shellfish Interp., International Seafood Inc, Cherrystone Aqua-Farms, Bevans Oyster
- Funded Research: Product Development 1991; FRG Portable Anchor Trap Net, 2001(Jenkins); FRG Value of Cownose Ray: Population size, Harvesting, Processing and Marketing Acceptance, 2005 (Ransone) Extension into 2006


Tropical and Subtropical Fisheries
Technological Conference of the Americas
(Raleigh, NC 1991)
Product Development: Cownose Ray (Rhinoptera bonasus)
Robert Fisher, VIMS-VA Sea Grant
Patricia Lacey, VPI-VSAES

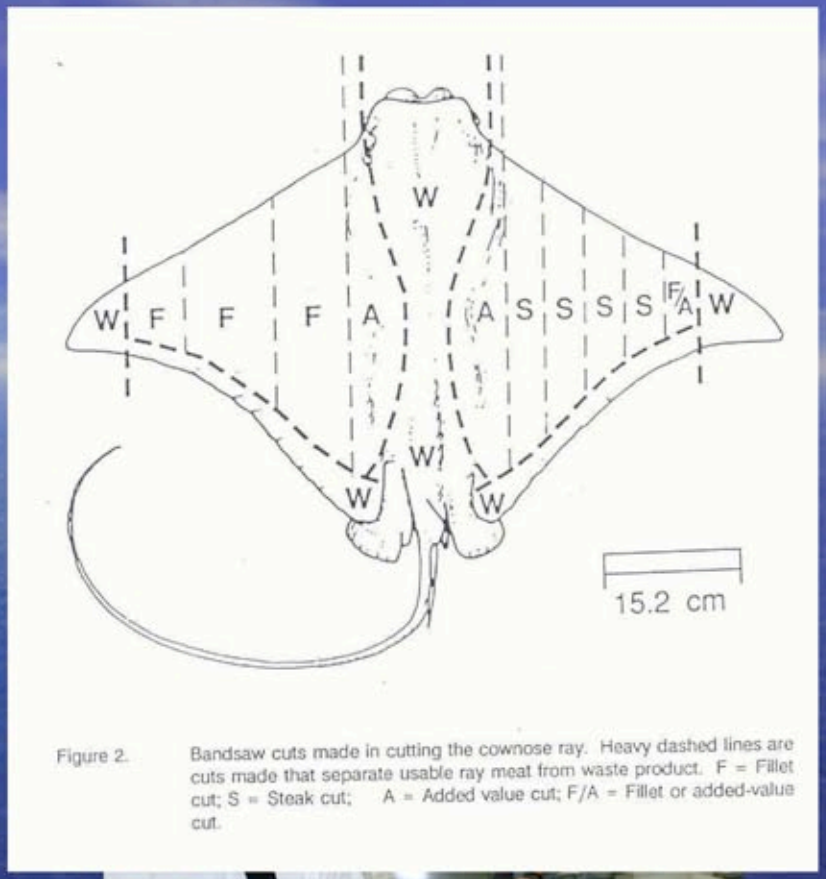
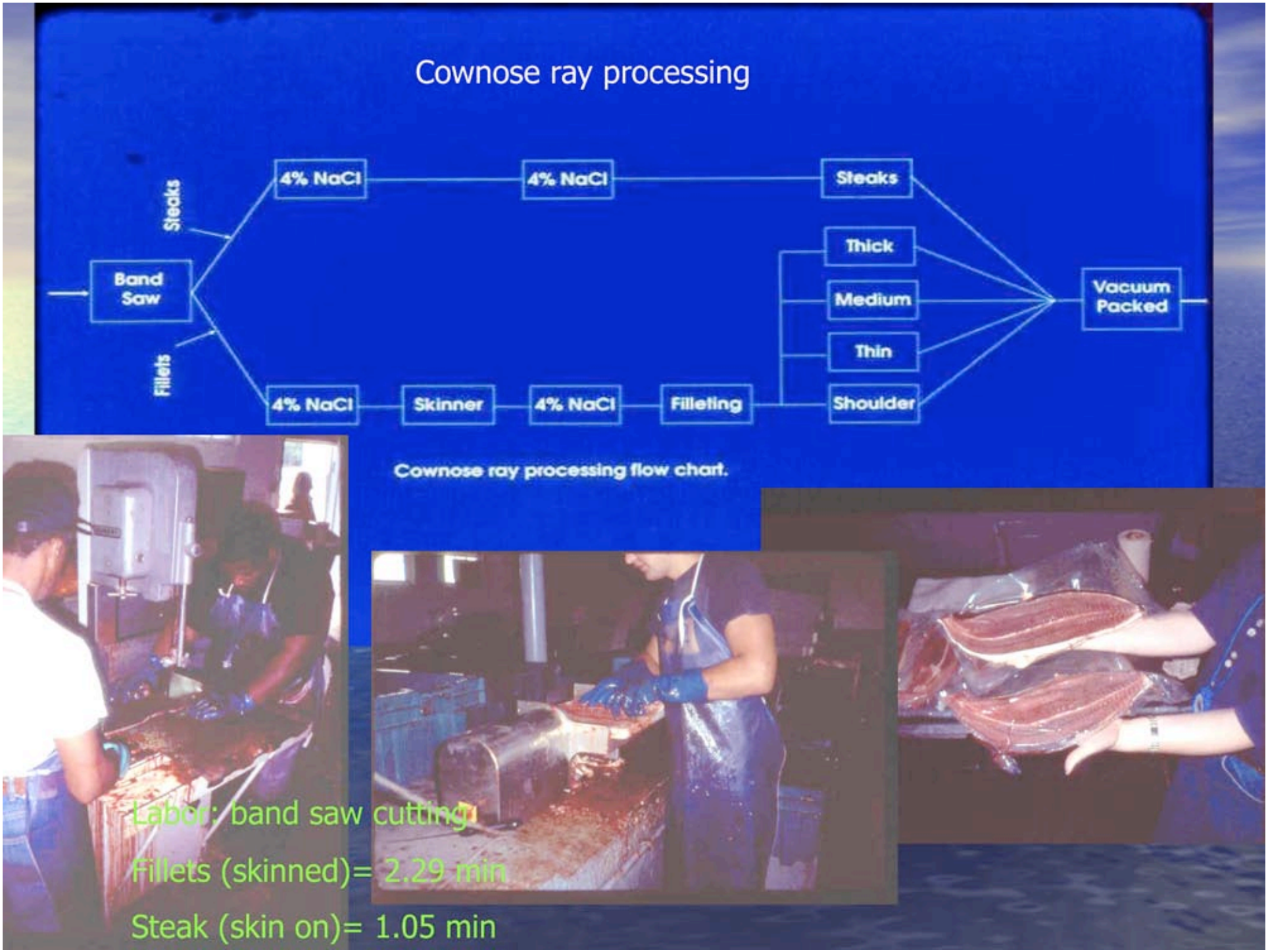


Figure 2. Bandsaw cuts made in cutting the cownose ray. Heavy dashed lines are cuts made that separate usable ray meat from waste product. F = Fillet cut; S = Steak cut; A = Added value cut; F/A = Fillet or added-value cut.

Ray body meat not used in previous "wing" market attempts


Cownose ray processing
Steaks
Band Saw
Fillets
4% NaCl
4% NaCl
Steaks
Thick
Medium
Thin
Shoulder
Vacuum Packed
4% NaCl
Skinner
4% NaCl
Filleting
Cownose ray processing flow chart.
Labor: band saw cutting
Fillets (skinned)= 2.29 min
Steak (skin on)= 1.05 min

CNR Processing yields, Economic Cost

(1991)

- Product Yield; edible 29.03%, waste 70.97%
- Cost of producing vacuum packed product

Prime contributors:	Ray purchase	41%
	direct labor	20%
	ice	14%
	packaging	9%

Estimated over all cost to produce vac pack ray (fillet or steak) $1.26/lb

Public tasting of "Chesapeake Ray"

- Hampton Bay Days: family oriented 3 day outdoor festival

ray preparation; grilled, bite size portions

Approximately 500 people tried the ray

232 completed the questionnaire provided

207 rated the ray "good" or "very good" (89%)

165 had never heard of cownose ray

Frozen storage study

-Cost of producing vacuum packed product $1.26 per pound

-Previous study (Licciardello and Ravesi, 1987), sensory and chemical analyses acceptable after 60 weeks

Test market in retail outlet

50lbs of ray wing fillets and steak cuts; priced at $1.99/lb

Sold out over weekend

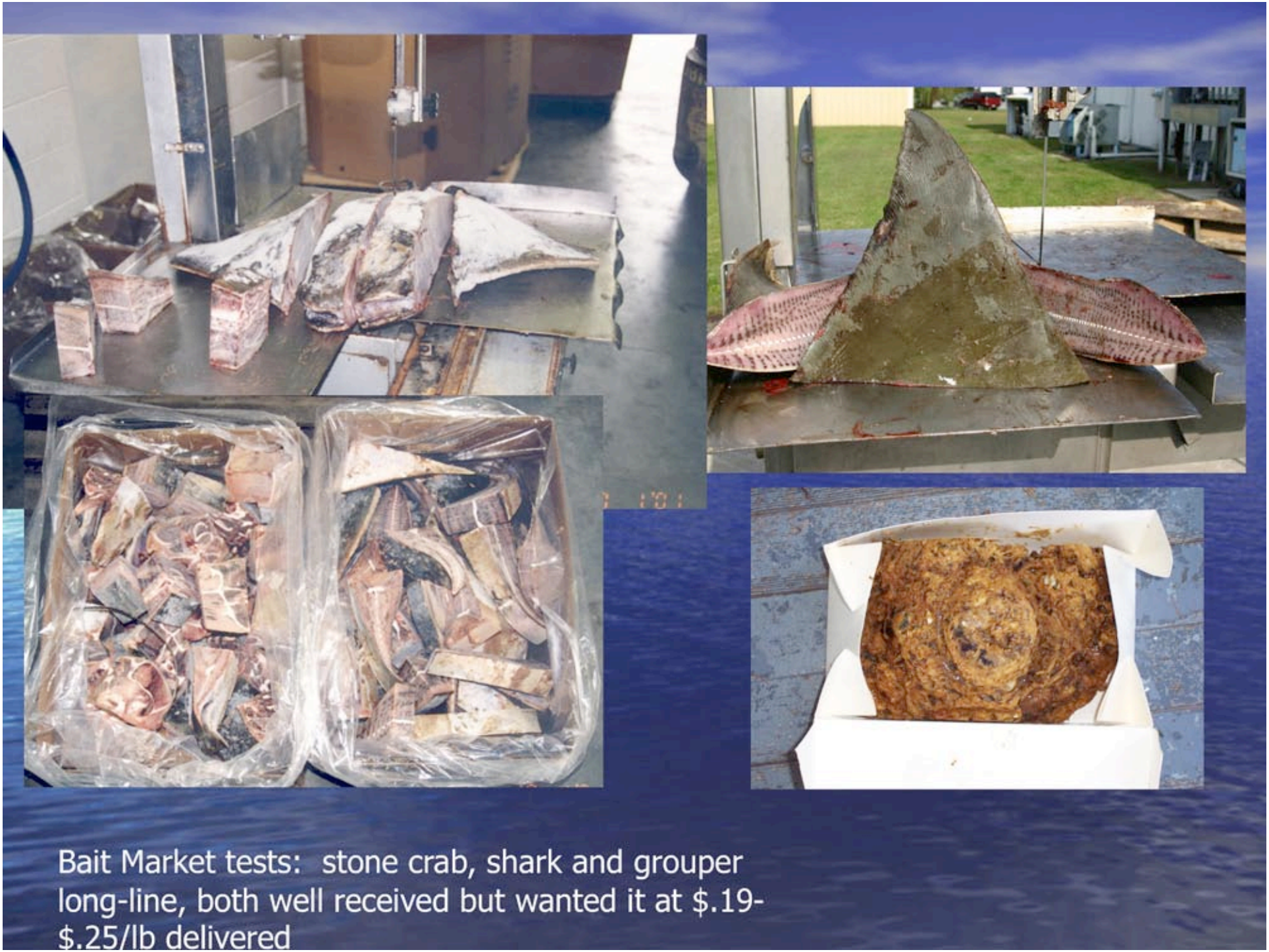
FRG Portable Anchor Trap Net (2003/4)

Pound net design: 7″ str mesh, fished in 8-16 ft of water, set in 6-8 hrs, taken up in 4-5 hrs.

Ray Processing Yield (1991)

Edible flesh	29.03%
Waste	70.97%

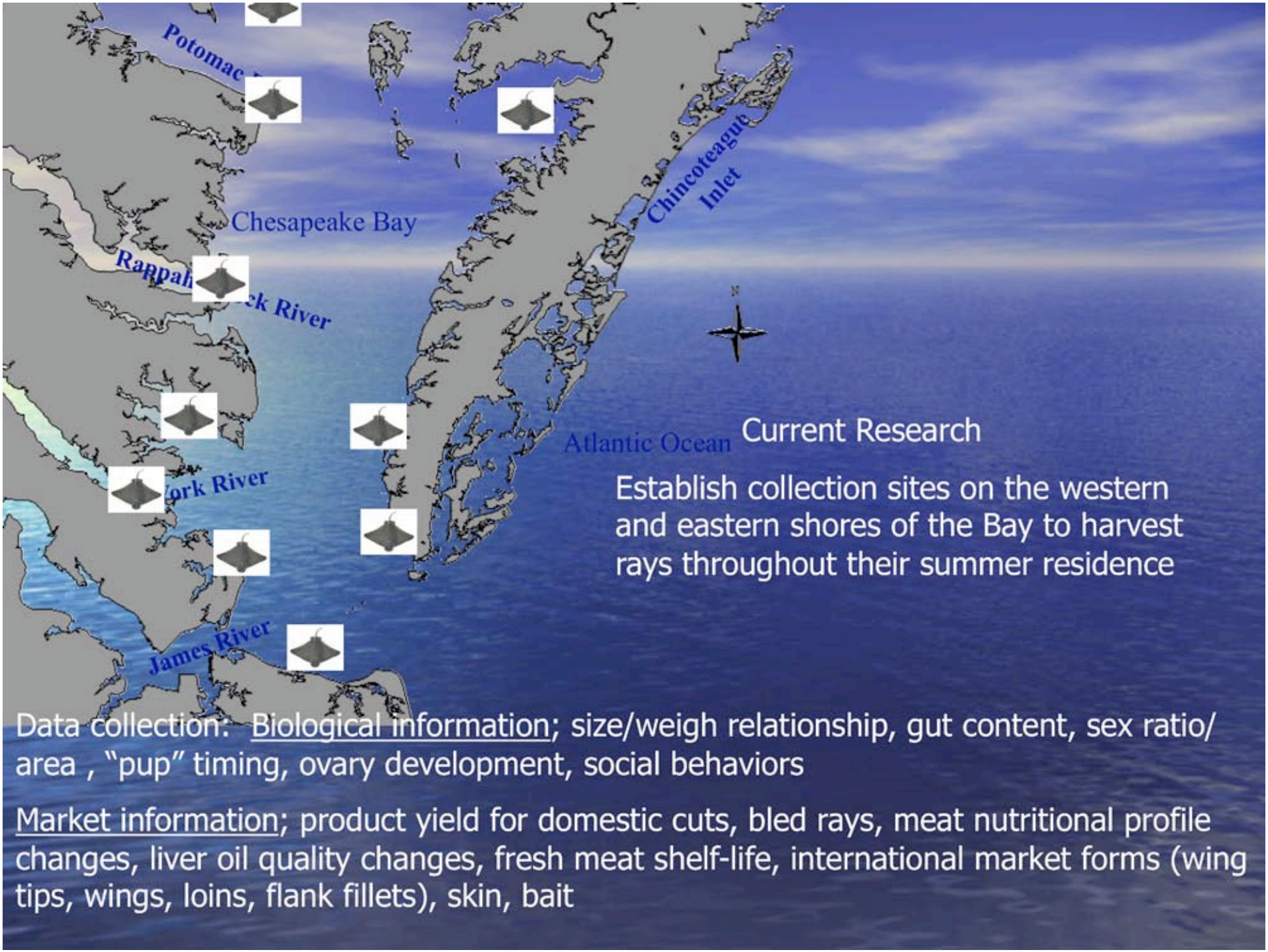

For bait markets
Easier and safer to cut rays frozen
(except for chum in commercial opperations, ruptured exit hoses)


Bait Market tests: stone crab, shark and grouper long-line, both well received but wanted it at $.19-$.25/lb delivered

Tested as alternative bait in the VA whelk fishery, compared to horseshoe crab:

ray flesh, 0.59 catch rate

Being evaluated: ground ray/ground hsc (1:1)


Potomac
Chesapeake Bay
Rappah
ck River
ork River
James River
Chincoteague
Inlet
Atlantic Ocean
Current Research
Establish collection sites on the western and eastern shores of the Bay to harvest rays throughout their summer residence
Data collection: Biological information; size/weigh relationship, gut content, sex ratio/ area , "pup" timing, ovary development, social behaviors
Market information; product yield for domestic cuts, bled rays, meat nutritional profile changes, liver oil quality changes, fresh meat shelf-life, international market forms (wing tips, wings, loins, flank fillets), skin, bait

Cownose ray wing fillets including the body meat

Ray flesh yield= 33.6% (2006)


Visiting Korean buyers evaluating cownose ray prepared using traditional Korean recipes.

A Ray of Hope: Finding a Market for the Chesapeake Ray

Shirley Estes
Virginia Marine Products Board
554 Denbigh Blvd., Suite B
Newport News, VA 23608

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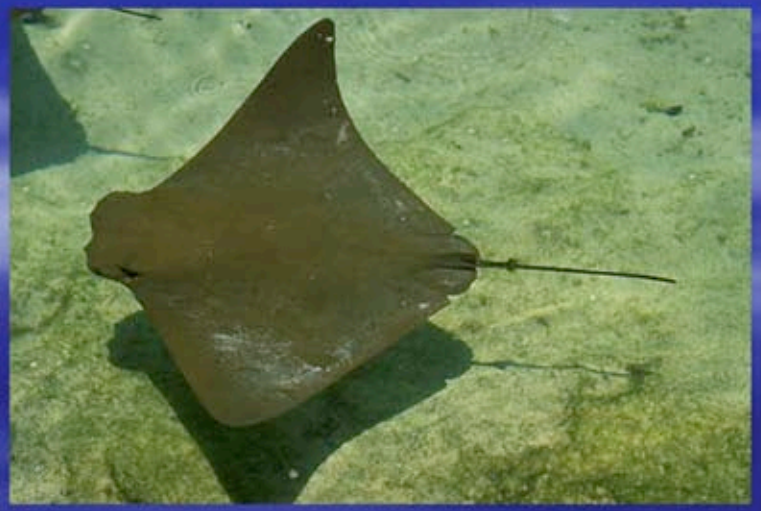
A Ray of Hope

Finding a Market for the Chesapeake Ray



International

- South Korea imports approximately 18 million dollars of frozen ray annually
- Top suppliers are Argentina, Brazil, Vietnam and USA
- Ninety five percent of all ray is sold as frozen wings—both skin on and skin off. Sizes are 2.2-4.4 lbs Average price less than $1 per pound

Busan International Seafood and Fisheries Expo Busan, Korea 2005

- Largest seafood show in Korea.
- Displayed, prepared and sampled ray
- Ray importers are interested in price quotes

Ray Korean Style

- Ninety five percent of the ray is sold in restaurants
- The most popular way ray is prepared is with hot or cold noodles
- Another is in a traditional hot, red chili sauce

The Great American Seafood Festival

- A two week event featuring VA Seafood sponsored by SUSTA at the Chosin Beach Hotel in Busan, Korea
- The American Embassy hosted eleven major Korean Buyers for Thanksgiving
- Ray was featured with rave reviews

Domestic Market

- Potential in Food Service Market
- Work with Chef John Maxwell and Culinary Students
- Presentation to the Northeast Regional American Culinary Federation Conference

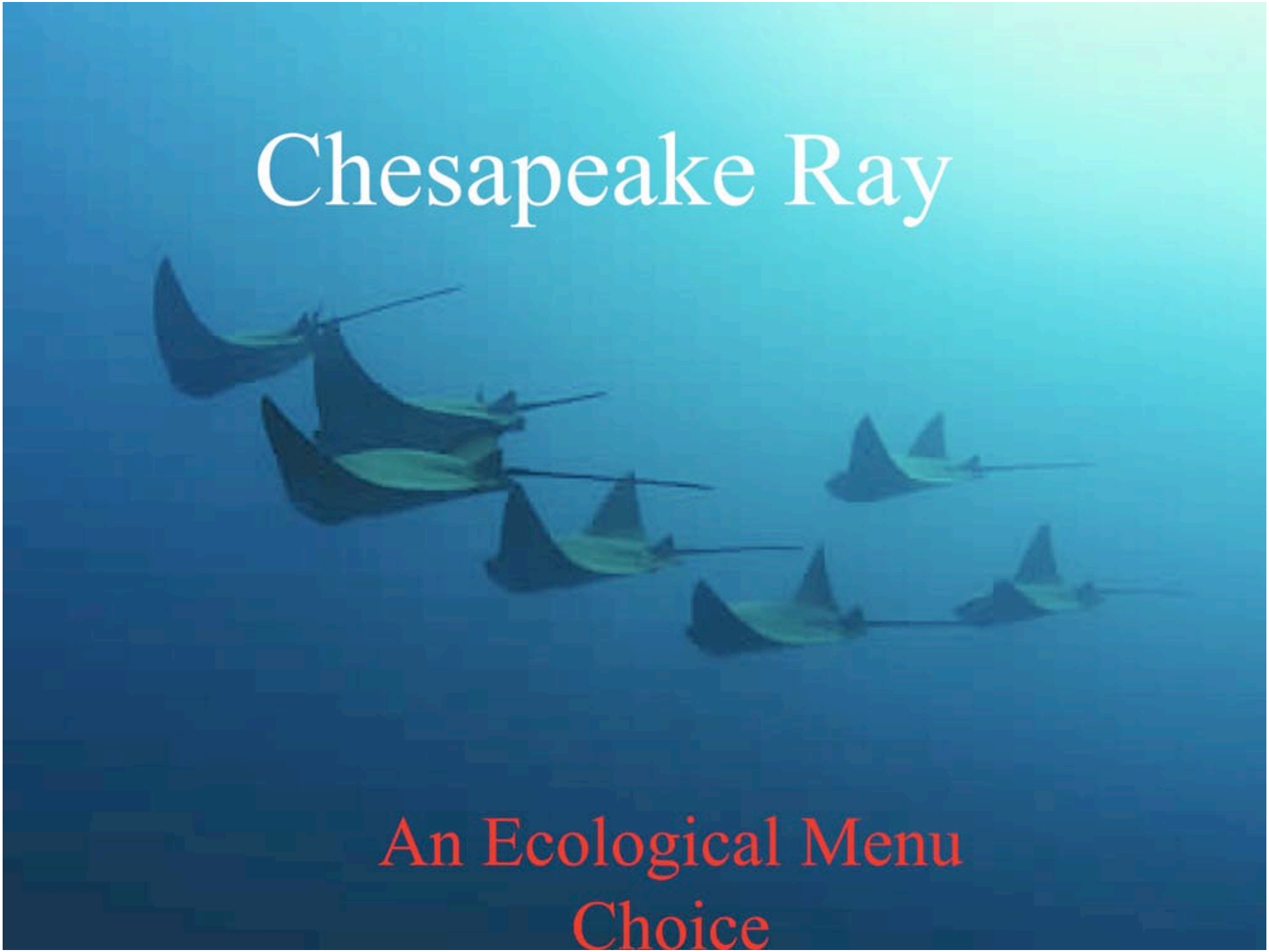
Leather Market

- Sting ray leather items are very high end--handbags, belts, wallets, briefcases, boots
- Sold in US. Also popular in Korea. Many appear to be made in Thailand
- Next step to test Chesapeake ray with tanners

Chesapeake Ray: An Ecological Menu Choice

Chef John Maxwell, CEC, AAC
Culinary Instructor
1936 North Washington Street
Highland Springs, Virginia 23075

Presenter did not provide abstract. Page intentionally left blank.


Chesapeake Ray
An Ecological Menu Choice

Marketing The New Red Meat

- Presented By
  - John T. Maxwell, CEC, AAC

- Purpose
- To Discuss Recent Domestic Marketing Efforts
- To Discuss Potential Domestic Marketing Efforts

Initial Research and Development

The Culinary School at J. Sargeant Reynolds Community College

- Fabrication
- Cooking Methods
- Recipe Development

Learning Fabrication

Hands on For Students

Cooking Methods

- Smoking Cured Ray

Many Methods Were Tried

Southern Fried Was Popular

The Most Successful Methods

- Sautéed
- Grilled
- Broiled

- Ray Takes Marinades Well
- Useable in a Variety of Recipes
- Useable in Cross Cultural Applications
- Makes a Wonderful Soup

Recipe Development

- Caul Wrapped Ray With Truffles
- Chesapeake Ray Fajitas
- Chesapeake Ray Sauté
- Korean Inspired Ray Soup
- Pan Seared Ray with Mocha Red Eye
- Chesapeake Ray with Mushroom Crust

Presentation to ACF Virginia Chefs

- Demo Presented at Monthly Meeting
- Ray Used in Mystery Basket Cooking Competition Won By Rennie Parzialle of Williamsburg

American Culinary Federation Northeast Region Conference

Toronto Canada

Two Seminars

- Power Point Presentation
- Recipe Presentation
- Hands On Activities

The Toronto Power Point Presentation

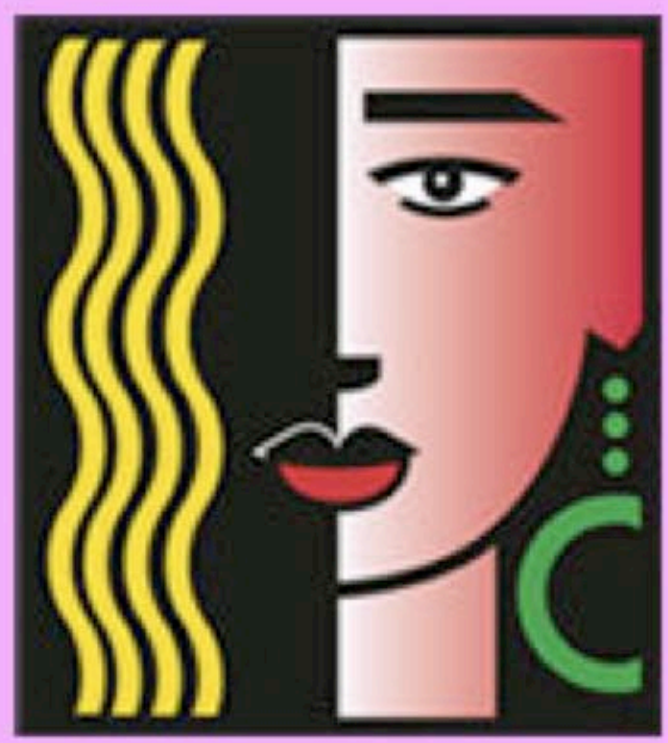
Microsoft
werPoint Presentati

Savor Virginia, Richmond, March 22

Presentation to Food Professionals

- Presentation on Cuisine
- Recipe Demonstration Using Ray
- Tasting of Ray and Other Products

Southern Women's Show



Three Days with Ray

- Tasting for several hundred visitors
- Use in Iron Chef Competition

Tasting Ray

Hundreds of Samplers Each Day

The Iron Chef Contest

- T. J.'s at the Jefferson vs. Morton's Steakhouse

Chef Jannika Bennet Defeats Chef Christopher Bak Using Chesapeake Ray

Chef Maxwell's Kitchen

- Reaches millions of viewers each month
- Airs in 85 markets
- Airs in 5 states and DC

Down Home Virginia

Biology and Life History of *Rhinoptera bonasus* (Cownose Ray)

R. Dean Grubbs
Virginia Institute of Marine Science
PO Box 1346
Gloucester Point, VA 23062

There are more than 650 living species of batoid fishes (skates, rays, and relatives). The cownose ray, *Rhinoptera bonasus*, is a member of the order Myliobatiformes which includes ten highly-evolved families of stingrays. Cownose rays and other members of the family Myliobatidae are coastal pelagic species that often travel in schools. They possess brains that are among the largest of all fishes and comparable to many mammals. From the Greek "Mylos" which translates to "grinder" and "batis" which translates to ray or skate, the name alludes to the fact that myliobatid rays are durophagous predators feeding primarily on mollusks and crustaceans. Enlarged jaw muscles, highly calcified jaws, and hard pavement-like tooth plates enable myliobatid rays to feed on these hard-shelled prey. In addition, the tooth plates are interlocked such that the bite force is distributed across the whole jaw, rather than on a single point.

Cownose rays (Genus *Rhinoptera*) possess jaws that are as strong as the bat rays and bullnose rays (Genus *Myliobatis*) and most studies have reported that the dominant prey for cownose rays are small, weak-shelled bivalves, though Collins et al. (2005) reported that cownose rays from the Gulf Coast of Florida fed primarily on crustaceans (mostly cumaceans) and sedentary polychaetes. Concerns over predation on commercial bivalve resources have been raised by the commercial industry for many decades and in several regions of the world. However, little evidence of actual predation on these resources has been documented. Smith and Merriner (1985) reported that the dominant prey for cownose rays caught in Chesapeake Bay during the late 1970's were soft clams (*Mya arenaria*), Baltic macoma clams (*Macoma balthica*), and stout razor clams (*Tagelus plebeus*). The remains of oysters (*Crossostrea virginica*) were only found in one stomach and hard clams (*Mercenaria mercenaria*) were only identified in three stomachs. No samples were collected in this study from known oyster beds however. In an analogous case study, the oyster aquaculture industry in California reported high losses due to predation by California bat rays (*Myliobatis californica*). However, examination of 503 stomachs collected by the oyster industry on the primary oyster beds revealed no predation on oysters (Gray et al. 1997). Like cownose rays in Chesapeake Bay, the primary prey were species of bivalves with relatively weak shells as well as various crustaceans and polychaetes. Gray et al. (1997) predicted that culling operations to rid the oyster beds of bat rays may actually increase oyster predation through increased survivorship of red rock crabs (*Cancer productus*), which are known oyster predators but are a major prey species for large bat rays. In Chesapeake Bay, soft clam populations are now depressed and there is concern that cownose rays have shifted to feeding on oysters and hard clams instead. In addition, the fact that cownose rays primarily feed on weakly calcified bivalves suggests that young life stages of oysters and clams may be particularly susceptible to predation

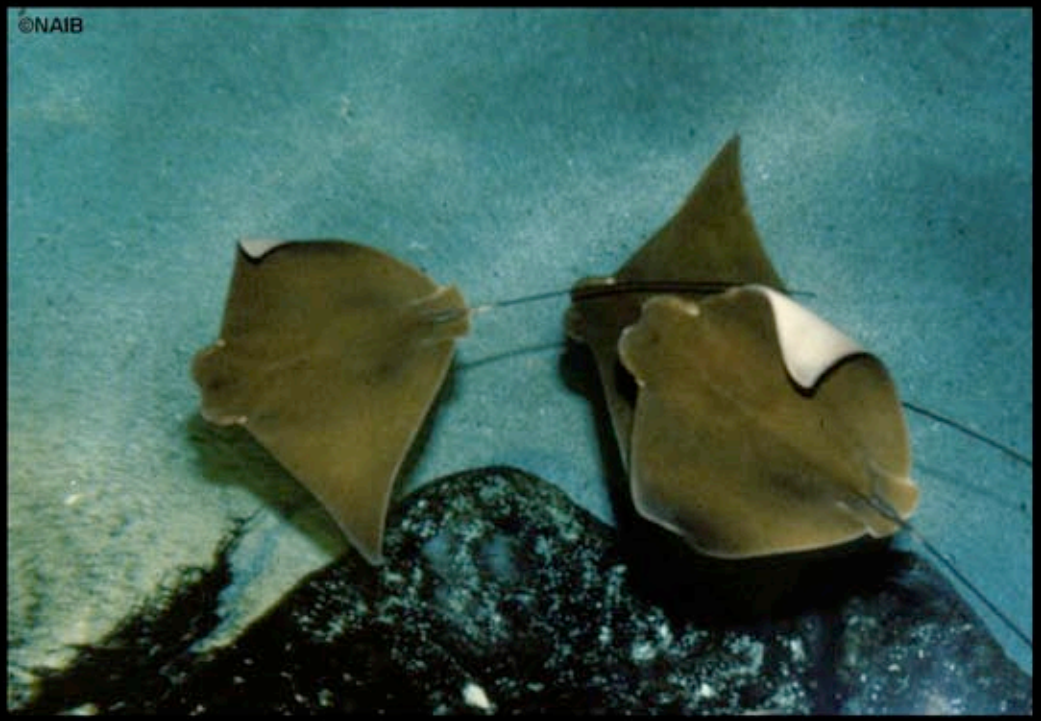
by cownose rays when concentrated by grow-out and seeding operations. Reports from the aquaculture industry support this hypothesis.

Like all elasmobranch fishes, cownose rays mature slowly. Smith and Merriner (1987) estimated that females mature in 7-8 years and males in 5-6 years in Chesapeake Bay. This study was based on relatively small sample sizes however, and more complete study of age and growth in cownose rays along the East Coast is needed. Cownose rays possess two parallel reproductive tracts. Both left and right testes are functional in males, however, only the left reproductive tract is functional in females. Fertilization is internal through paired claspers that act as intromittant organs. An ovulated egg is fertilized in the oviducal gland and passed into the uterus where development takes place. The developing embryo initially gains nourishment from protein- and lipid-rich yolk in an external yolk-sac attached directly to the digestive tract. Later development is supported by lipid-rich histotroph (uterine milk) secreted by trophenemata, thousands of villi which extend from the mother's uterine wall. Most embryonic growth is through digestion of histotroph and the relative change in organic content between the egg and the term embryo is several thousand percent (Ranzi 1934). A female cownose ray only gives birth to a single offspring following a gestation period of 11 to 12 months (Smith and Merriner 1986, Neer 2005). Reports of cownose rays producing more than one pup are likely due to confusion with closely related bullnose rays (*Myliobatis fremenvillii*) which commonly produces up to eight pups (Grubbs, unpublished data) and bluntnose stingrays (*Dasyatis say*) which produce up to six pups (Snelson et al. 2005). Ovulation takes place soon after parturition, suggesting one pup is produced annually by a mature female. Chesapeake Bay may be the largest pupping area for cownose rays in the western Atlantic.

There are five species of cownose rays (Genus *Rhinoptera*) worldwide, but only *R. bonasus* occurs along the East Coast of the United States. In the Western Atlantic, this species is distributed from southern New England to Brazil and throughout the Gulf of Mexico. Tagging studies and differences in life history data suggest cownose rays in the Gulf of Mexico, U.S. East Coast, and Brazil may be distinct subpopulations. Cownose rays undergo long seasonal migrations similar to those exhibited by most coastal sharks (Smith and Merriner 1987, Grusha 2005). In spring, they migrate north, reaching the Outer Banks of North Carolina by April. The first cownose rays enter Chesapeake Bay in early May and peak abundance occurs from June through September. Cownose rays are abundant in Chesapeake Bay and its tributaries throughout summer, occurring at salinities as low as 8 (practical salinity scale) and temperatures from 15-29°C (Smith and Merriner 1987). By early October, most cownose rays have vacated Chesapeake Bay to begin their southerly migration to wintering areas, primarily off the coast of Florida. Cownose rays equipped with satellite transmitters traveled an average of 6.7 NM per day during this south-bound migration and wintered offshore near the edge of the continental shelf off Florida (Grusha 2005).

Late maturity and extremely low fecundity render the cownose ray highly susceptible to overexploitation. No reliable estimates of population size or population change exist. Reports of large population increases have been based on highly-biased data sets. Neer (2005) reported that the maximum rate of population change for cownose rays in the Gulf of Mexico is only 2.7%. Their life history mandates that extreme caution be exercised in developing any fishery for this species. High fishing pressure in seine and pair trawl fisheries in Brazil have resulted in very large declines in the sympatric Ticon cownose ray (*Rhinoptera brasiliensis*) which is currently listed by the World Conservation Union's Redlist of Threatened Species as "Endangered". Due to its similar life history and unregulated mortality due to interactions with bivalve fisheries and aquaculture operations, the IUCN currently lists the cownose ray (*R. bonasus*) as "Near Threatened" worldwide, but "Least Concern" in the United States. However, it is stated in the assessment "if a fishery for cownose rays is ever established, it could be devastating to the population without proper monitoring." Cownose rays are highly-migratory, which mandates regional management, and many biological data gaps must be filled prior to developing a fishery to insure sustainability. Of utmost importance are estimates of intrinsic rates of population growth and population doubling times. This requires investigation of age and growth, natural mortality rates, and estimation of population size. In addition, thorough studies of the trophic ecology, habitat use, and ecosystem function of cownose rays are needed.

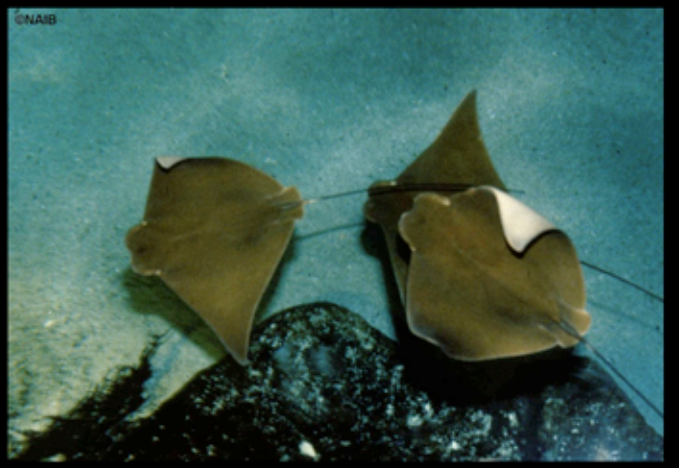
Biology and Life History of *Rhinoptera bonasus* (cownose ray)



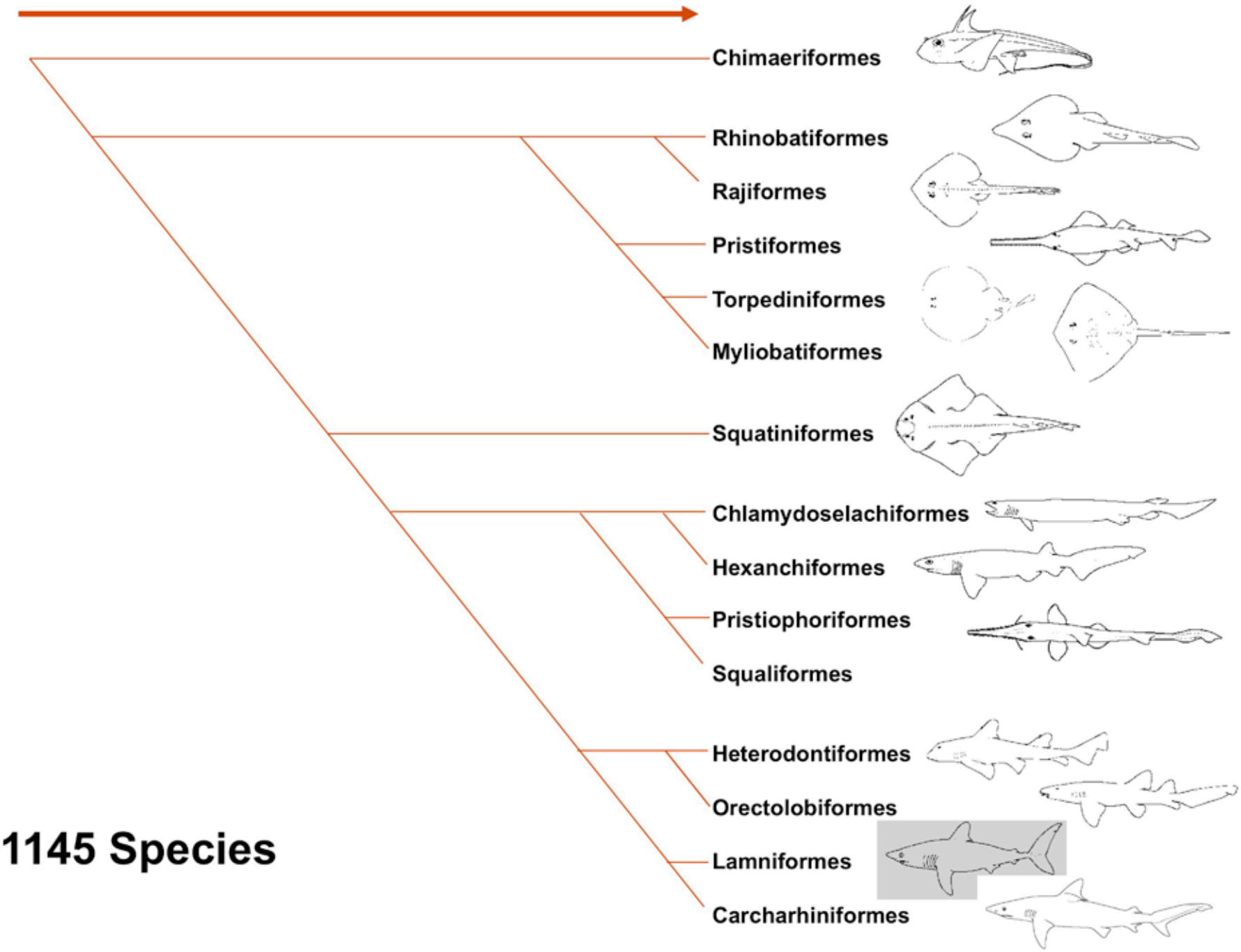
Dean Grubbs
Program Manager – VIMS Shark Ecology Program
and VIMS Shark Longline Survey

Virginia Institute of Marine Science

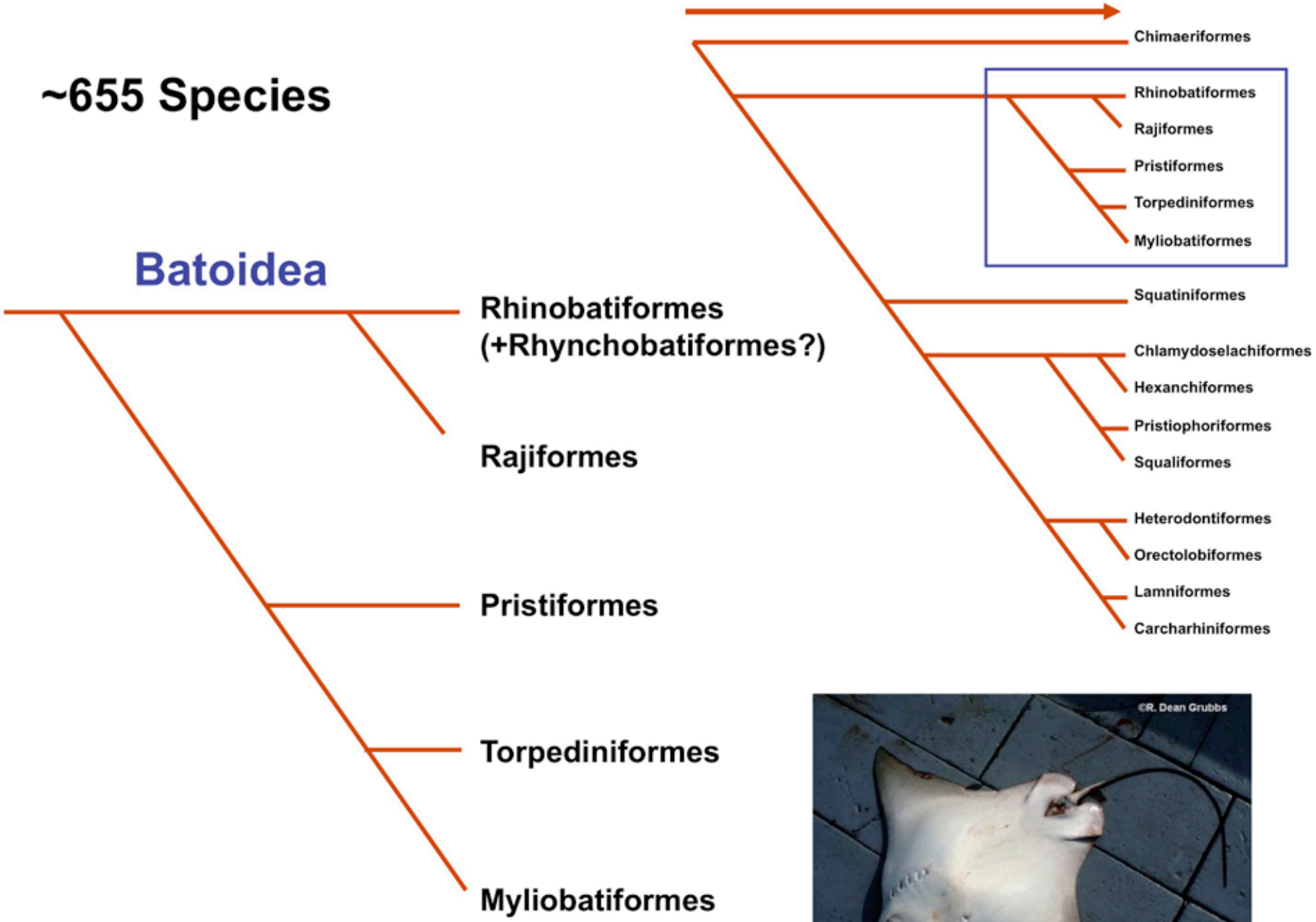
Biology and Life History of *Rhinoptera bonasus* (cownose ray)



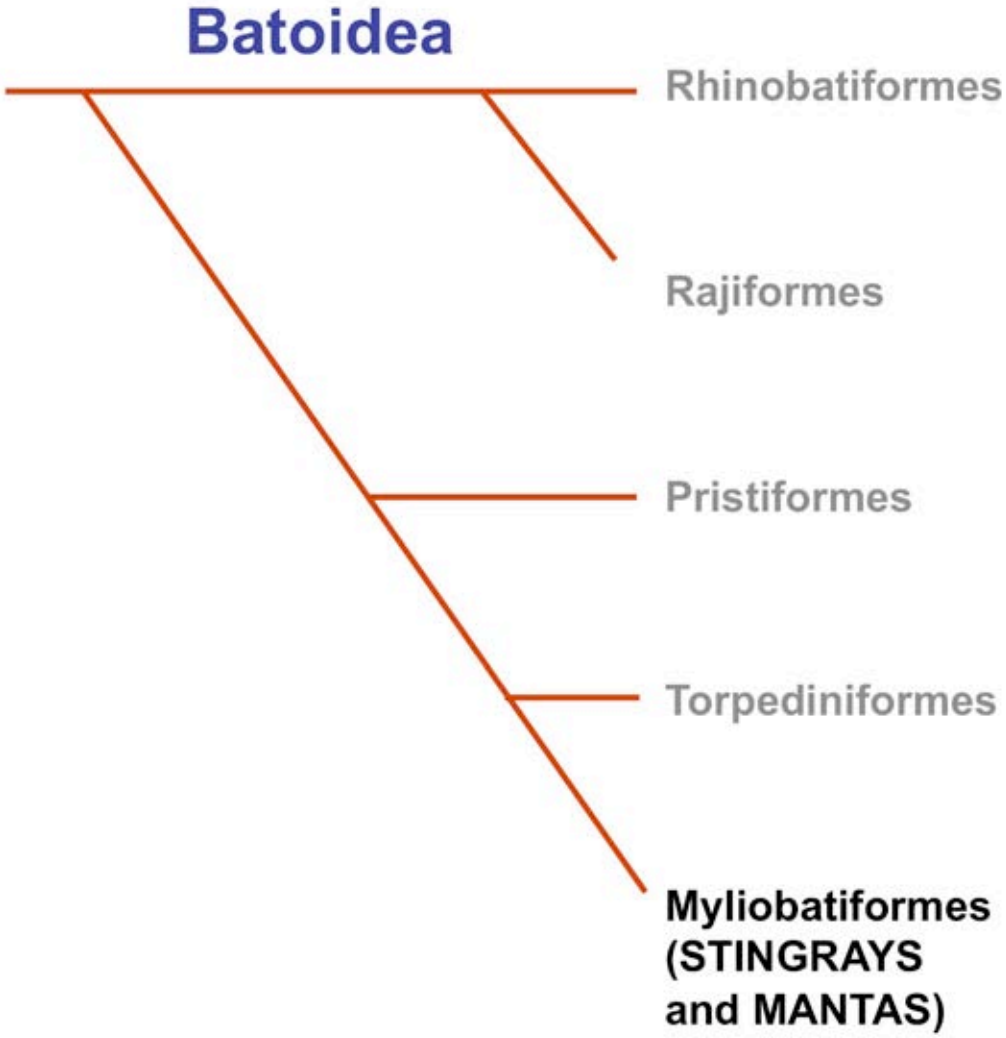
- Taxonomy
  - Trophic Ecology
- Life History Traits
  - Reproductive Biology
  - Age and Growth
  - Population Growth / Data Needs
- Movements and Distribution
- History in Chesapeake Bay
- Conservation and Sustainability


Chimaeriformes
Rhinobatiformes
Rajiformes
Pristiformes
Torpediniformes
Myliobatiformes
Squatiniformes
Chlamydoselachiformes
Hexanchiformes
Pristiophoriformes
Squaliformes
Heterodontiformes
Orectolobiformes
Lamniformes
Carcharhiniformes
~1145 Species

~655 Species


Batoidea
Rhinobatiformes
(+Rhynchobatiformes?)
Rajiformes
Pristiformes
Torpediniformes
Myliobatiformes
Chimaeriformes
Rhinobatiformes
Rajiformes
Pristiformes
Torpediniformes
Myliobatiformes
Squatiniformes
Chlamydoselachiformes
Hexanchiformes
Pristiophoriformes
Squaliformes
Heterodontiformes
Orectolobiformes
Lamniformes
Carcharhiniformes

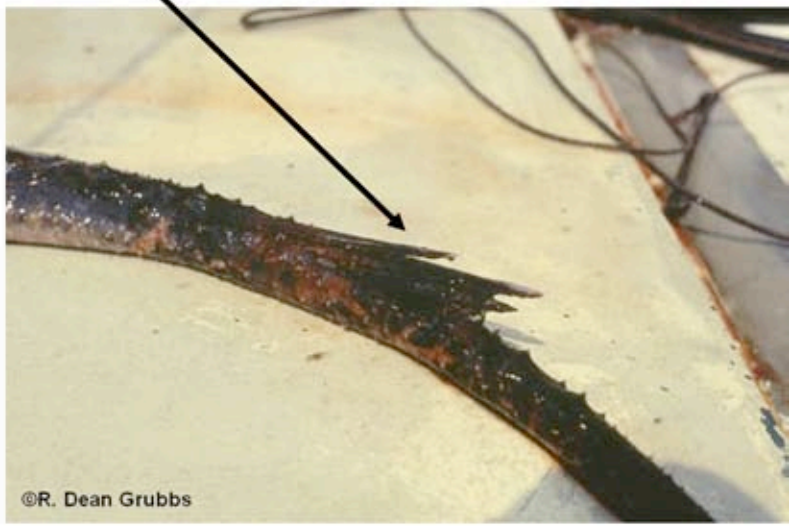
©R. Dean Grubbs



Greek "*Mylos*" = grinder

Greek "*batis*" = ray, skate

SPINES from *Dasyatis centroura*



Durophagy = consumption of hard prey

durus **– Latin for "hard" or "tough", root of durable**

phagein **– Greek meaning "to eat"**

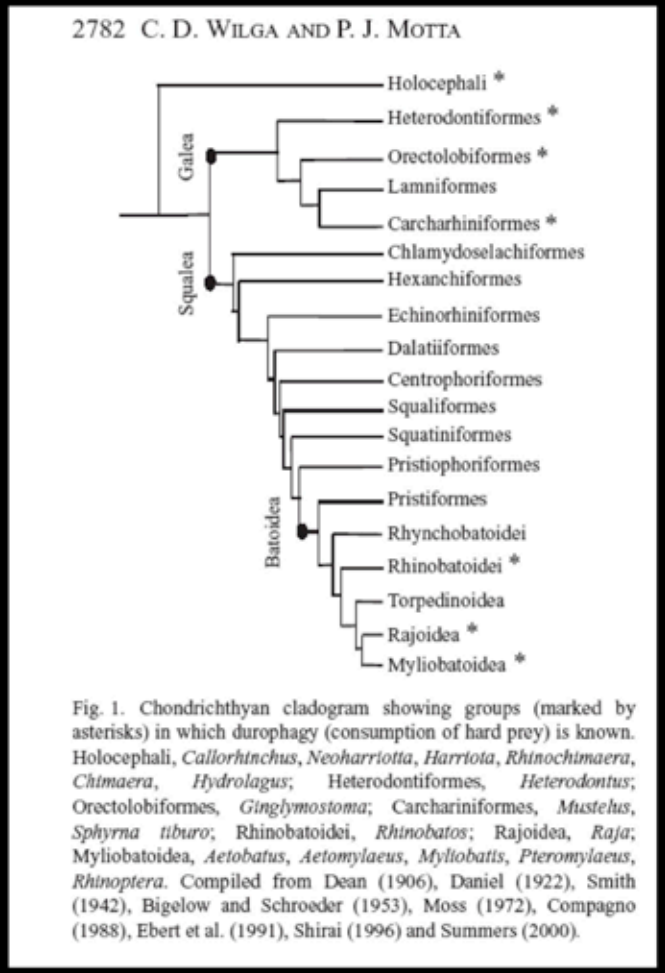


Fig. 1. Chondrichthyan cladogram showing groups (marked by asterisks) in which durophagy (consumption of hard prey) is known. Holocephali, *Callorhinchus*, *Neoharriotta*, *Harriota*, *Rhinochimaera*, *Chimaera*, *Hydrolagus*; Heterodontiformes, *Heterodontus*; Orectolobiformes, *Ginglymostoma*; Carchariniformes, *Mustelus*, *Sphyrna tiburo*; Rhinobatoidei, *Rhinobatos*; Rajoidea, *Raja*; Myliobatoidea, *Aetobatus*, *Aetomylaeus*, *Myliobatis*, *Pteromylaeus*, *Rhinoptera*. Compiled from Dean (1906), Daniel (1922), Smith (1942), Bigelow and Schroeder (1953), Moss (1972), Compagno (1988), Ebert et al. (1991), Shirai (1996) and Summers (2000).

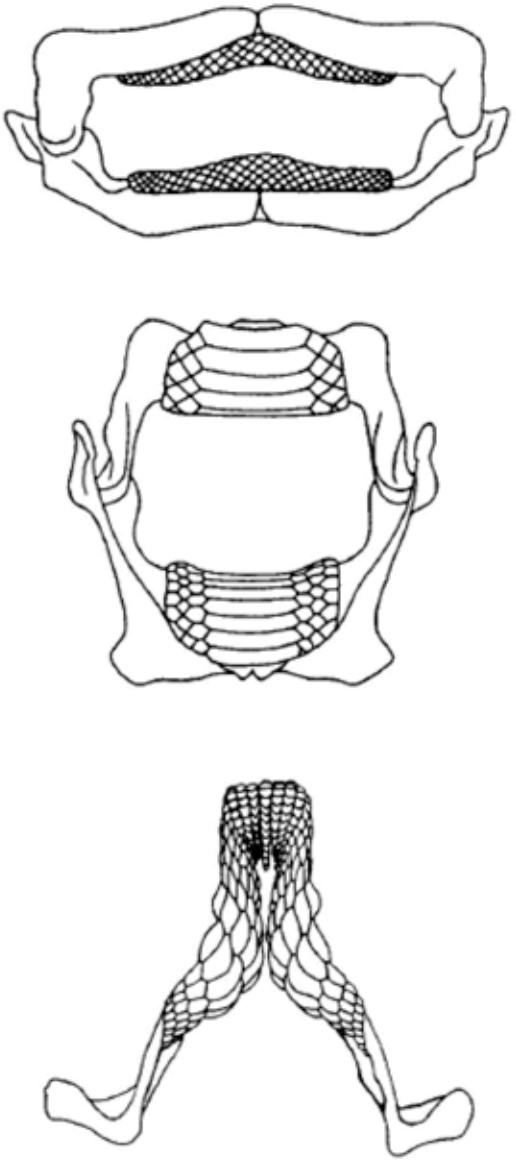


Fig. 2. Selected dental types in elasmobranchs. Crushing type represented by *Raja* (top), grinding by *Myliobatis* (middle) and clutching-grinding by *Heterodontus* (lower jaw only) (bottom) (after Cappetta, 1987).

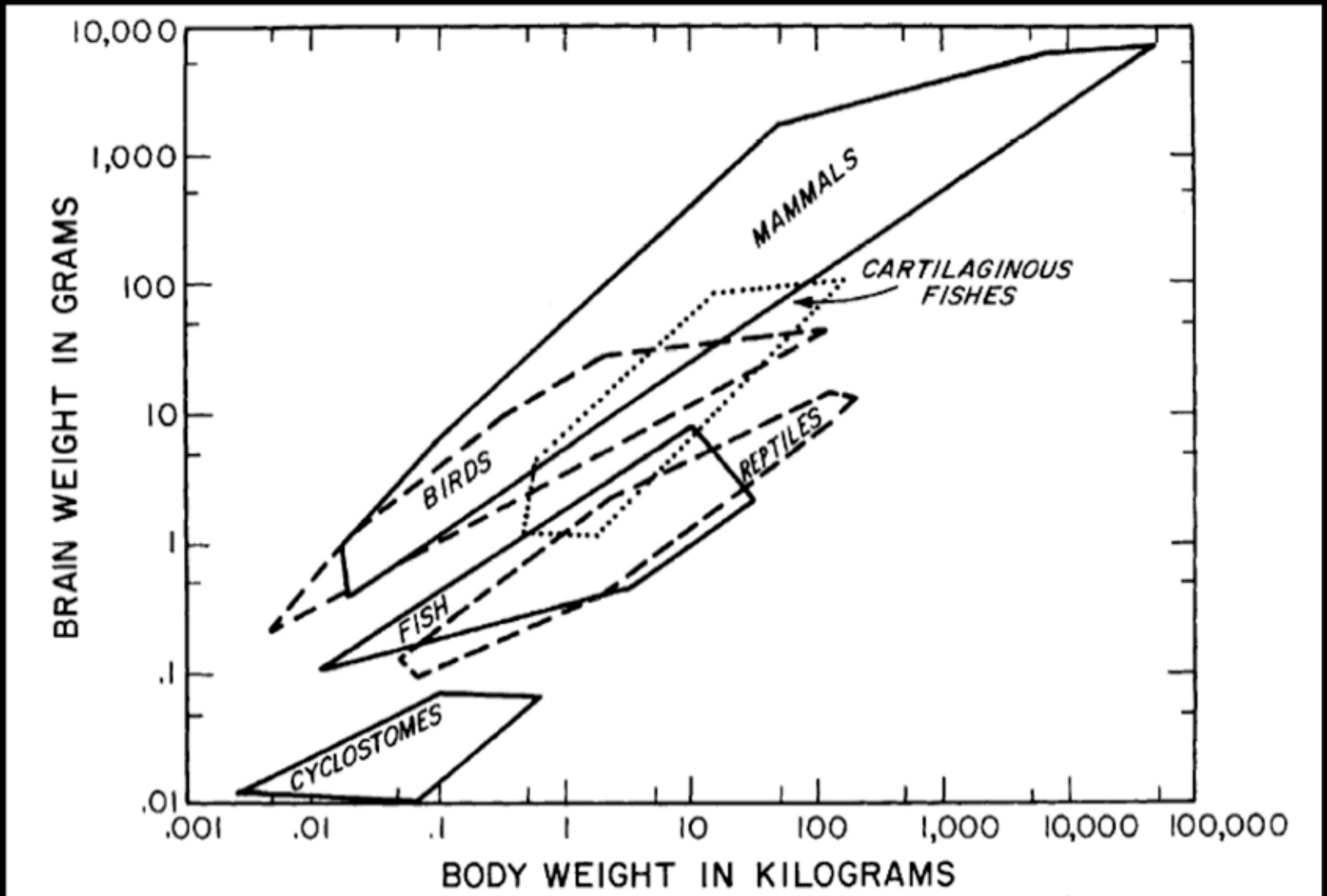
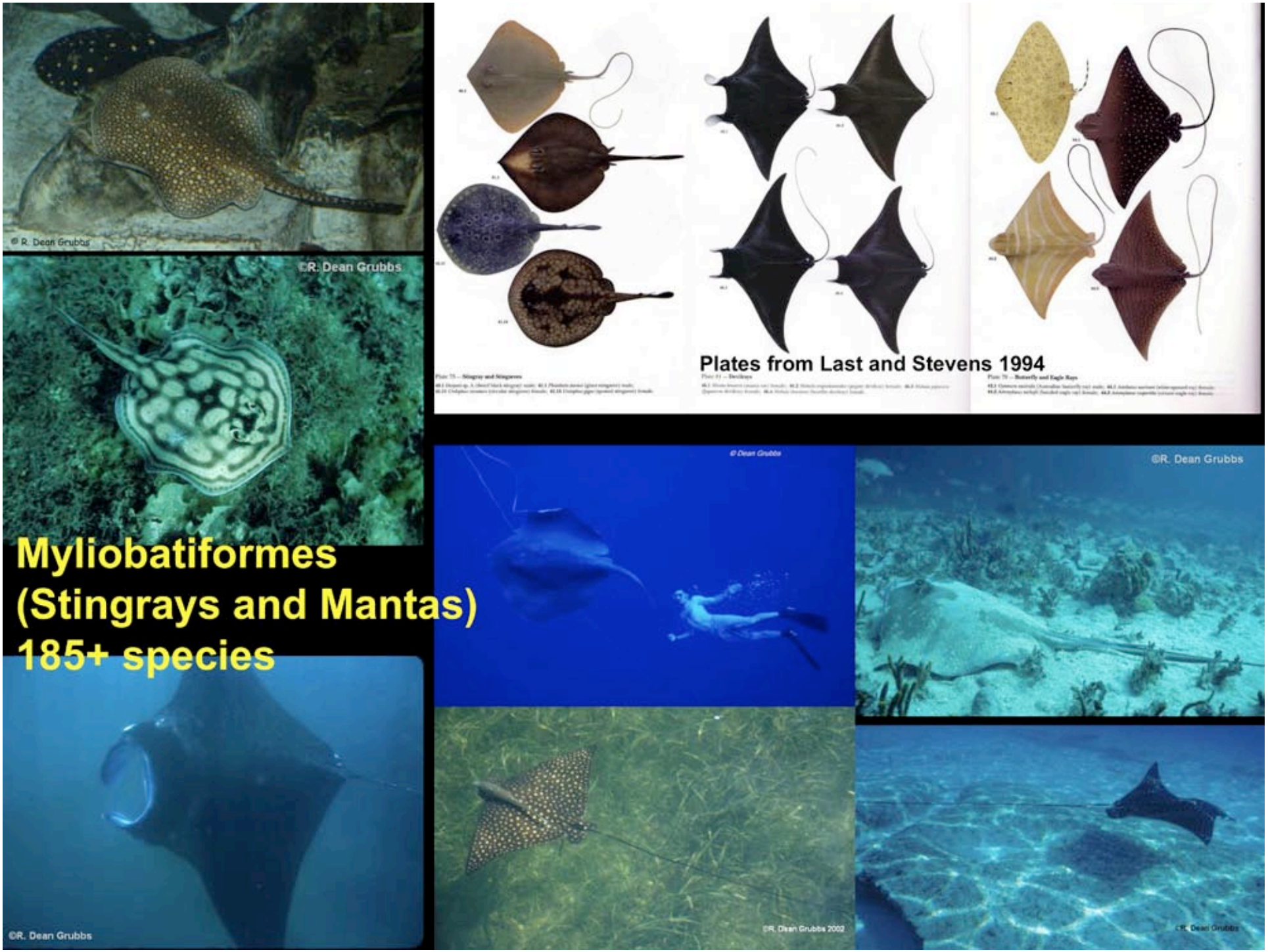
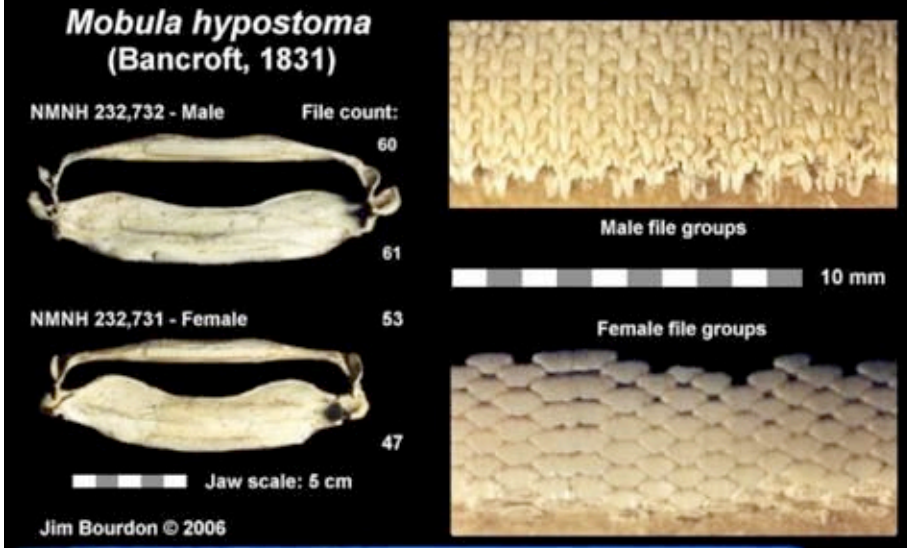


Fig. 3. Brain and body weights for major vertebrate radiations expressed as minimum convex polygons. (After Northcutt, '85b.)


© R. Dean Grubbs
©R. Dean Grubbs
Plates from Last and Stevens 1994
Myliobatiformes
(Stingrays and Mantas)
185+ species
© Dean Grubbs
©R. Dean Grubbs
©R. Dean Grubbs
©R. Dean Grubbs 2002

Myliobatiformes

Mobulidae? =~13 species; 2 in VA (rare)



Manta birostris – Giant Manta

Mobula hypostoma – Lesser Devil Ray

Myliobatiformes

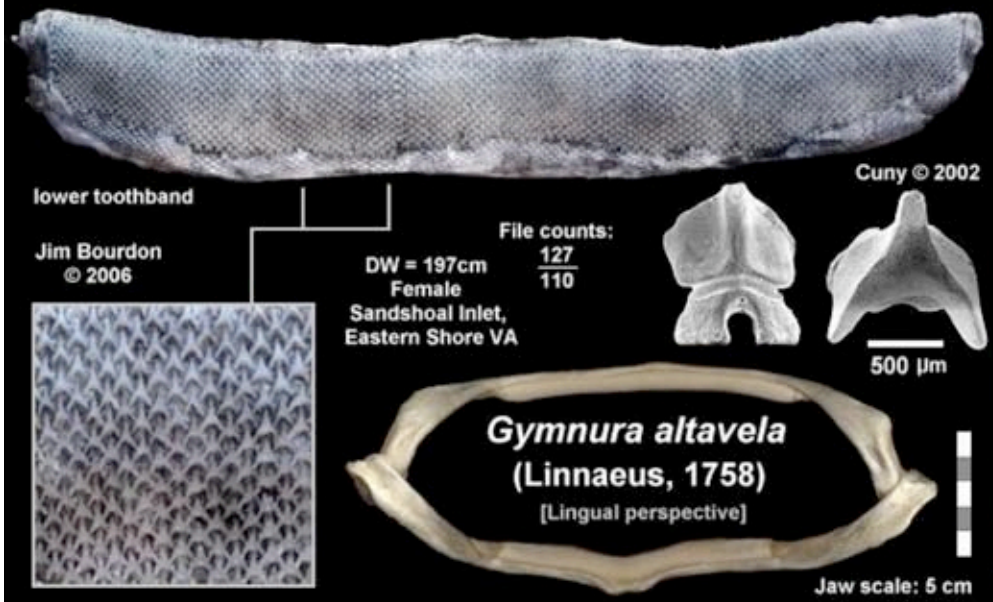
Gymnuridae =
~14 species; 2 in VA

Gymnura altavela - Spiny Butterfly Ray

Gymnura micrura – Smooth Butterfly Ray
Virginia 1999

Myliobatiformes

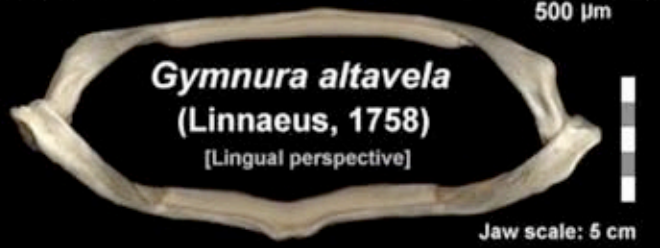
Gymnuridae = ~14 species



Gymnura altavela
Virginia 1996

Myliobatiformes

Gymnuridae = ~14 species



Myliobatiformes

Dasyatidae = ~50 species; 4 in VA

Dasyatis sabina – Atlantic Stingray

D. say – Bluntnose Stingray

D. centroura – Roughtail Stingray

D. americana – Southern Stingray

Myliobatiformes
Dasyatidae = ~50 species

Myliobatiformes
Dasyatidae = ~50 species

Myliobatiformes

Myliobatidae = ~24 species; 2 in VA

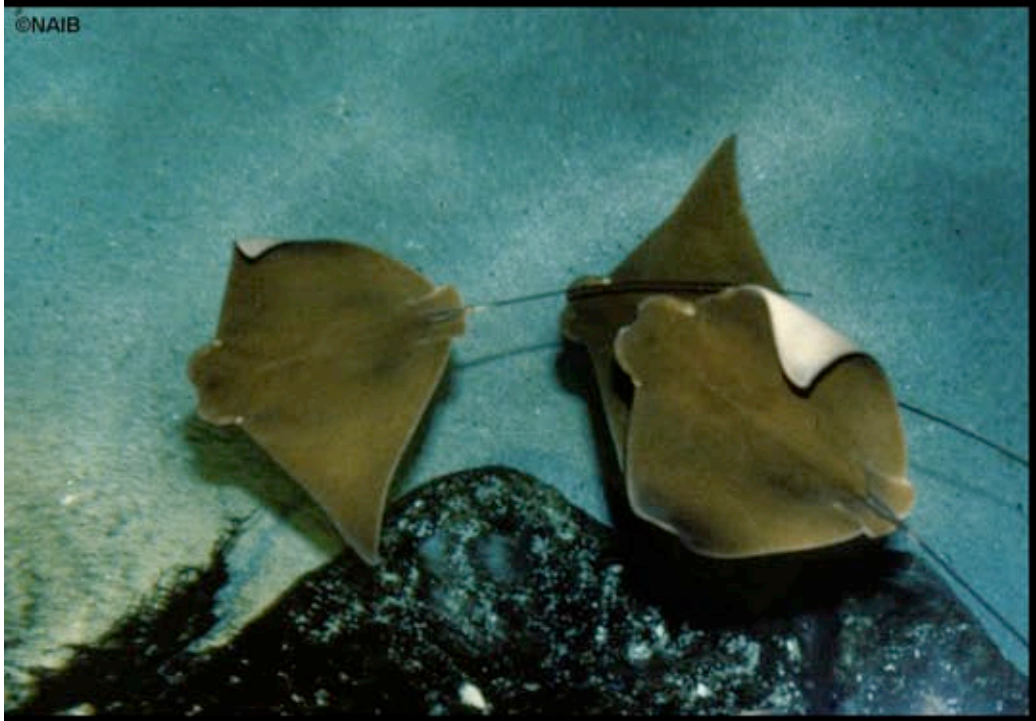
Myliobatis fremenvillii – Bullnose Ray

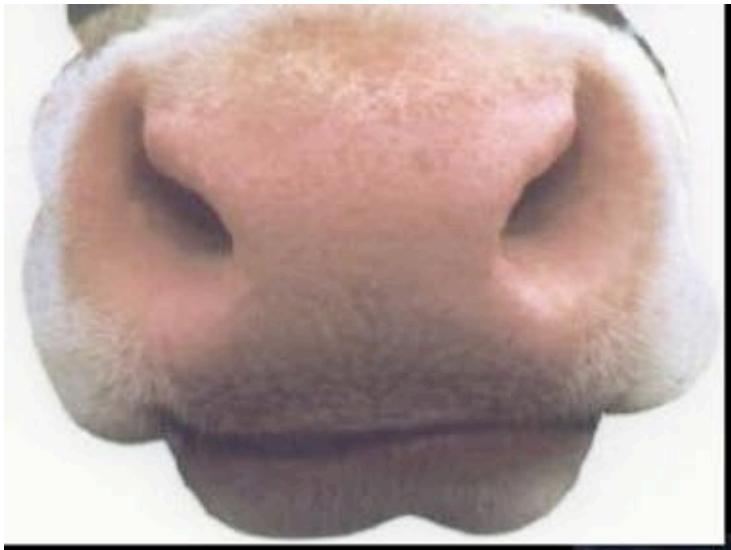
Aetobatus narinari – Spotted Eagle Ray

Myliobatiformes

Rhinopteridae = ~5 (11) species, 1 in VA

Rhinoptera bonasus –
Chesapeake Cownose Sun Whipperee Ray





COWNOSE RAY

Rhino = Greek for “snout”

ptero = Greek for “wing”

BONASUS

A beast like a bull, that uses its dung as a weapon

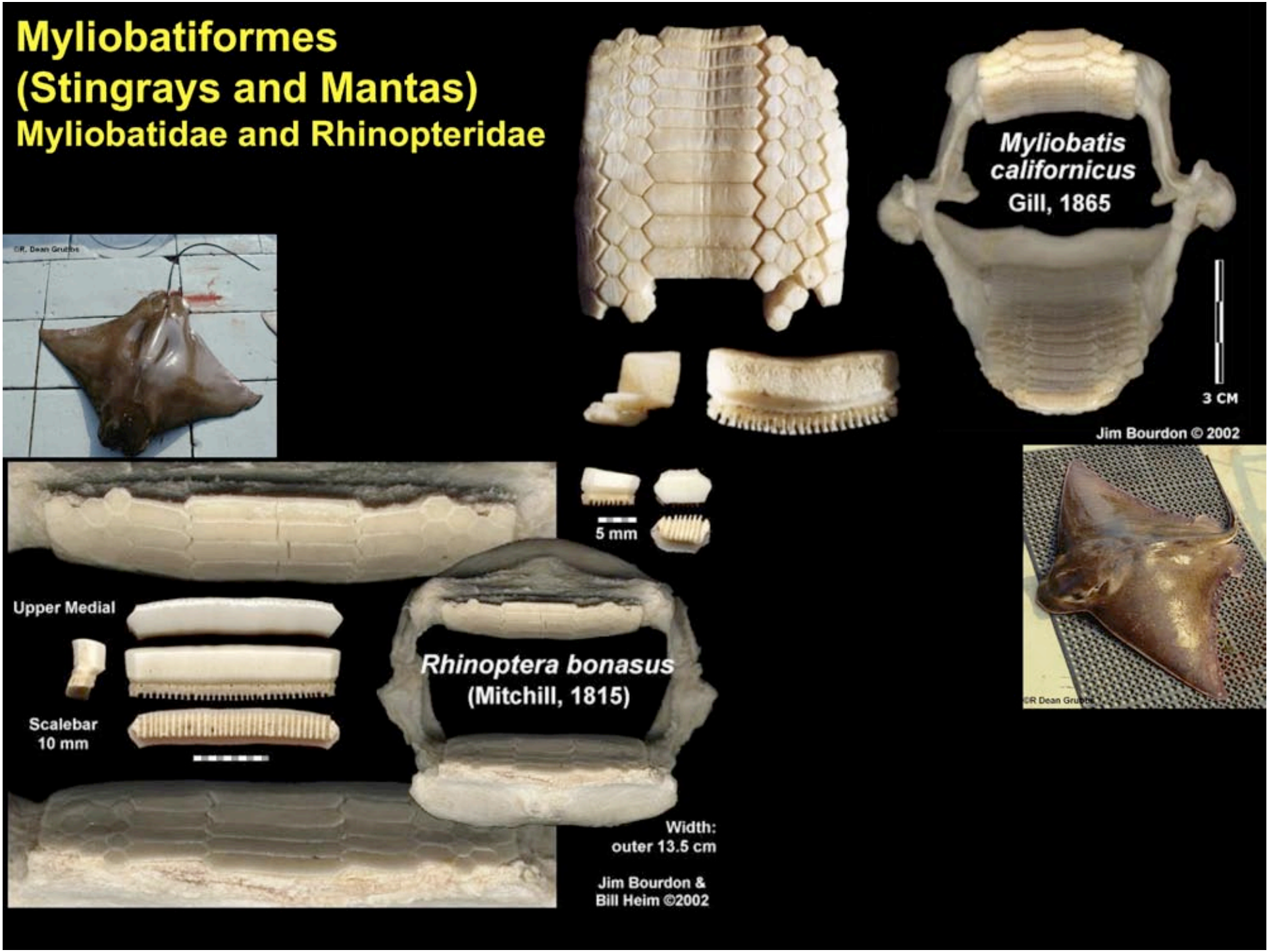
Pliny the Elder [1st century CE]: The bonasus is has the mane of a horse but otherwise resembles a bull. It has horns that curve back so they are useless for fighting; when attacked, it runs away, while releasing a trail of dung that can cover three furlongs. Contact with the dung burns pursuers as though they had touched fire.

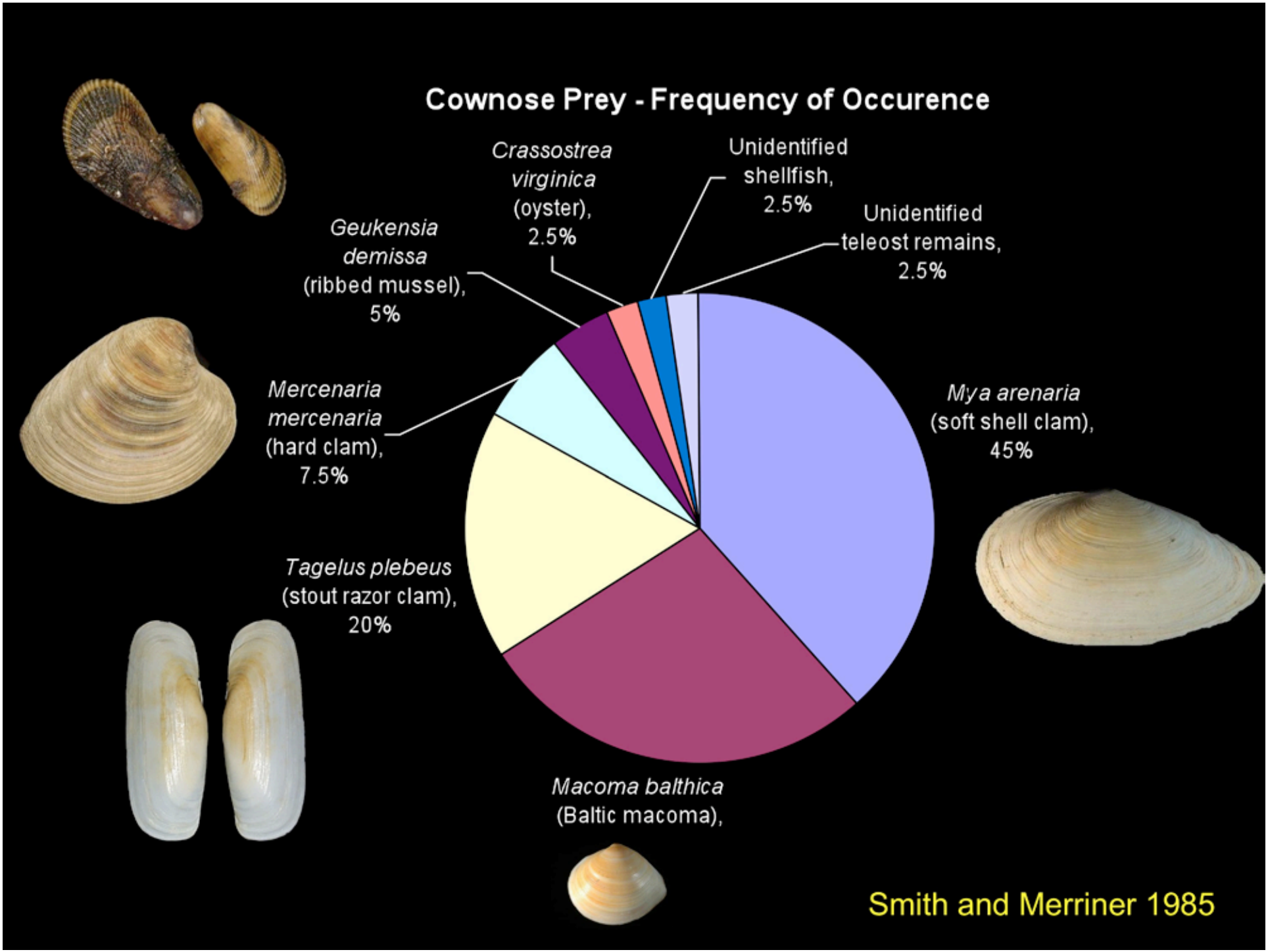
Myliobatiformes

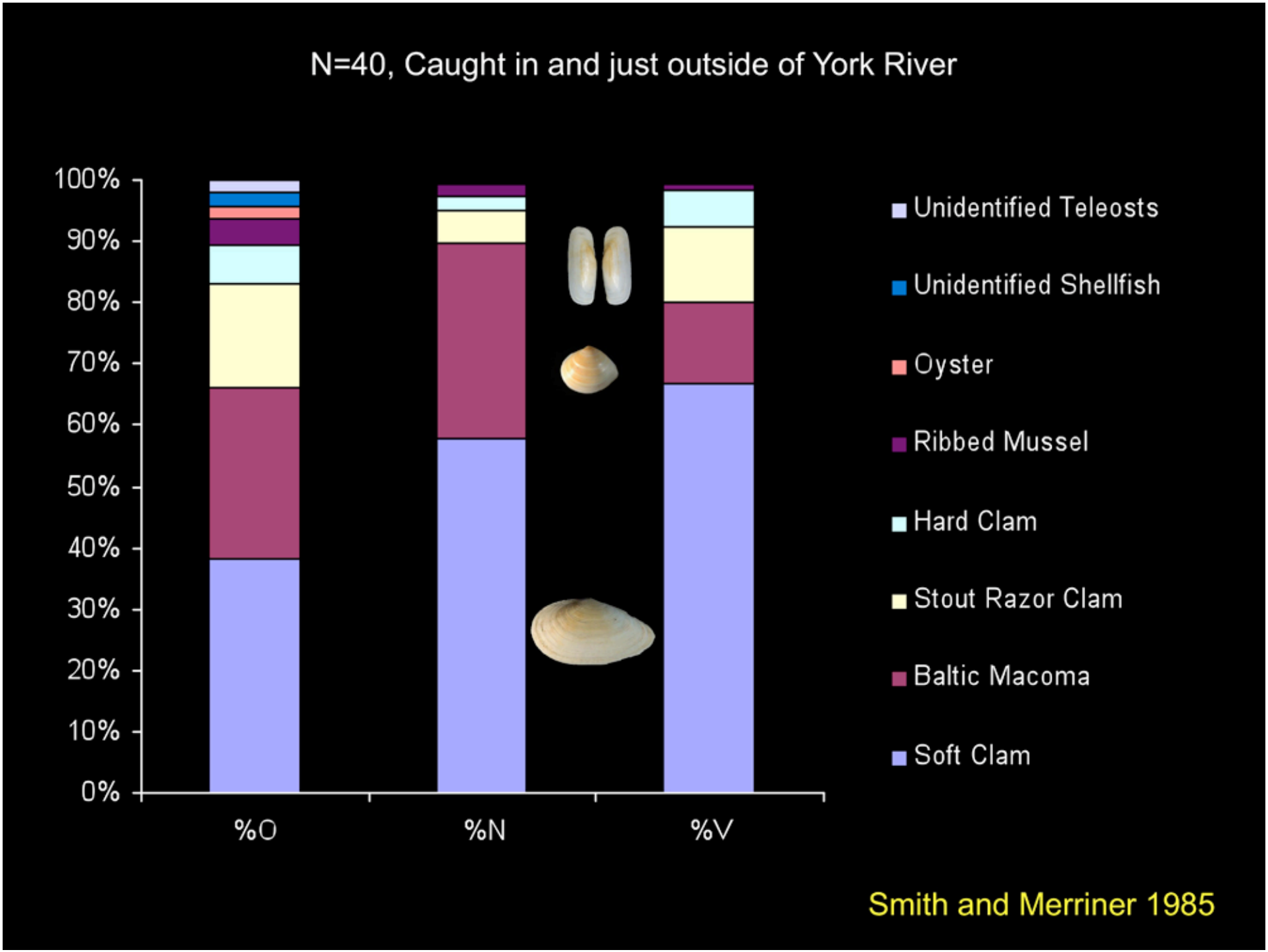
Myliobatidae and Rhinopteridae

Bullnose Ray

Cownose Ray


Myliobatiformes
(Stingrays and Mantas)
Myliobatidae and Rhinopteridae
Myliobatis californicus
Gill, 1865
3 CM
Jim Bourdon © 2002
5 mm
Upper Medial
Scalebar
10 mm
Rhinoptera bonasus
(Mitchill, 1815)
Width:
outer 13.5 cm
Jim Bourdon &
Bill Heim ©2002


Cownose Prey - Frequency of Occurence
Crassostrea virginica (oyster), 2.5%
Unidentified shellfish, 2.5%
Unidentified teleost remains, 2.5%
Geukensia demissa (ribbed mussel), 5%
Mercenaria mercenaria (hard clam), 7.5%
Mya arenaria (soft shell clam), 45%
Tagelus plebeus (stout razor clam), 20%
Macoma balthica (Baltic macoma),
Smith and Merriner 1985


N=40, Caught in and just outside of York River
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
%O
%N
%V
Unidentified Teleosts
Unidentified Shellfish
Oyster
Ribbed Mussel
Hard Clam
Stout Razor Clam
Baltic Macoma
Soft Clam
Smith and Merriner 1985

Soft clamming in 1957,
The Mariner's Museum

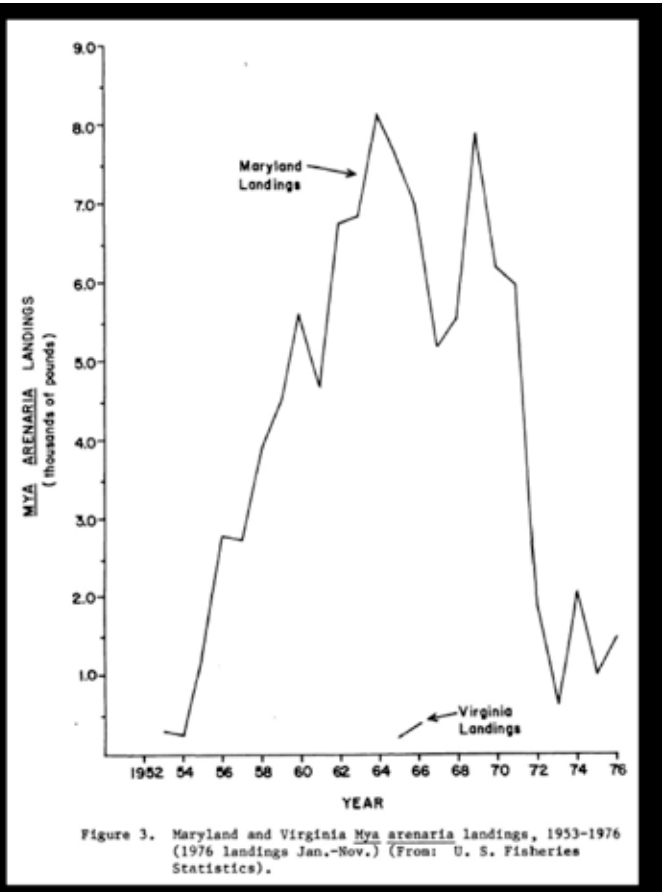
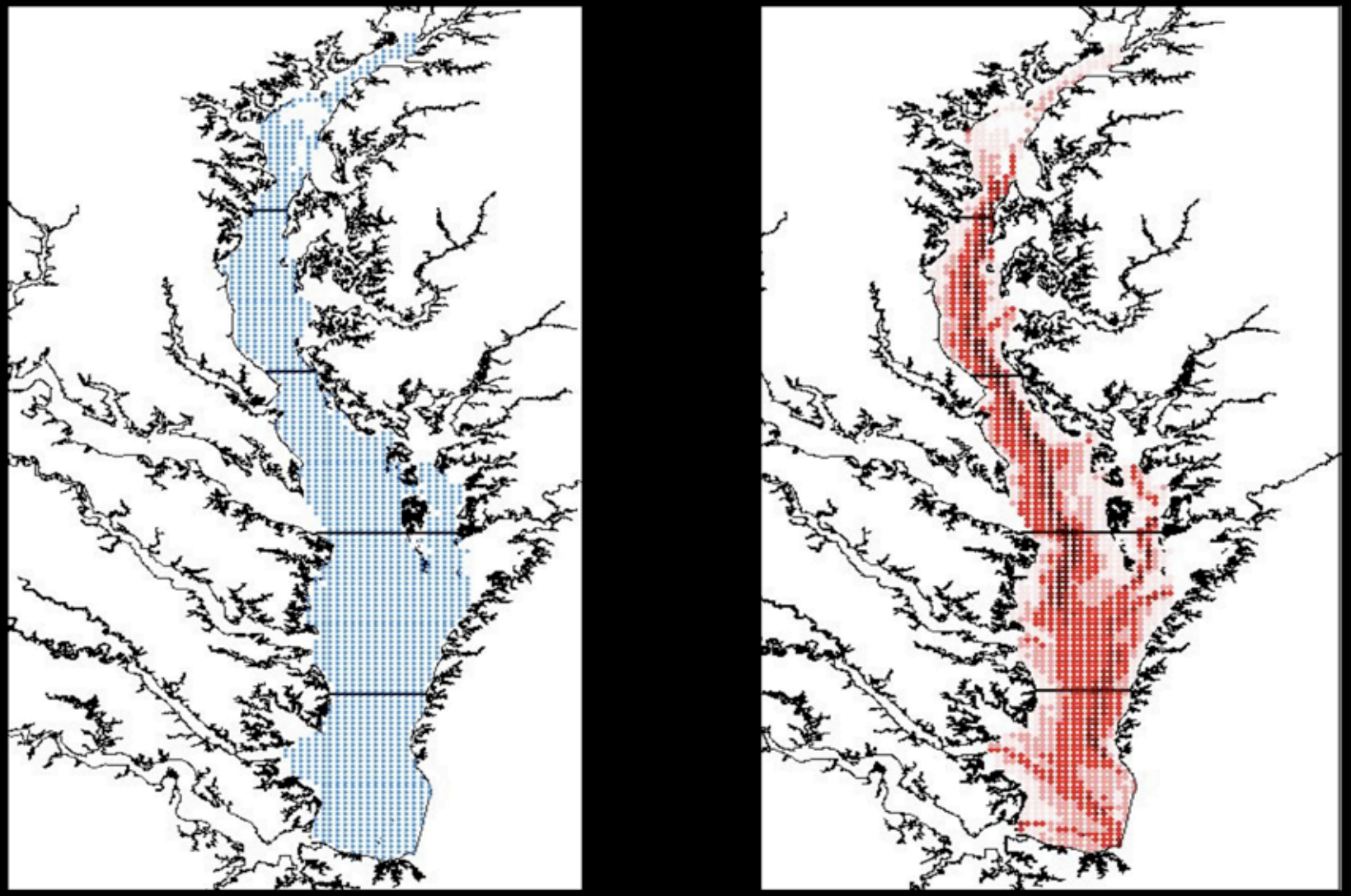
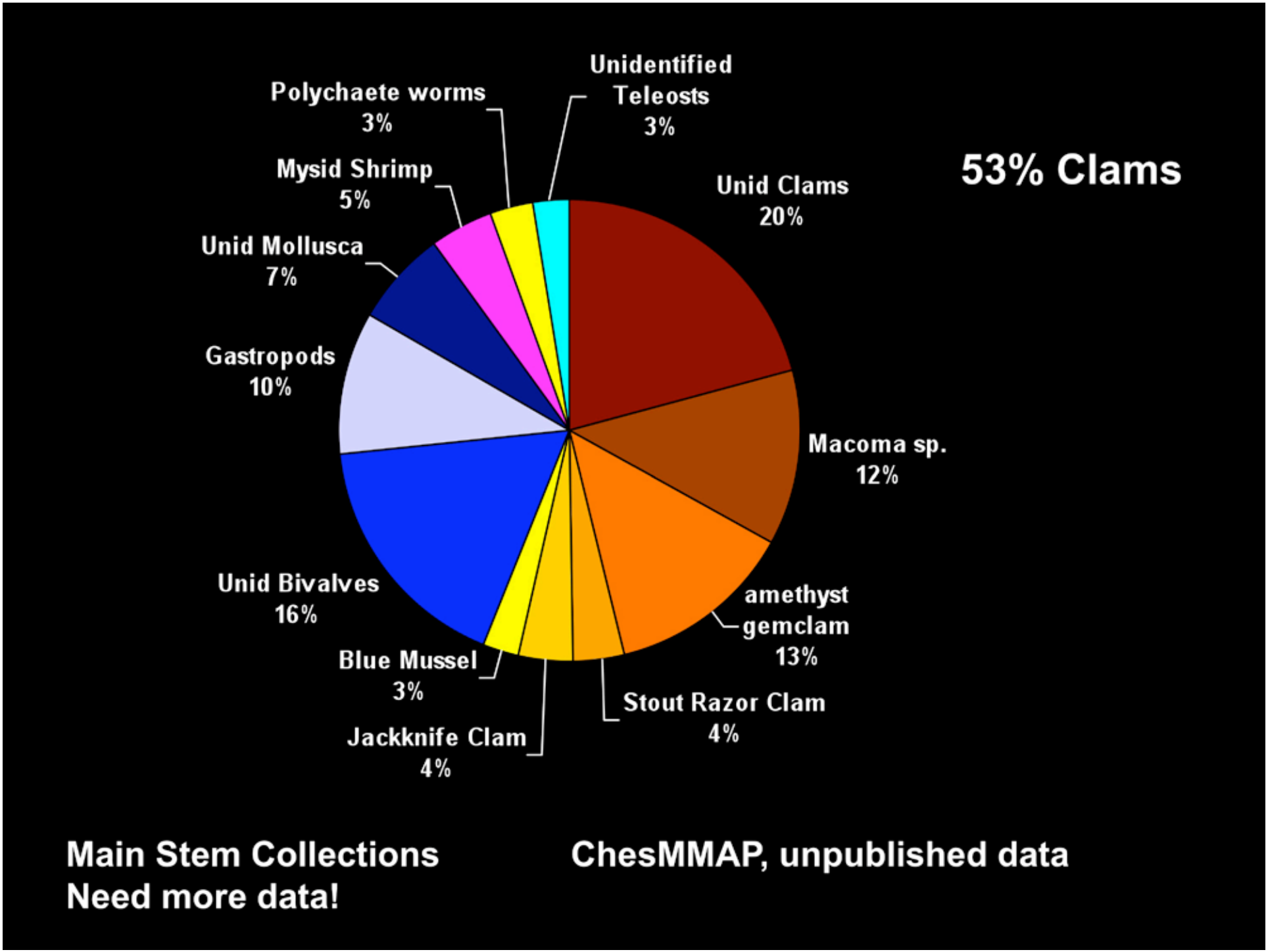


Figure 3. Maryland and Virginia Mya arenaria landings, 1953-1976 (1976 landings Jan.-Nov.) (From: U. S. Fisheries Statistics).

ChesMMAP – Stratification of Chesapeake Bay



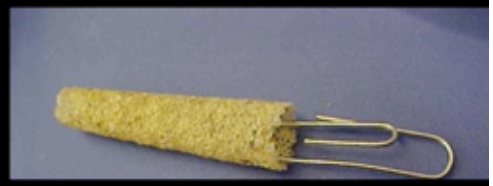

Unidentified Teleosts 3%
Polychaete worms 3%
Mysid Shrimp 5%
Unid Clams 20%
53% Clams
Unid Mollusca 7%
Gastropods 10%
Macoma sp. 12%
Unid Bivalves 16%
amethyst gemclam 13%
Blue Mussel 3%
Stout Razor Clam 4%
Jackknife Clam 4%
Main Stem Collections
Need more data!
ChesMMAP, unpublished data

Collins et al. 2005

Diet of the Atlantic cownose ray Rhinoptera bonasus in Charlotte Harbor, Florida, USA

92,576 prey items from 38 families

Crustaceans (%IRI = 56.85) with cumaceans accounting for the majority (94%) of crustaceans



Polychaetes (%IRI = 25.90) and Pectinaria gouldii representing the bulk (70%) of the polychaetes.

Bivalves (% IRI = 12.93).

All cumaceans and polychaetes within ray stomachs were intact, indicating capture through suction feeding.

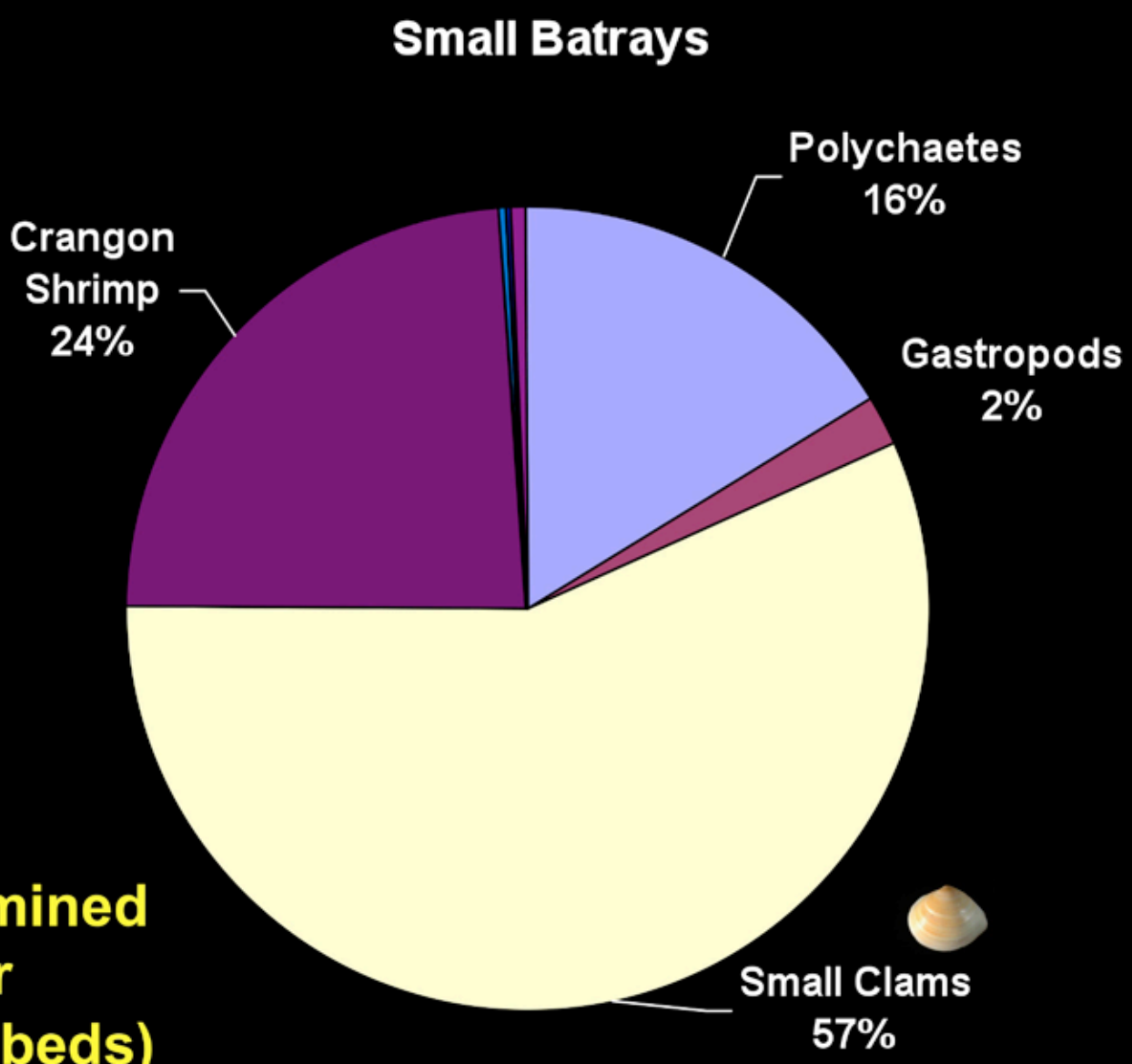
All larger, hard prey showed evidence of crushing (fractured and broken shells).

California Bat Ray (*Myliobatis californica*)

"Previous studies (Ridge 1963, Karl & Obrebski 1976, Talent 1982) have examined the diet of bat rays in Tomales Bay and Elkhorn Slough, but found no evidence of predation on oysters, even in large animals collected over oyster beds (Ridge 1963)."

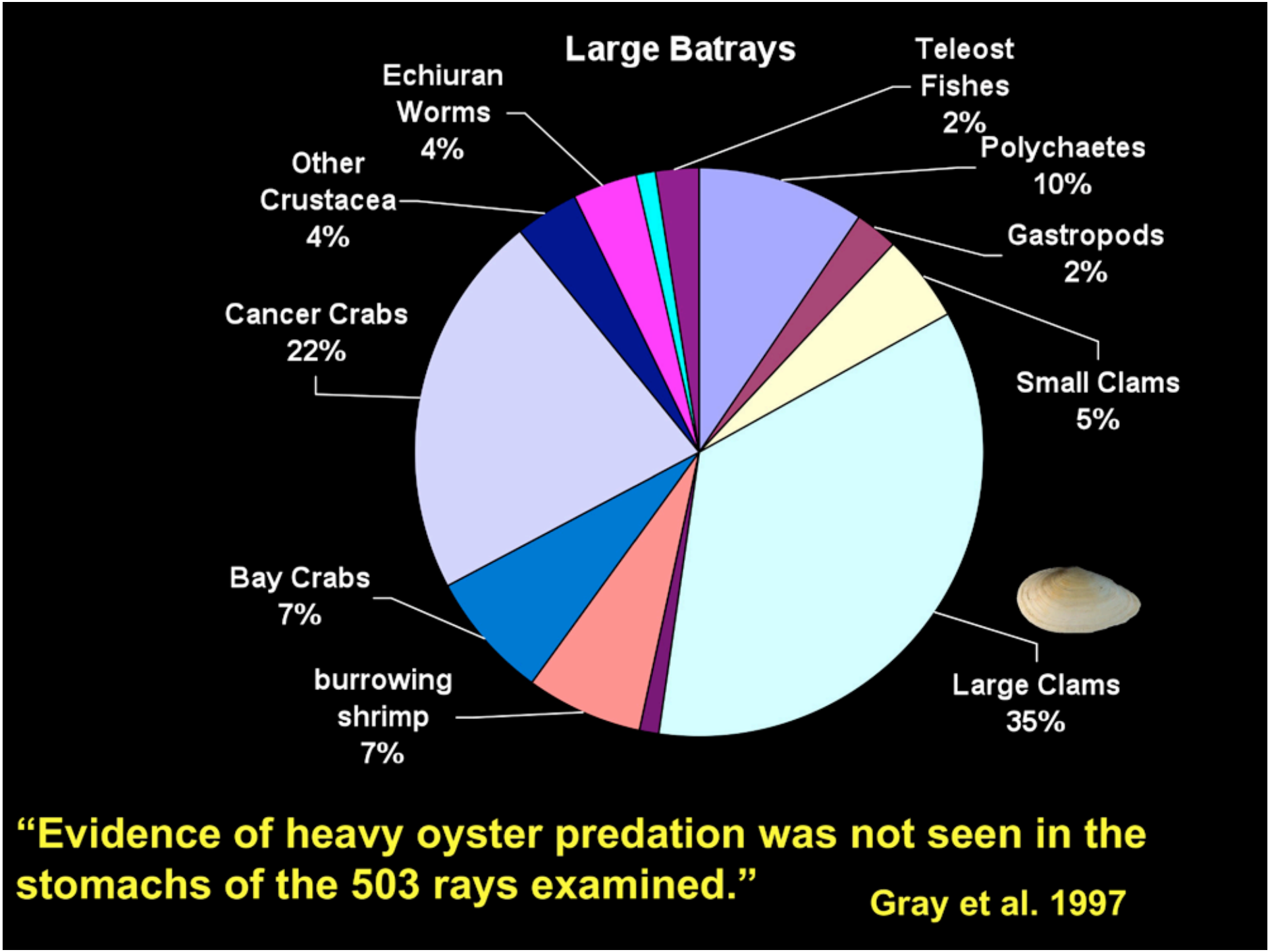
From Gray et al. 1997

Gray et al. 1997



503 bat rays examined (caught by oyster industry near/on beds)

93% contained prey


Large Batrays
Teleost Fishes 2%
Polychaetes 10%
Gastropods 2%
Small Clams 5%
Large Clams 35%
Bay Crabs 7%
burrowing shrimp 7%
Cancer Crabs 22%
Other Crustacea 4%
Echiuran Worms 4%
"Evidence of heavy oyster predation was not seen in the stomachs of the 503 rays examined."
Gray et al. 1997

"Lack of direct evidence of oyster predation in this study indicates that bat rays do not significantly impact oyster culture in Humboldt Bay."

"Trawling operations conducted to eliminate rays from the oyster beds are time consuming and expensive. In addition, a local oyster company fishes several hundred crab pots around their oyster beds to deter oyster predation by red rock crabs, *Cancer productus*. Ironically, bat rays are one of the major predators of these crabs in Humboldt Bay, and thus a decrease in ray populations may inversely affect the red rock crab populations."

Gray et al. 1997

Reproductive Biology

Sexual Dimorphism

Elasmobranch Karma Sutra

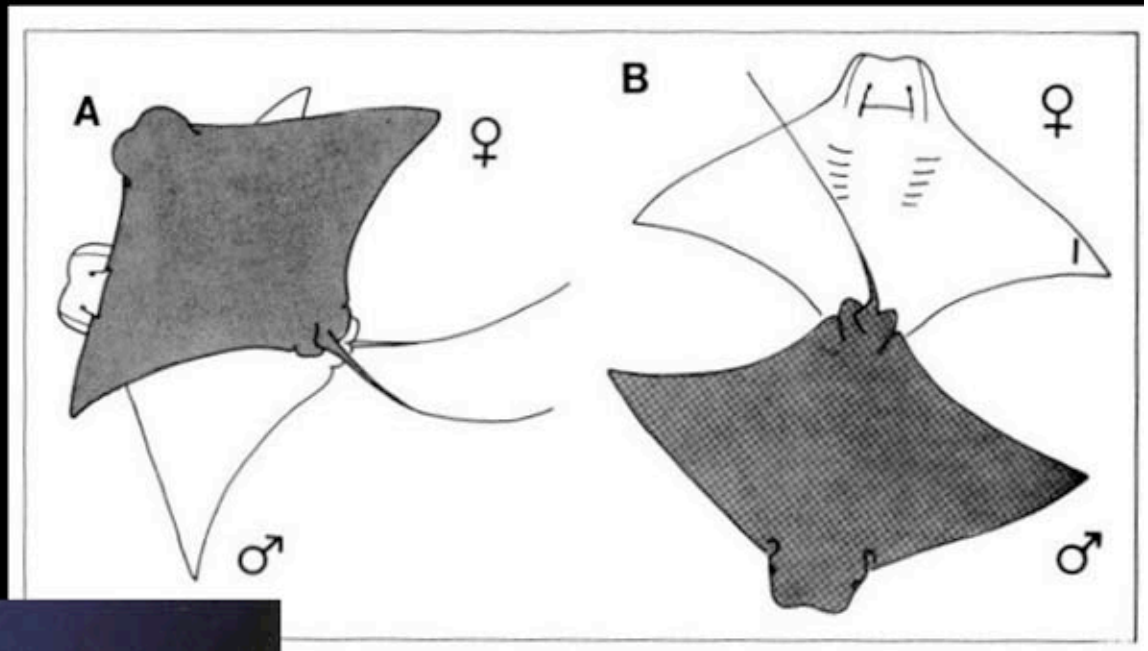
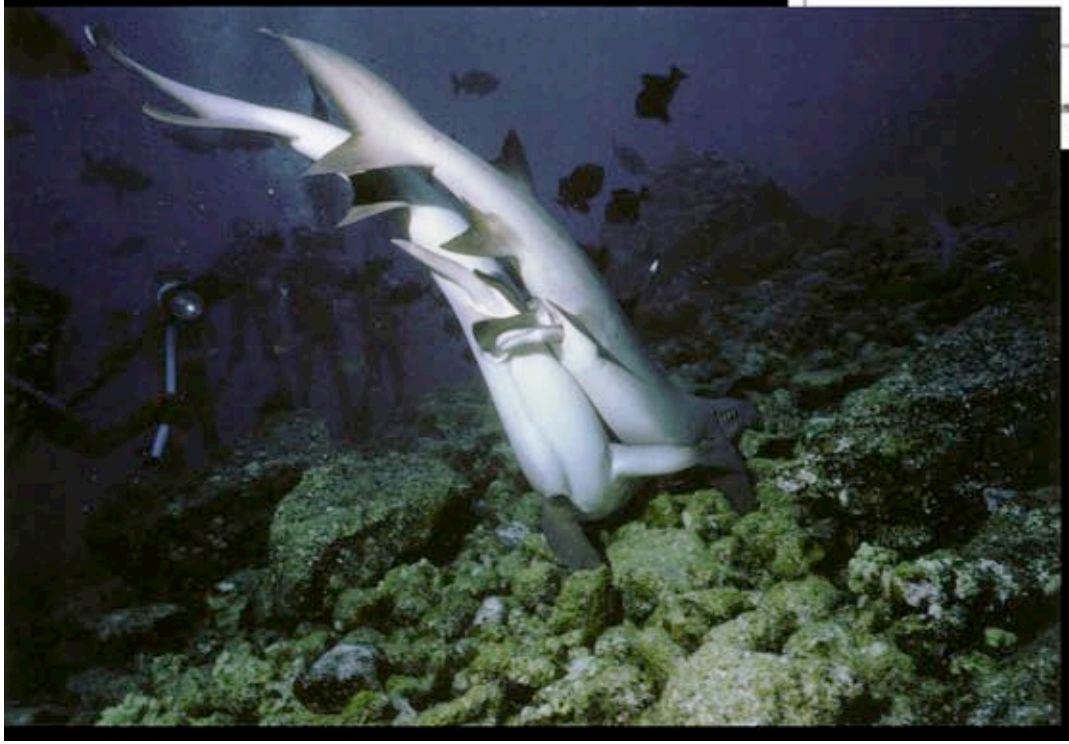


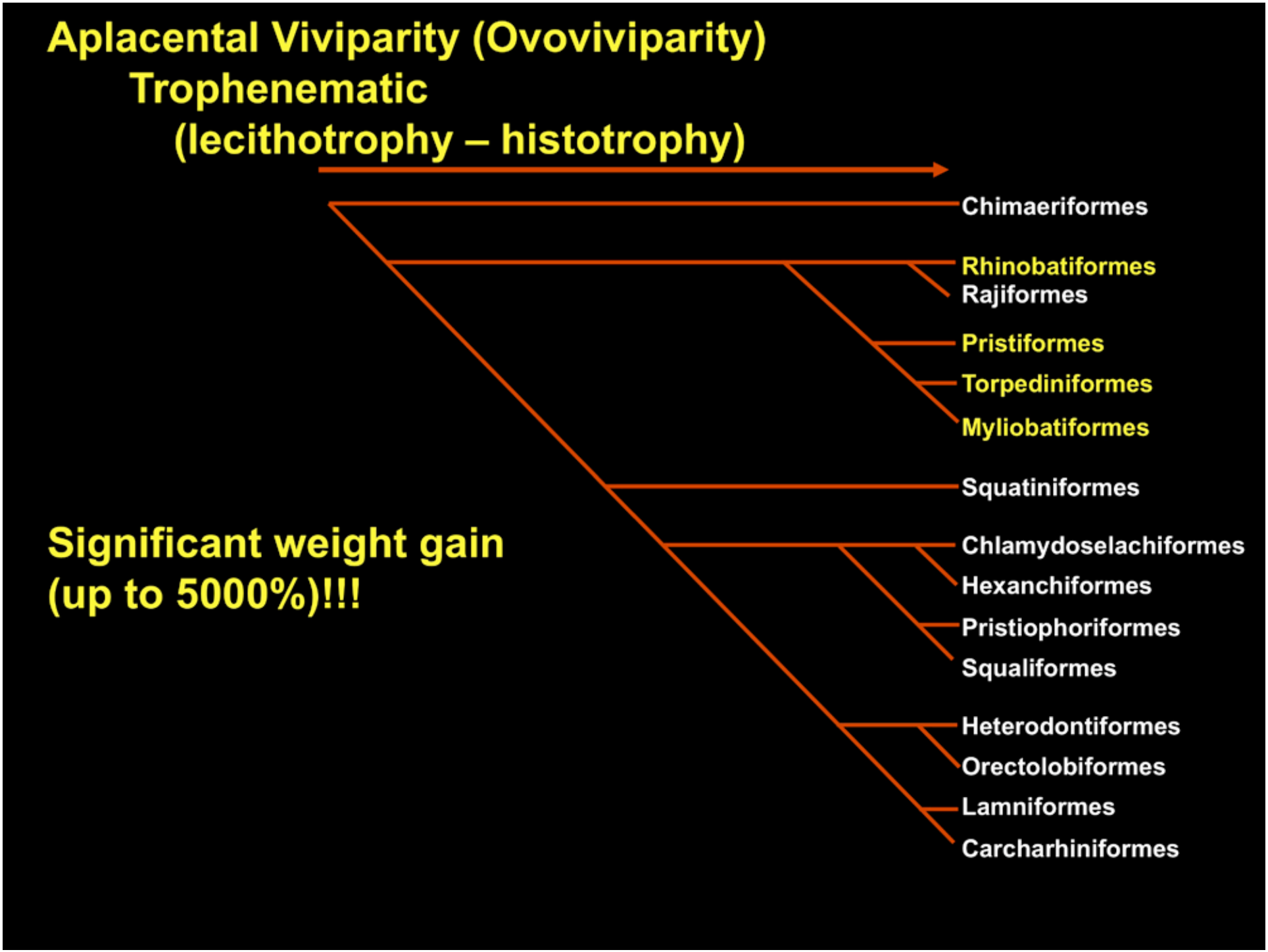
Figure 9.
nica, 1979. A, Male inserting clasper in abdomen-to-abdomen posture from beneath female. B, Pair swivelling horizontally, 180° on axis of inserted clasper.



Uchida1990


©R. Dean Grubbs

Elasmobranch Reproduction


Aplacental Viviparity (Ovoviviparity)
Trophenematic
(lecithotrophy – histotrophy)
Chimaeriformes
Rhinobatiformes
Rajiformes
Pristiformes
Torpediniformes
Myliobatiformes
Squatiniformes
Chlamydoselachiformes
Hexanchiformes
Pristiophoriformes
Squaliformes
Heterodontiformes
Orectolobiformes
Lamniformes
Carcharhiniformes
Significant weight gain
(up to 5000%)!!!

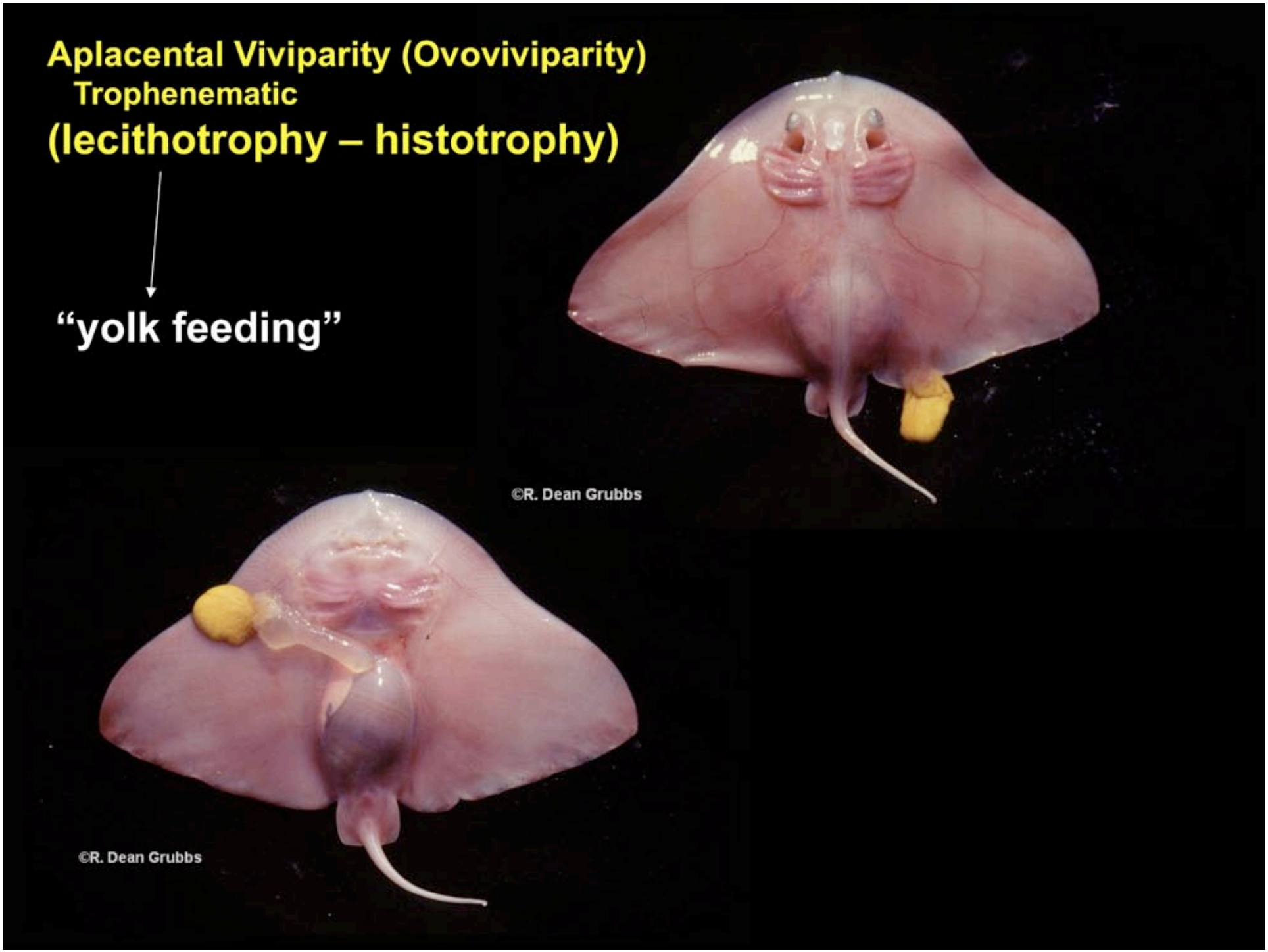
Aplacental Viviparity (Ovoviviparity)
Trophenematic
(lecithotrophy – histotrophy)

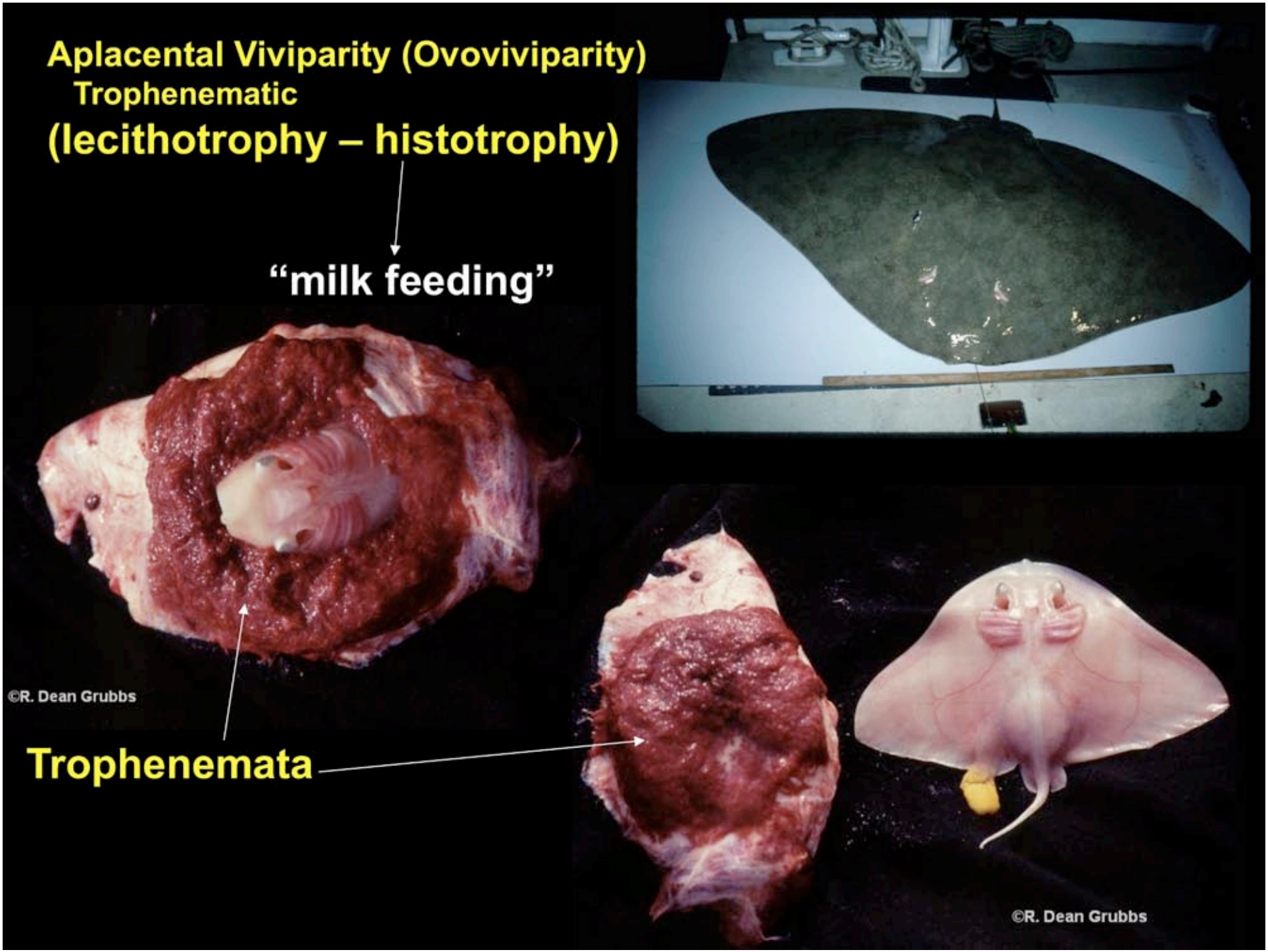
One functional uterus

Aplacental Viviparity (Ovoviviparity)

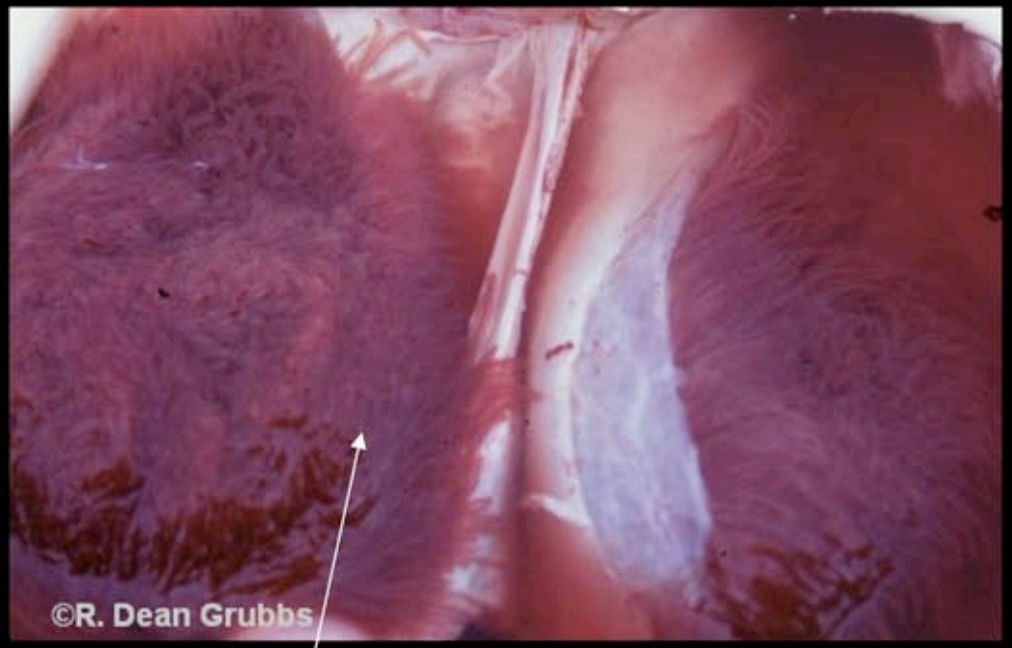
Trophenematic
(lecithotrophy – histotrophy)

Two functional uteri


Aplacental Viviparity (Ovoviviparity)
Trophenematic
(lecithotrophy – histotrophy)
"yolk feeding"
©R. Dean Grubbs
©R. Dean Grubbs


Aplacental Viviparity (Ovoviviparity)
Trophenematic
(lecithotrophy – histotrophy)
"milk feeding"
©R. Dean Grubbs
Trophenemata
©R. Dean Grubbs

Aplacental Viviparity (Ovoviviparity)
Trophenematic
(lecithotrophy – histotrophy)



Trophenemata

Aplacental Viviparity (Ovoviviparity)

COWNOSE RAY

Fallacies:

1) Cownose rays produce 2-8 pups per litter

2) Cownose rays have a gestation of 5-6 months and produce two litters per year.

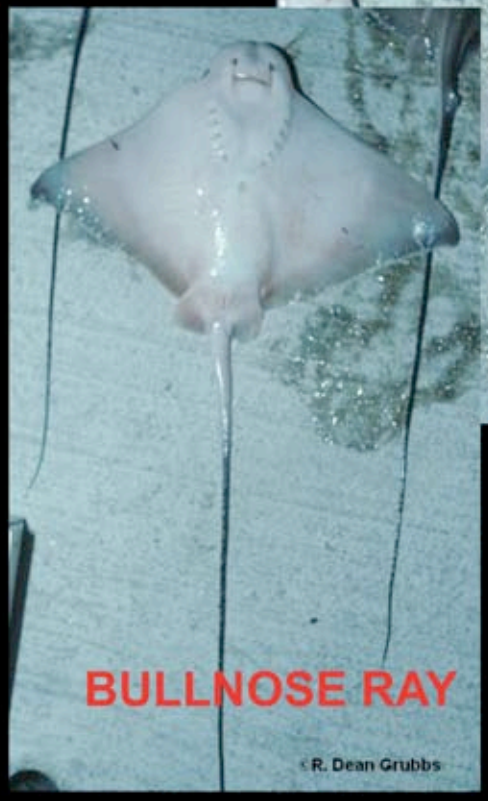
Smith and Merriner (1986), pupping Late June – early July
86 Pregnant females - All with a single pup
11-12 month gestation with no resting period OR 5-6 month gestation

Neer & Thompson 2005, pupping in May
33 Pregnant females – All with a single pup
11-12 month gestation period

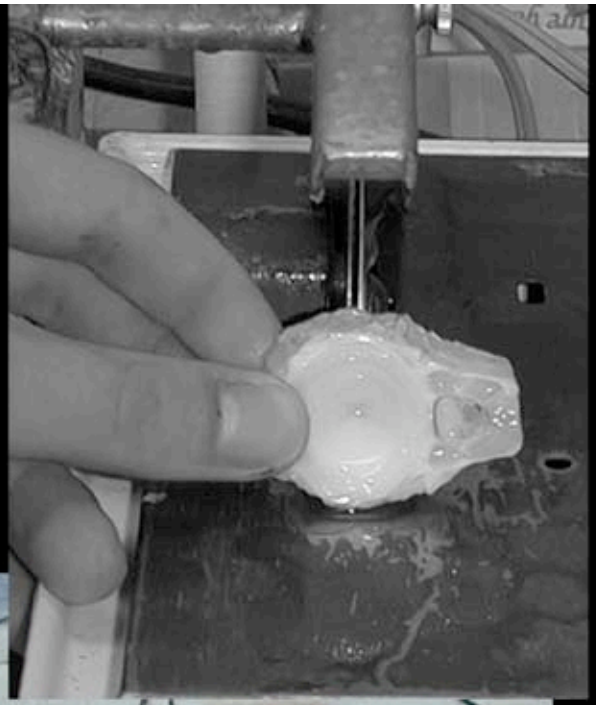
Reproductive data and information on reproductive hormonal cycling in captive animals do not support two litters per year.
(Alan Henningsen, Baltimore Aquarium)

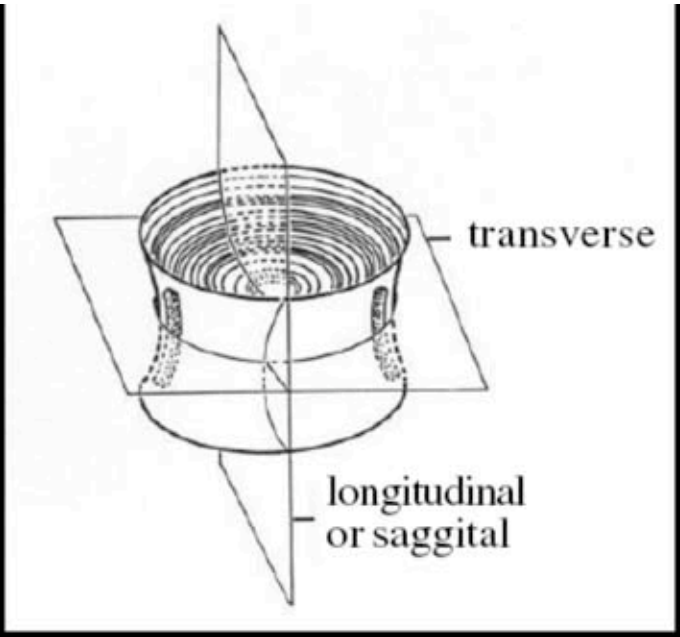
Aplacental Viviparity (Ovoviviparity)

Can not use the Myliobatis examples; they are much more fecund.

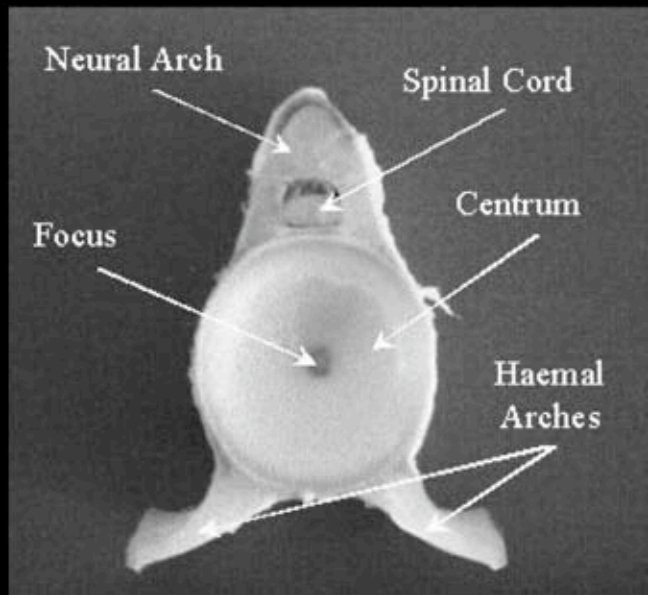


Age and Growth



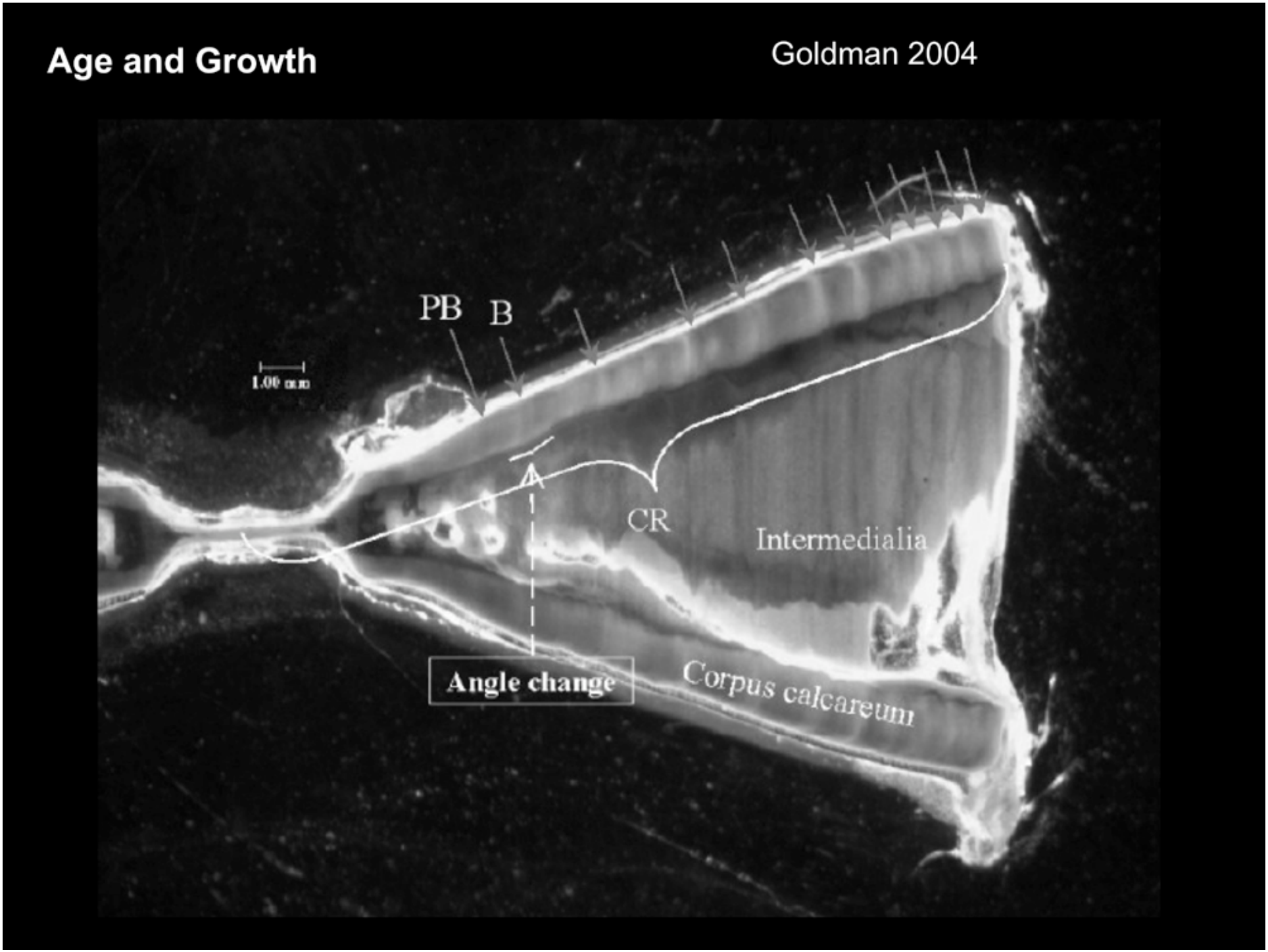


Vertebral centra removed.



Age and Growth

Goldman 2004



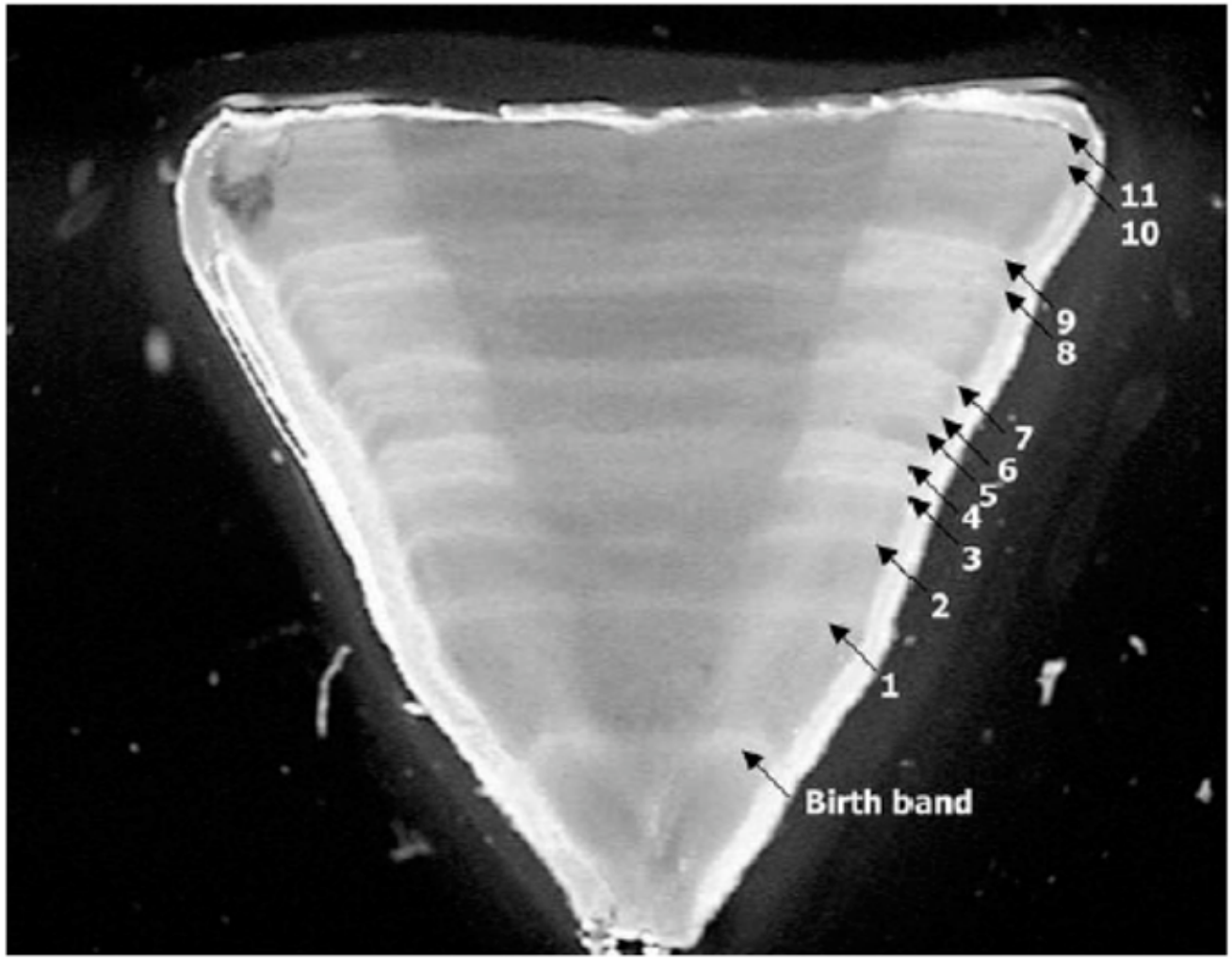


Figure 1. Sagittal vertebral section from a 860 mm female cownose ray. This ray was estimated to be 11+ years-old.

Neer and Thompson 2005

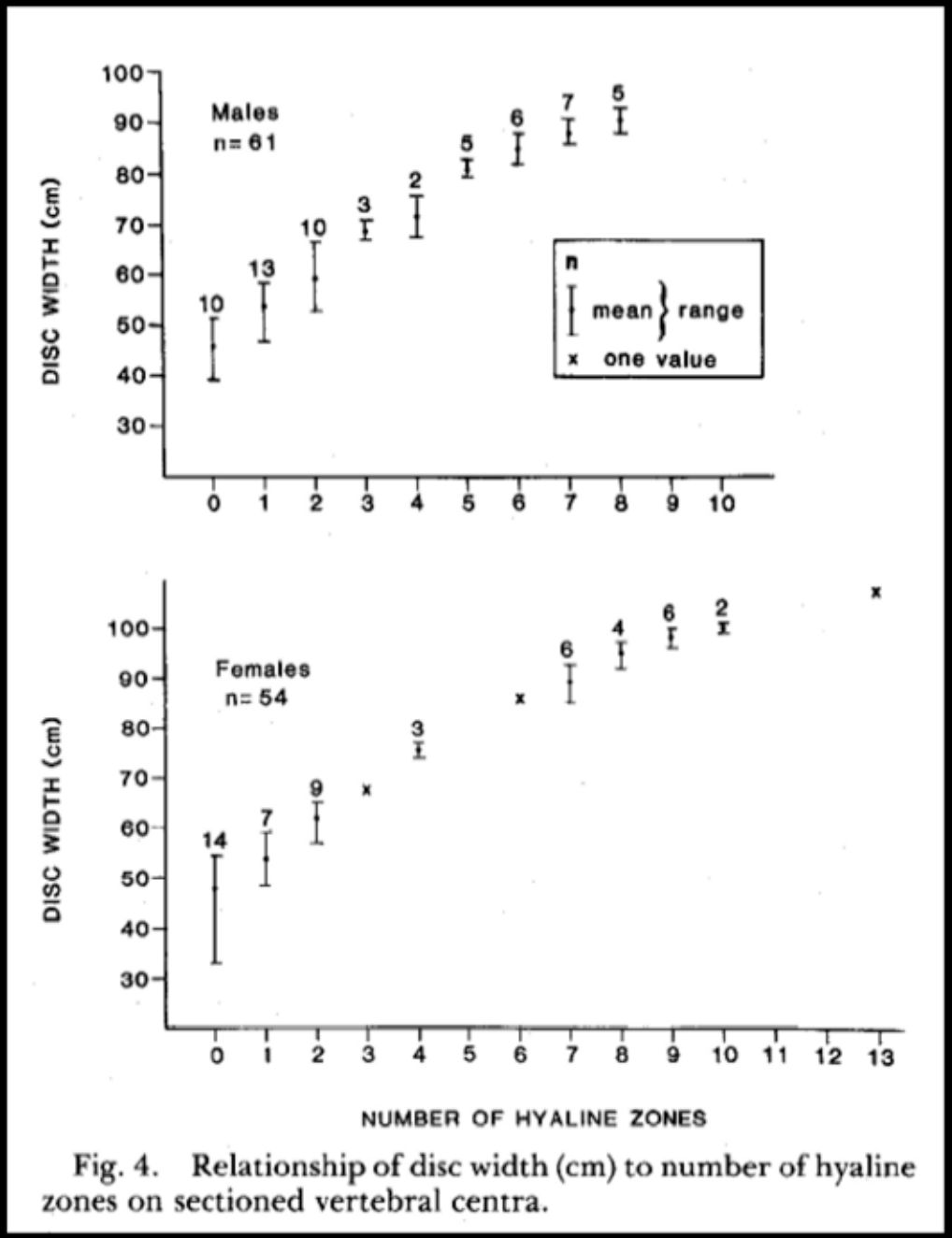
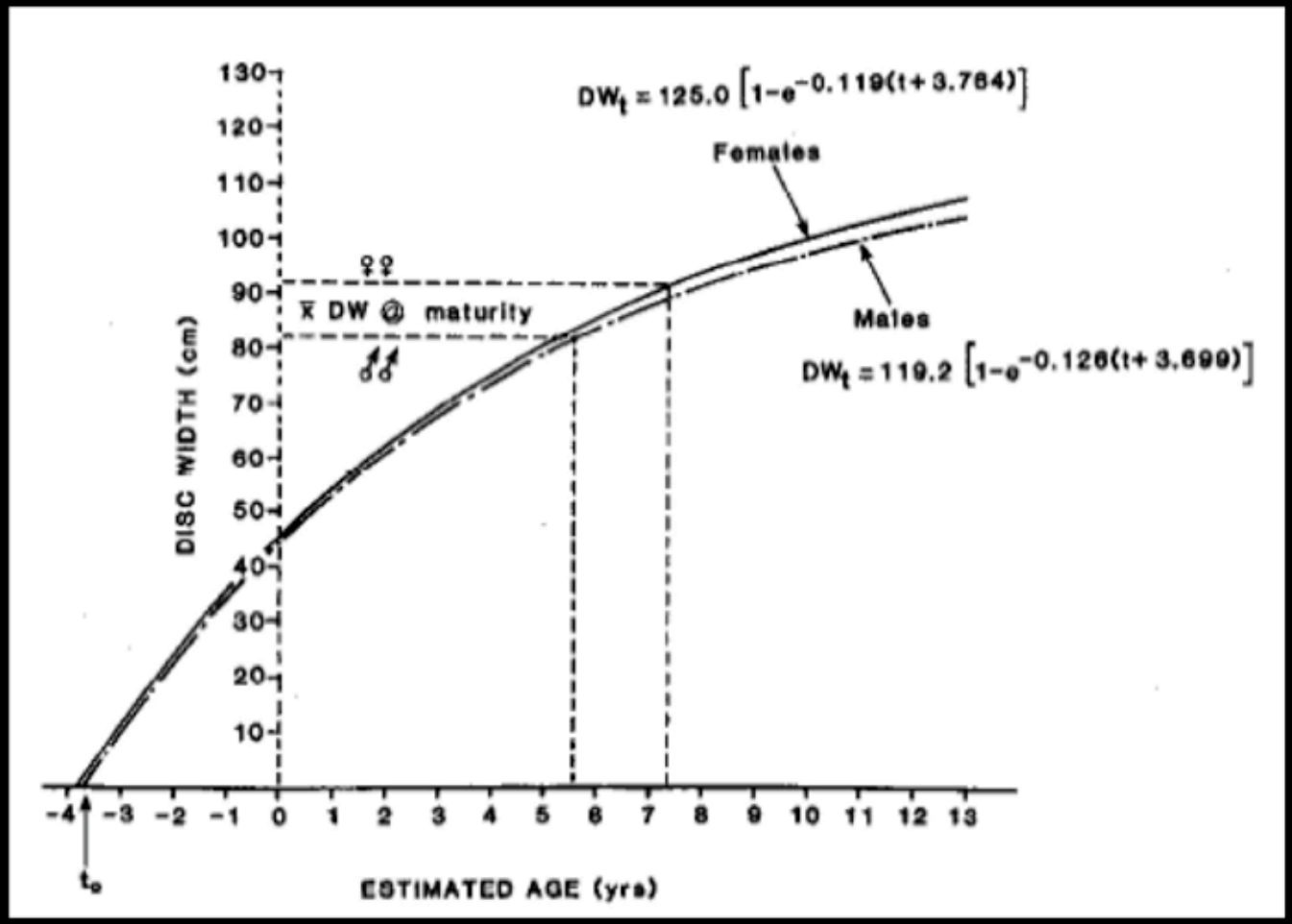


Fig. 4. Relationship of disc width (cm) to number of hyaline zones on sectioned vertebral centra.

Smith and Merriner 1987

Chesapeake Bay:
~115 samples

Only one animal greater than 10 years old (13)



Males mature in ~5-6 years (~82 cm DW)
Females mature in ~7-8 years (~92 cm DW)

Smith and Merriner 1987

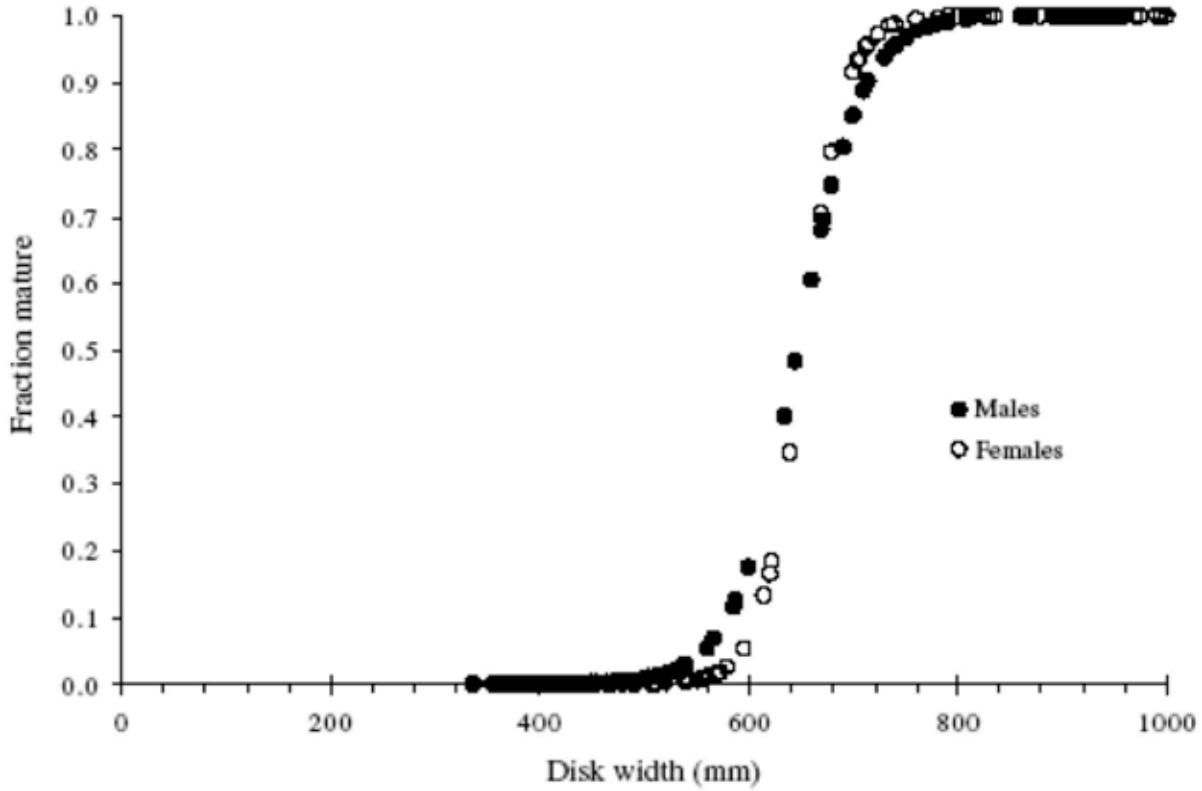


Figure 5. Relationship between maturity and disk width for the cownose ray. A logistic model was fitted to the binominal maturity data (0 = immature, 1 = mature).

Males and females mature at ~68 cm DW

Neer and Thompson 2005

Gulf of Mexico: 200+ samples

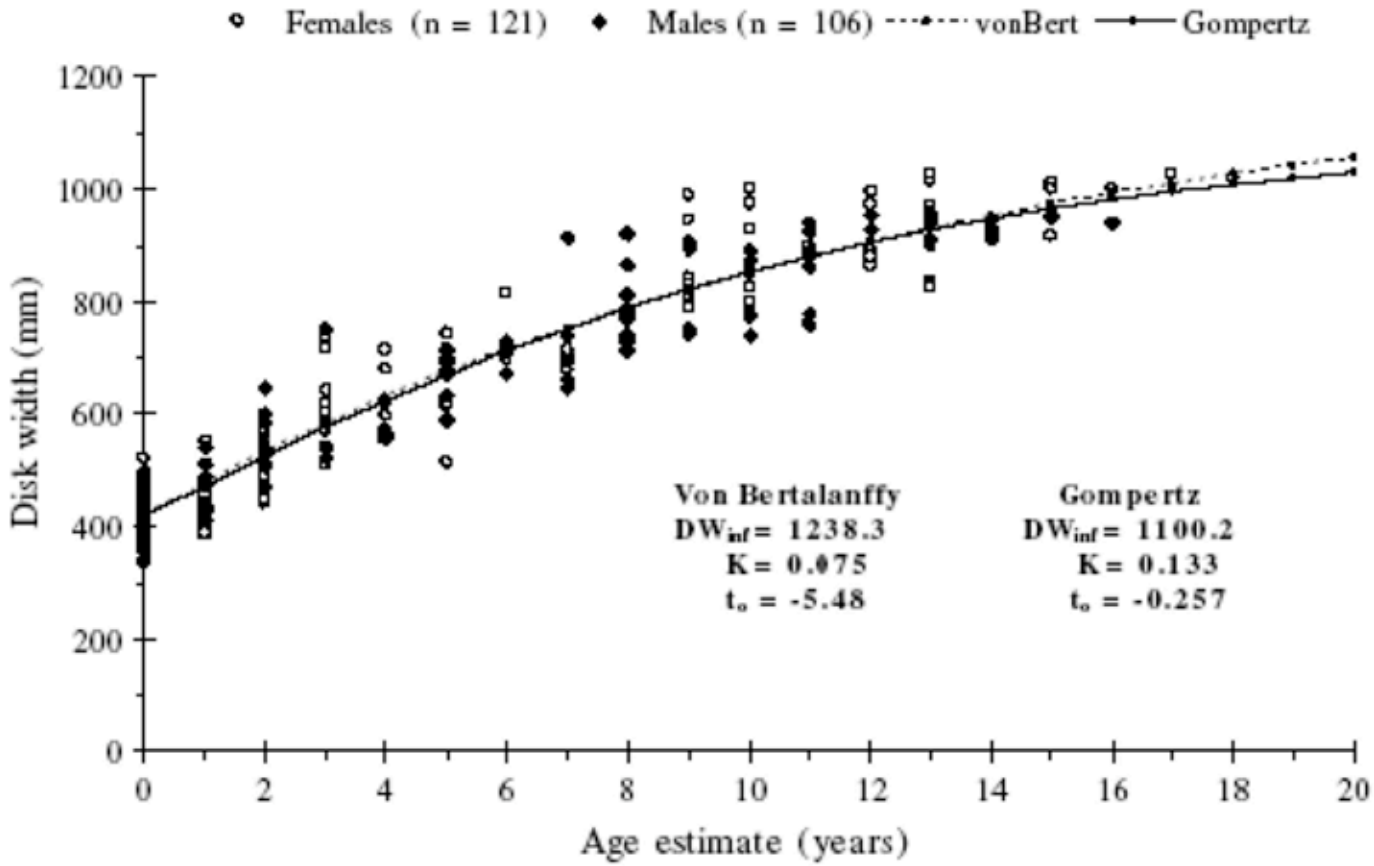


Figure 4. Growth functions fitted to the combined sexes observed size-at-age data for cownose rays (n = 227).

Males and females mature at ~68 cm DW = ~ 6 years

Oldest age: 18 years

Neer and Thompson 2005

Population Growth Rates

Estimated maximum rate of population change of 2.7% per year in the Gulf of Mexico!!!

Neer 2005

T_{max}	T_{mat}	b_x	S		R_o	% Δ
13	7	0.5	0.71		0.143	-19.96

Grusha and Hoenig, unpublished

Must know r, N, M

Population Growth Rates

Estimated maximum rate of population change of 2.7% per year in the Gulf of Mexico!!!

Neer 2005

T_{max}	T_{mat}	b_x	S		R_o	% Δ
13	7	0.5	0.71		0.143	-19.96
14	7	0.5	0.88		1.090	0.88

Grusha and Hoenig, unpublished

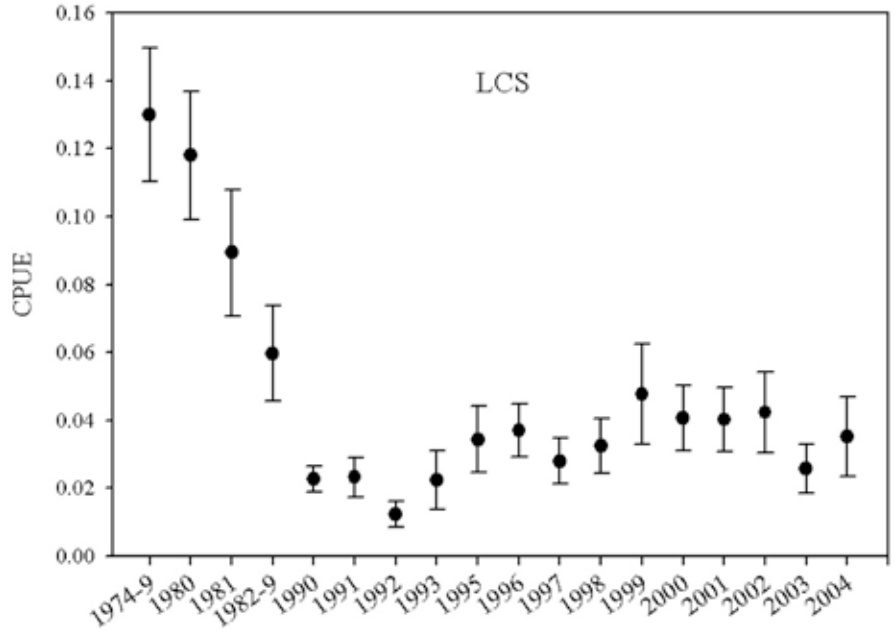
Must know r, N, M

Is predation release lowering M?

Cownose ray predators:

Dusky Shark (*Carcharhinus obscurus*)
Sandbar Shark (*C. plumbeus*)
Cobia (*Rachycentron canadum*)


©R Dean Grubbs



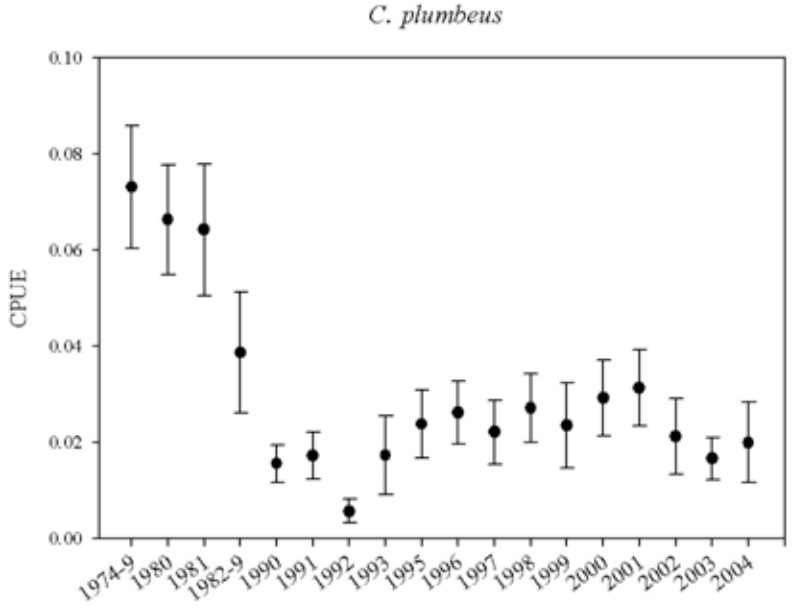
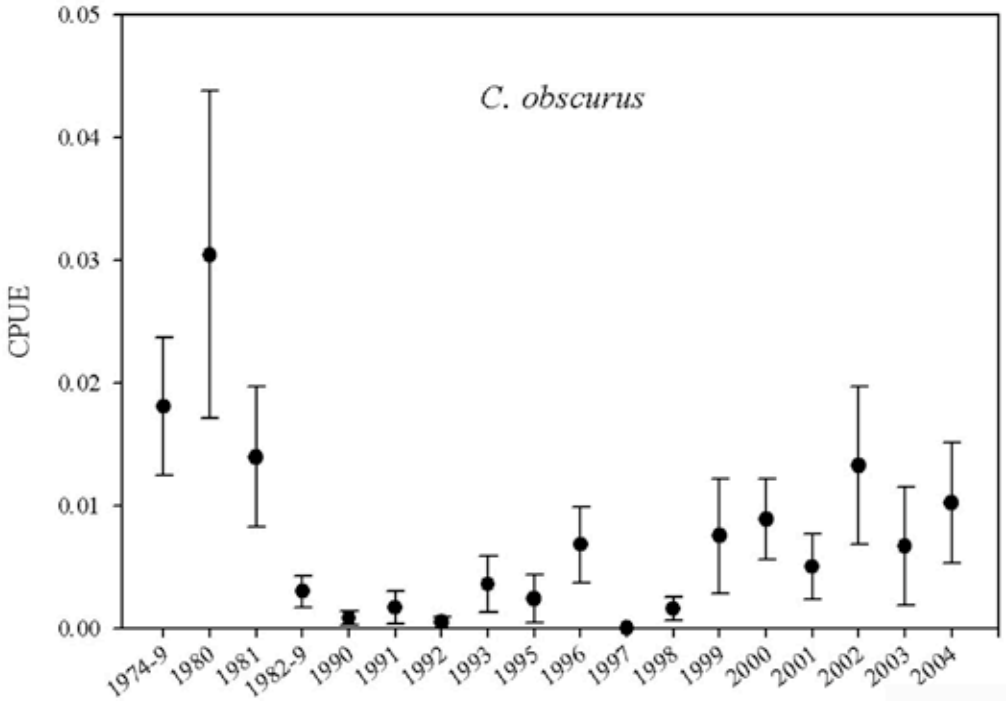


Table 2.5.1 Summary table of the status of the biomass of large coastal sharks. Sources: 2002 LCS stock assessment; E. Cortes, personal communication; L. Brooks, personal communication.

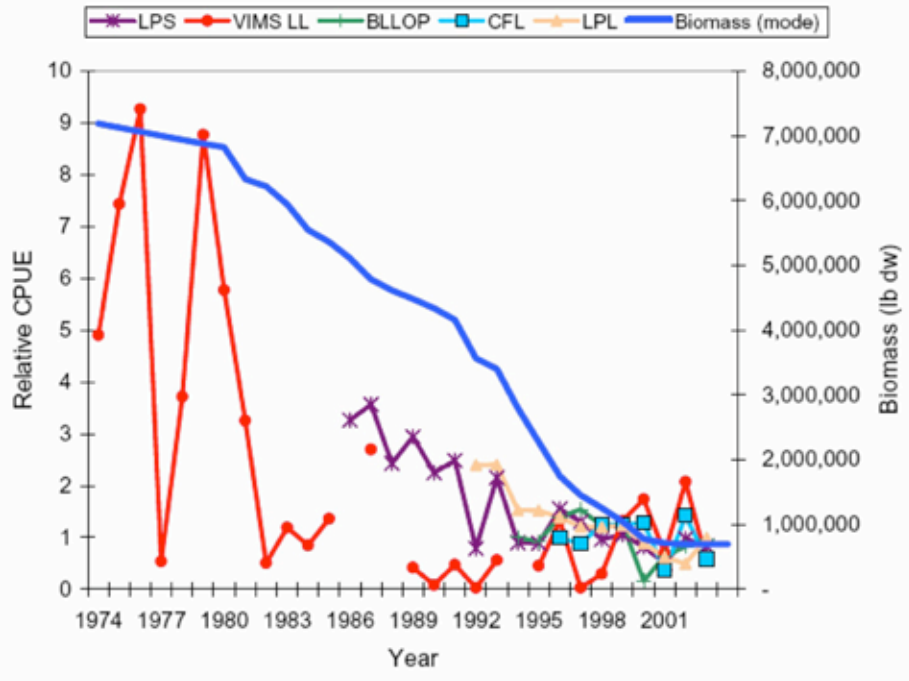
Species	Current Biomass N_{2001}	N_{MSY}	Current Relative Biomass Level N_{2001}/N_{MSY}	Biomass Target B_{OY} = 125%B_{MSY}	Outlook
Large Coastal Complex	2,940 - 10,156	4,469 - 8,371	0.46 - 1.18	5,586 - 10,464	STOCK IS OVERFISHED. $B_{2001}<B_{OY}$ The majority of the models, including the models not summarized here, indicate that the resource is overfished. Even in the models where the resource is not overfished, the rebuilding target (B_{OY}) has not been met.
Sandbar	1,027 - 4.86 E8	786 - 1.50 E12	3.25 E-4 - 2.22	983 - 1.88 E12	STOCK IS NOT OVERFISHED; REBUILDING IS STILL NEEDED. $B_{2001}<B_{OY}$ The models have conflicting results. These conflicts are due, in part, to the sensitivity of certain models to catch or CPUE series. The Bayesian SPM models and SSLRSG models appear to correspond with each other, have good convergence[2], and fit well with CPUE data. These models generally indicate that the biomass is at or above B_{MSY} levels and below B_{OY} levels.
Blacktip	5,587 - 3.16 E7	3,43 - 1.90 E7	0.79 - 1.66	4,288 - 2.38 E7	STOCK IS NOT OVERFISHED AND IS REBUILT. $B_{2001}>B_{OY}$ The majority of the models indicate that biomass levels exceed B_{MSY} and B_{OY}. Some of the models that were very optimistic had difficulty converging. The other models were sensitive to the catch series.

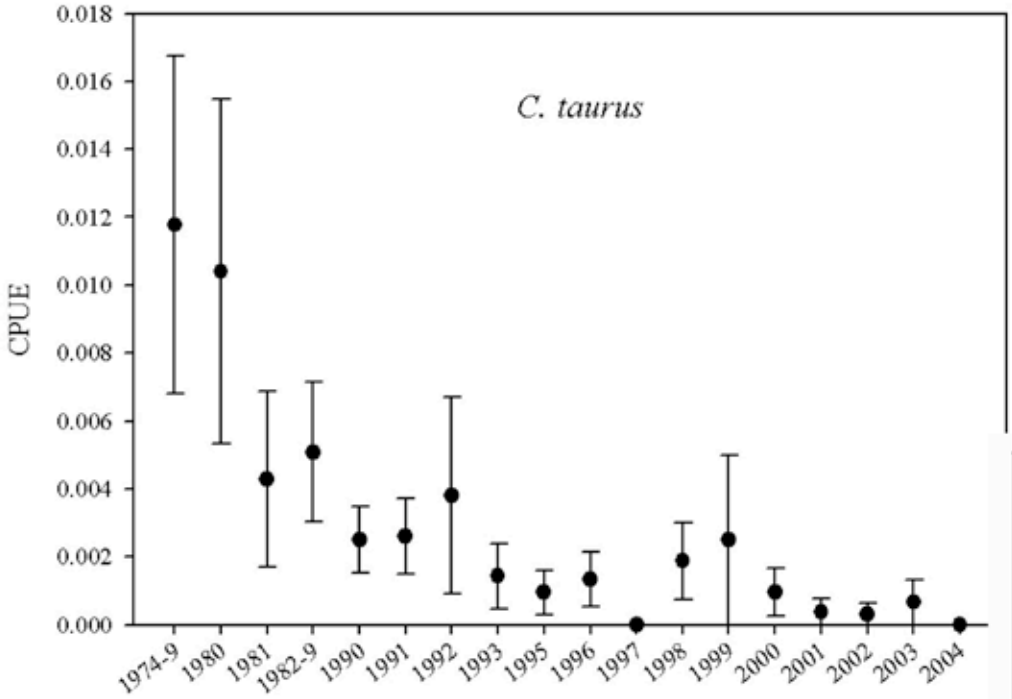
1 MSC for age structures models is in biomass, not numbers.
2. Convergence indicates that the algorithm has become stable and come to an optimal solution.



VIMS Data

2006 Stock Assessment





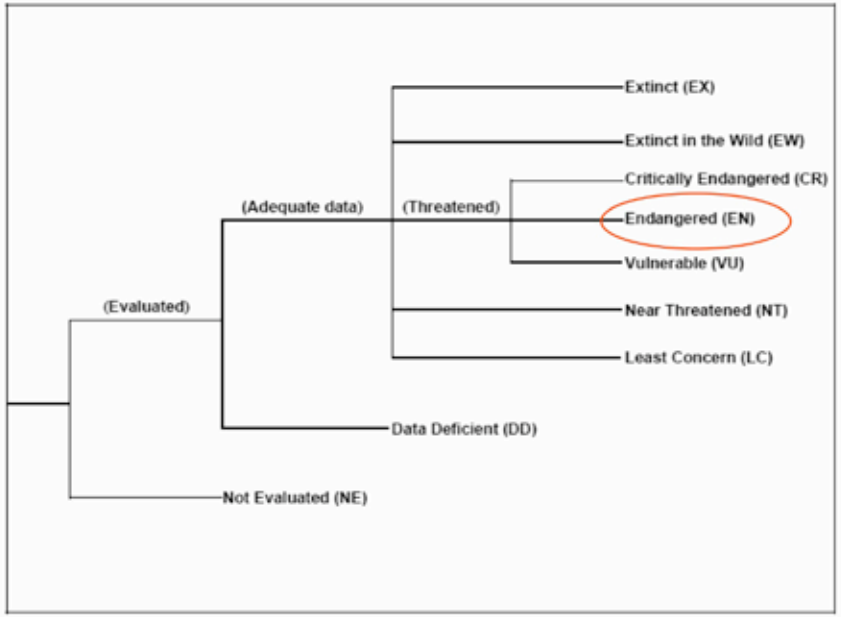


Figure 2.1. Structure of the IUCN Red List categories

IUCN 2005

Goldman, K.J, R.D. Grubbs and Musick, J.A.. In Review. Sandtiger shark, *Carcharias taurus*. *In*: The Conservation Status of North and Central American Chondrichthyans - Report of the IUCN Shark Specialist Group North and Central America Red List Workshop. 15th-18th June 2004, Mote Marine Lab, Florida, USA. IUCN, Gland, Switzerland, and Cambridge, UK. 2006.

MOVEMENTS
Fallacy:
Cownose rays migrate seasonally between the East Coast of the U.S. and Brazil

Schwartz, F.J. 1965. Inter-American migrations and systematics of the western Atlantic cownose ray, *Rhinoptera bonasus*. Author's Abstract. *Association of Island Marine Laboratories of the Caribbean*, 6th Meeting, Isla Margarita, Venezuela Jan. 20-22, 1965, 1 p.

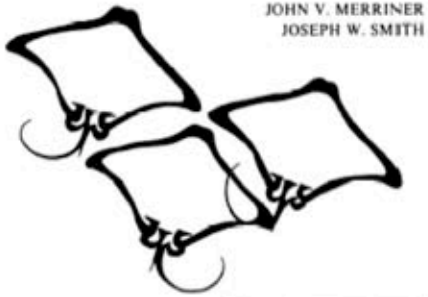
"Smith (1980) had previously estimated a fall migration rate of 7.9 NM/d based on data from Schwartz (1965). Smith, in turn, questioned the feasibility of a trans-Caribbean component to the migration based on this rate of movement. He believed cownose rays more likely over-wintered along the South Atlantic Bight either off-shore of North Carolina or as far south as Cape Canaveral, Florida."

Grusha 2005

FIGURE 3-10. Bathymetry contours of the South Atlantic Bight.

A REPORT TO THE
OYSTER INDUSTRY
OF VIRGINIA ON THE
BIOLOGY AND MANAGEMENT
OF THE COWNOSE RAY
(Rhinoptera bonasus, Mitchill)
IN LOWER CHESAPEAKE BAY

JOHN V. MERRINER
JOSEPH W. SMITH



SPECIAL REPORT IN APPLIED MARINE SCIENCE AND OCEAN ENGINEERING NO. 216

AUGUST 1979

Merriner and Smith (1979)
Cape Lookout in Mid-April
Enter Chesapeake Bay in early May.
Clay Bank in York River by early June
Depart in September/October
Overwinter in South Atlantic Bight, to 27°N

FIGURE 3-10. Bathymetry contours of the South Atlantic Bight.

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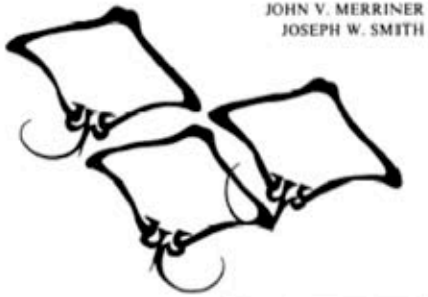

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Overwinter in South Atlantic Bight, to 27°N

FIGURE 3-15. Nominal migration track of fall migration for cownose rays (in yellow).

Grusha 2005: Satellite Tags

Leave CB in Sept-Oct

Migrate south to 27°N by Mid-Dec

Leave in March

6.3-7.3 NM/day
Mean: 6.7 NM/day

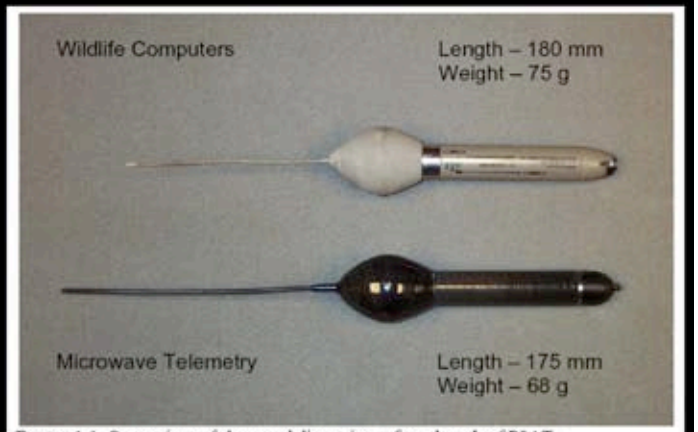


FIGURE 1-1. Comparison of shape and dimensions of two brands of PSAT.

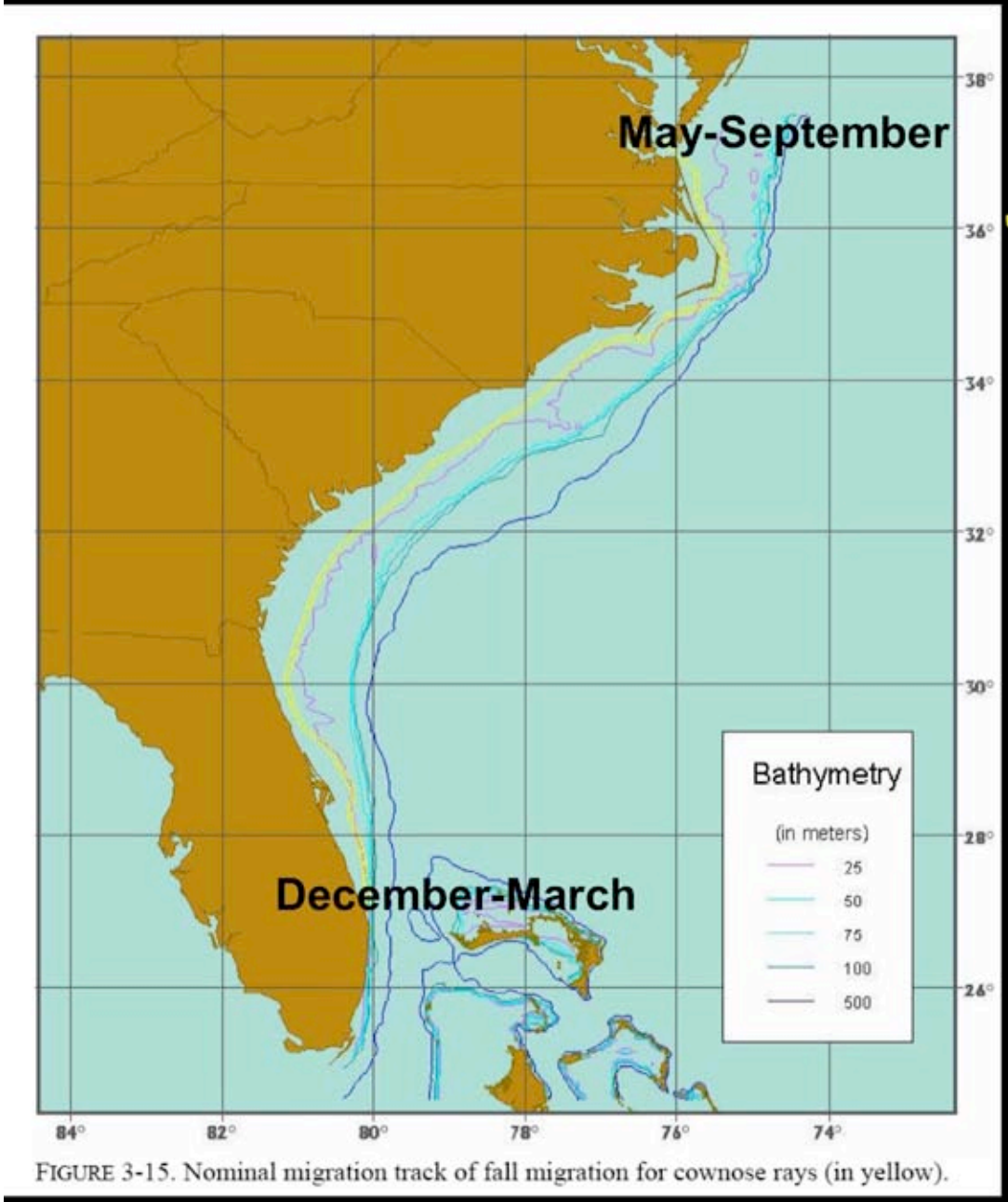


FIGURE 3-15. Nominal migration track of fall migration for cownose rays (in yellow).

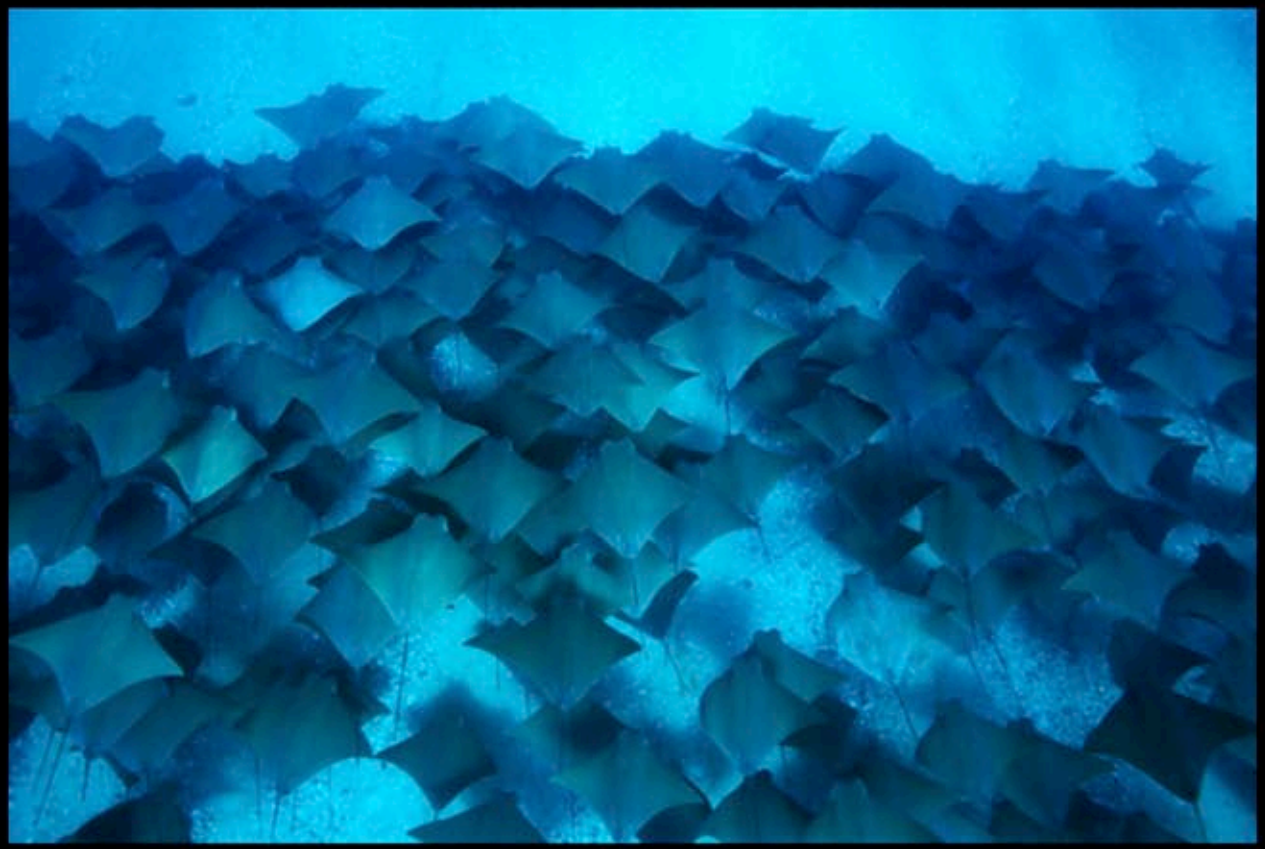
Interjurisdictional Fisheries Act

"interjurisdictional fishery resource"

Has the population increased?

Hildebrand and Schroeder (1928)

Cownose rays "are apparently rare in Chesapeake Bay."



Hildebrand and Schroeder (1928)

Cownose rays "are apparently rare in Chesapeake Bay."

Smooth dogfish were "previously unrecorded from the Bay, record based on one specimen from a pound net."

Sandbar shark is "rather rare in Chesapeake Bay…"

Hildebrand and Schroeder (1928)

Cownose rays "are apparently rare in Chesapeake Bay."

Smooth dogfish were "previously unrecorded from the Bay, record based on one specimen from a pound net."

Current harvest rate in VA:
300,000-800,000 pounds per year
($250,000-$500,000)

Sandbar shark is "rather rare in Chesapeake Bay…"

60% Directed Commercial Shark Catch on East Coast

Chesapeake Bay is largest summer nursery in Atlantic (world?)

Current harvest rate in VA:
200,000-400,000 pounds per year
($150,000-$250,000)

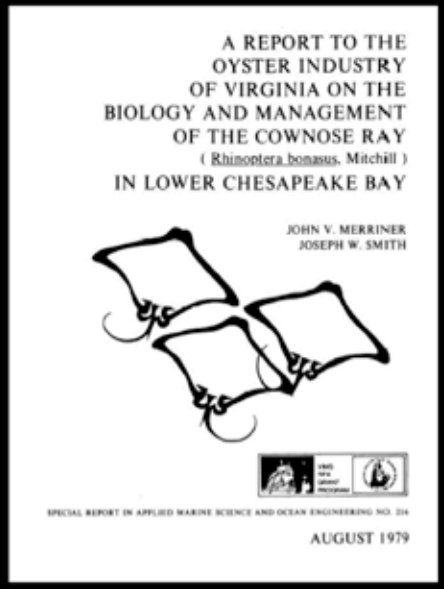
John Smith 1608 exploration of the Chesapeake Bay. Rappahannock River. In the words of three of Smith's crew members: *"…But our boat, by reason of the ebb [tide] chancing to ground on a many shoals lying the entrances, we spied many fishes lurking in the reeds…"*

: *"...Our Captain sporting himself by nailing them [the fishes] to the ground with his sword, set us all afishing in that manner: thus we took more in an hour than we could eat in a day."*

Smith 1980, Merriner and Smith 1979

In 1975, 8 oyster growers requested aid in the form of control measures to curb predation by rays

Schwartz (1965) – "Huge flotillas of R. bonasus annually invade the upper bay." Scwartz also witnessed the catch of 200,000 cownose rays in the Potomac River in 1964


A REPORT TO THE OYSTER INDUSTRY OF VIRGINIA ON THE BIOLOGY AND MANAGEMENT OF THE COWNOSE RAY (Rhinoptera bonasus, Mitchill) IN LOWER CHESAPEAKE BAY

JOHN V. MERRINER
JOSEPH W. SMITH

SPECIAL REPORT IN APPLIED MARINE SCIENCE AND OCEAN ENGINEERING NO. 216

AUGUST 1979

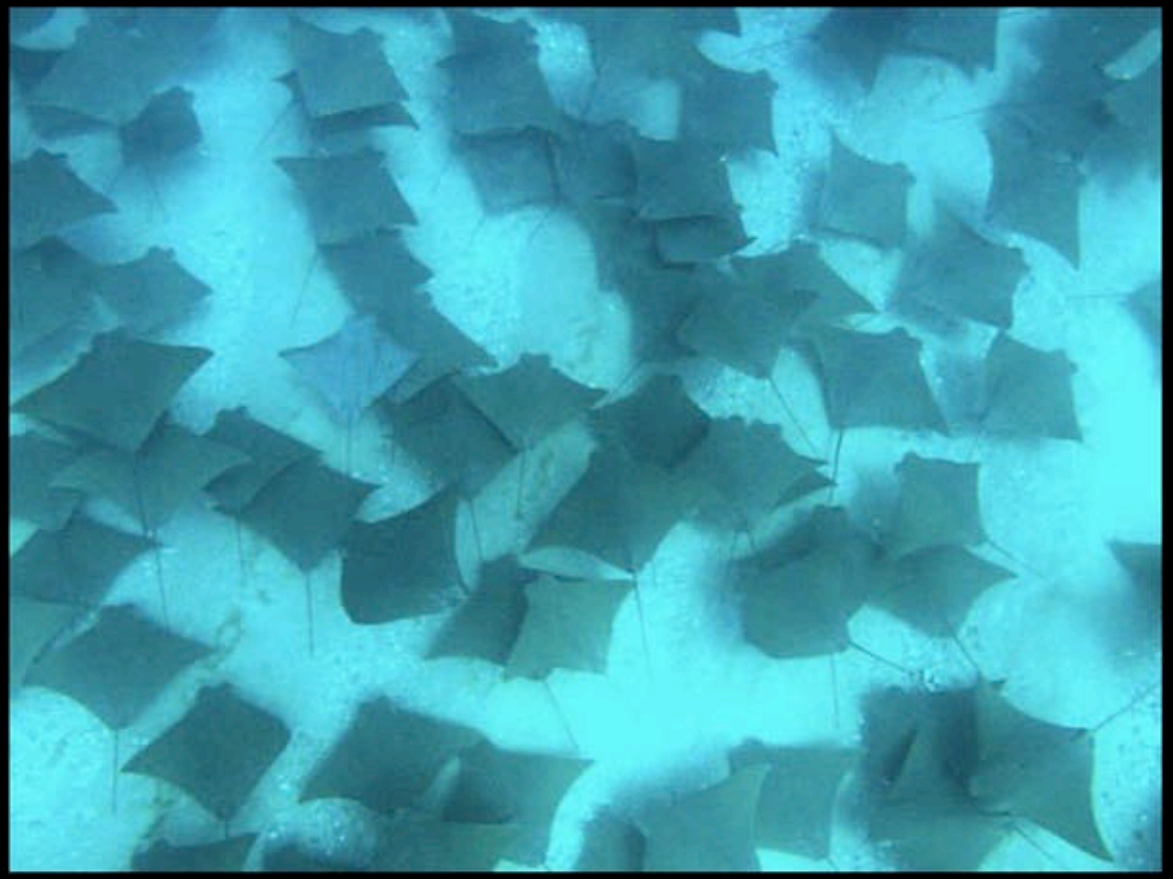
Blaylock 1989

Three Aerial Surveys in Chesapeake Bay (off Cape Charles)
25 July 1988, 02 August 1988, 09 August 1988

457 ha school (1,129 acres)

1.1 rays per square meter

School Size ~5,000,000 rays



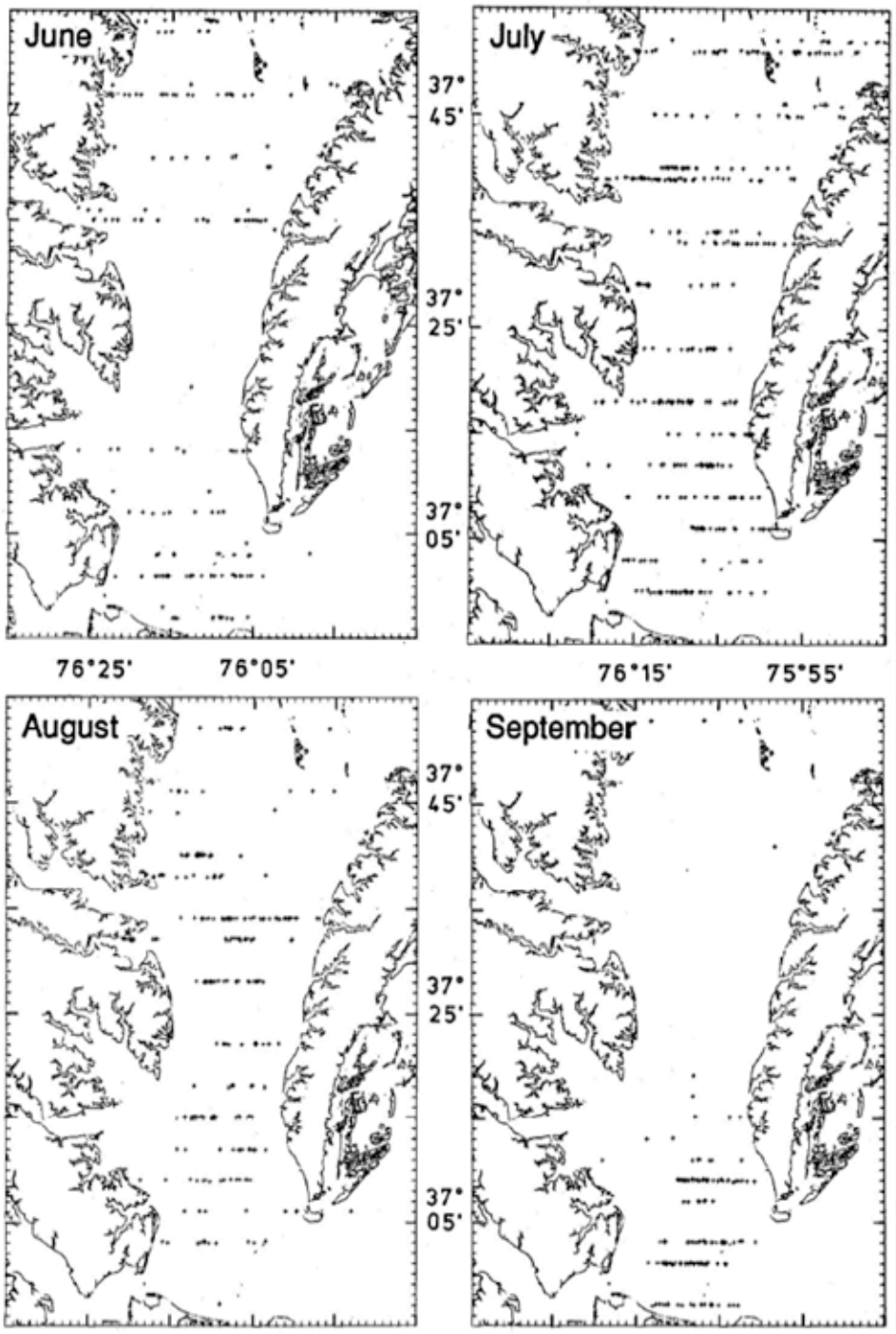
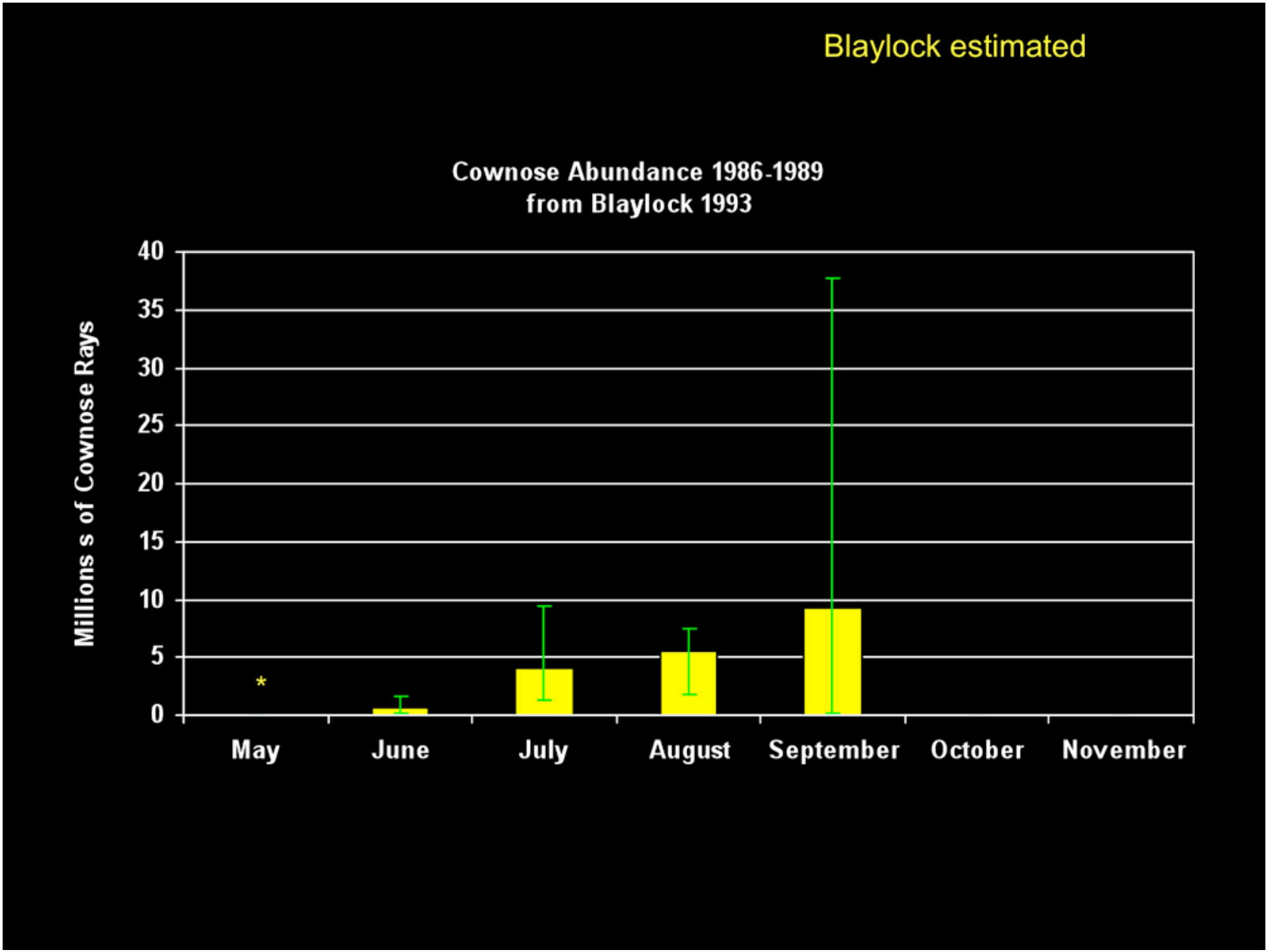


Fig. 6. Cownose ray sightings during June–September 1986–1989 aerial surveys.

Blaylock estimated

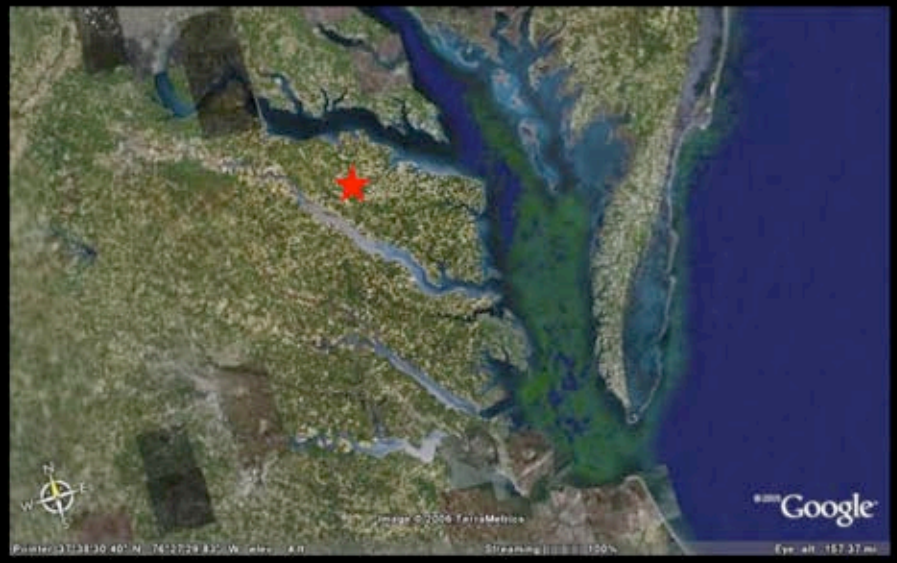
Must know r, N, M

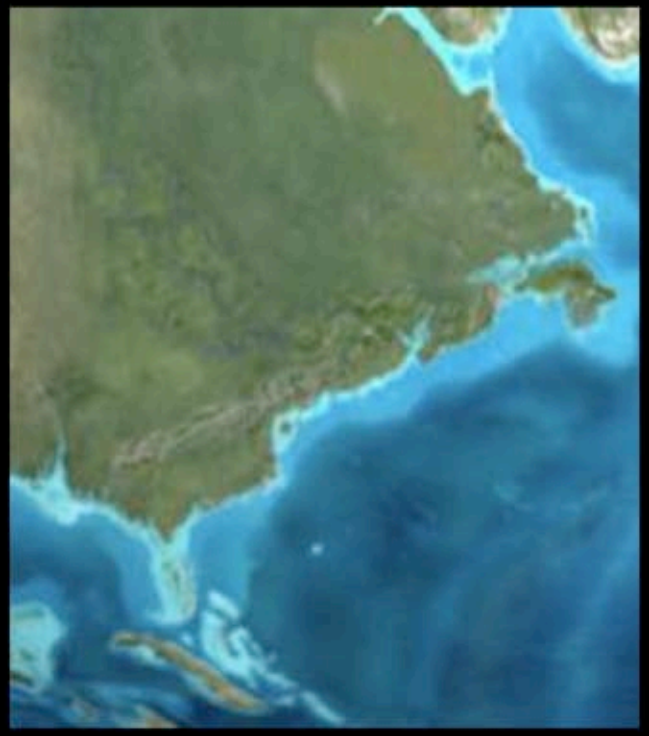

Blaylock estimated
Cownose Abundance 1986-1989
from Blaylock 1993
Millions s of Cownose Rays
40
35
30
25
20
15
10
5
0
*
May
June
July
August
September
October
November

Jim Bourdon

Cownose ray are the most common ray teeth found when surface collecting the Pungo River. Two *Rhinoptera* species tooth designs are commonly found.
Miocene - 5-23 million years old

Rhinoptera are common in Nanjemoy sediments
Stafford County, Virginia
Early Eocene (Ypresian) - ~50-55 million years old
Perhaps 10 species or cownose, bullnose, and eagle rays





IUCN Shark Specialist Group

Brazilian Cownose Ray (*Rhinoptera brasiliensis*)

Vooren & Lamónaca 2004

Listed as ENDANGERED

"It is viviparous with only one embryo per litter, and as such is highly vulnerable to recruitment overfishing. "

"In its southernmost distribution the species occurred as a summer migrant in coastal waters at depths of <20 m, where it was caught and discarded in large numbers during the 1980s by the summer beach seine fishery, with catches of up to 330 individuals in a single haul."

"In summer 2002/2003, during three months of surveying the shorebased fishery, the species was no longer caught. It is suspected that the species has been extirpated by intensive fishing in the restricted area of its southern summer habitat."

"Its restricted distribution, very low fecundity, apparent extirpation from the southern part of its range and intensive fishing across its entire range warrant at least an Endangered assessment. "

"It may prove to be Critically Endangered with further surveys, which are a priority."

Brazilian Cownose Ray

Brazilian Cownose Ray

IUCN Shark Specialist Group

Cownose Ray (*Rhinoptera bonasus)*

Barker, A.S. (2005)

Listed as: Near Threatened Globally; Least Concern USA

The schooling nature and inshore habitat of this species together with their relatively late maturity and low productivity (generally one young per litter) increases their susceptibility to overexploitation and will limit their ability to recover from population decline.

The species is assessed globally as Near Threatened due to heavy (and generally unregulated) fishing pressure on the inshore environment throughout large parts of Central and South America.

Rhinopterids are regularly landed around the world and heavy pressure on the inshore ecosystem is having negative impacts on congeners of *R. bonasus*, for example *R. javanica* throughout Asia and *R. brasiliensis* in Brazil.

IUCN Shark Specialist Group

Cownose Ray (*Rhinoptera bonasus)*

Barker, A.S. (2005)

Listed as: Near Threatened Globally; Least Concern USA

Although there is currently no directed fishery for the cownose ray in the US, it has been suggested due to their reputation as a "pest" species to the shellfish industry.

In US waters they are currently taken as bycatch in fisheries employing pound nets, haul seines and shrimp trawls, however, these activities do not pose a significant threat to the species at the present time and the population appears to be healthy.

As such the species is assessed as Least Concern in the USA. However, if a fishery for cownose rays is ever established, it could be devastating to the population without proper monitoring.

Ecosystem Function:

Bioturbation

Trophic function for juvenile fishes

Prey for sharks and cobia

Interjurisdictional resource

Chesapeake Bay may be the largest nursery for young-of-year rays for entire population

Primary data need:
Intrinsic rates of potential population growth and population doubling times

Therefore, need:
age and growth data
natural mortality estimates
population size estimates

Also:
trophic ecology
ecosystem function


© Dean Grubbs

Addressing Cownose Ray Predation in the North Carolina Bay Scallop Fishery Management Plan

Trish Murphy
North Carolina Division of Marine Fisheries
3441 Arendell Street
Morehead City, NC 28557

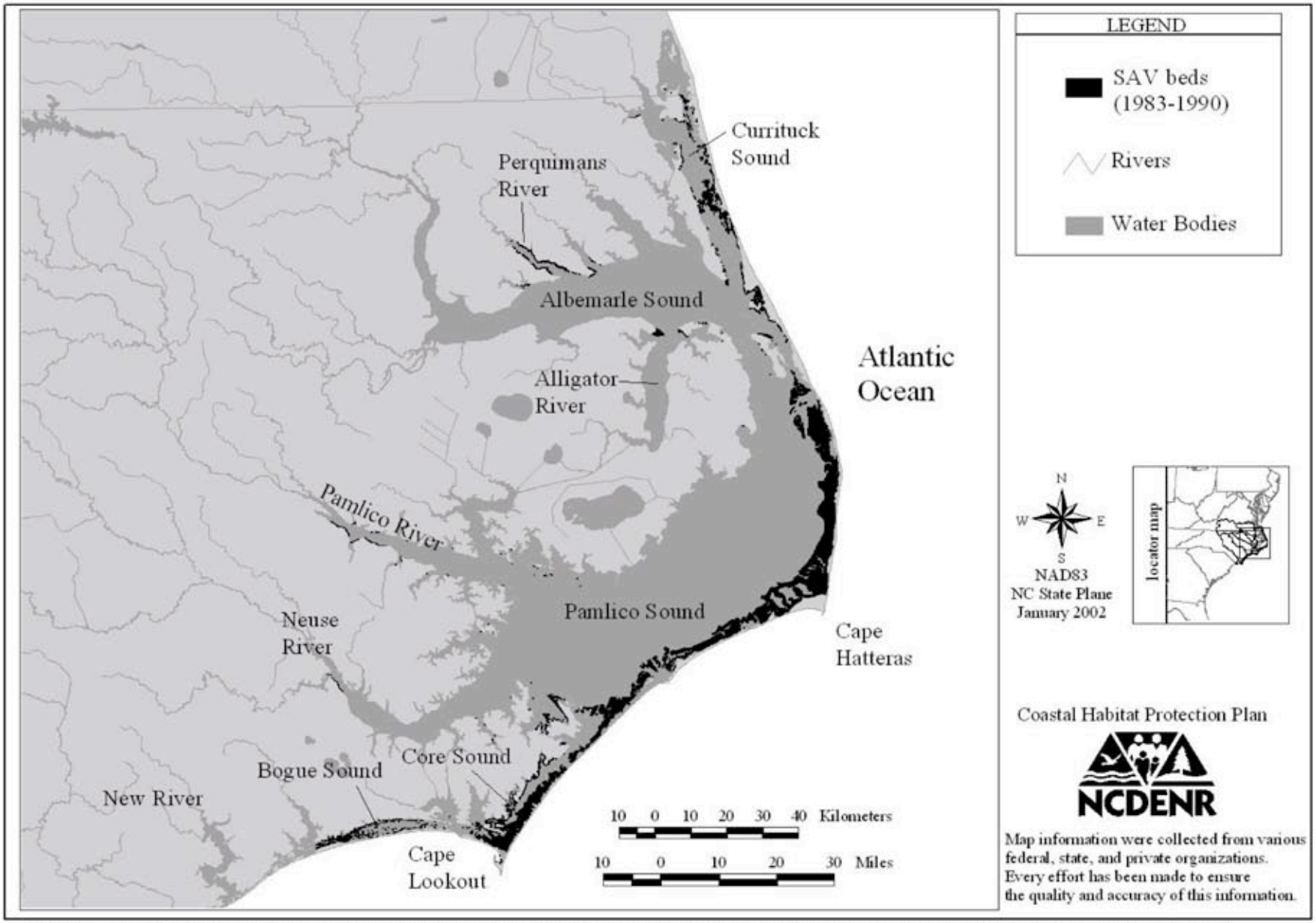
There has been a growing concern in North Carolina about predation on bay scallops (*Argopecten irradians*) by cownose rays (*Rhinpotera bonasus*). Bay scallop landings have dropped significantly since 2000 with cownose rays contributing to some of the decline. Because of the low harvest levels in recent years, the North Carolina Division of Marine Fisheries (DMF) began developing a Fishery Management Plan (FMP) for bay scallops in 2005. Several management options and enhancement measures to restore the fishery are being developed by DMF staff. A citizen Advisory Committee (AC) composed of commercial and recreational fishermen and scientists is providing input on these management measures. One issue that was recently addressed with the AC and must be considered in the restoration of the fishery is how to reduce cownose ray predation while rebuilding the scallop population. Management options considered include building stockades around productive areas and development of a cownose ray fishery.

Addressing Cownose Ray Predation in the NC Bay Scallop Fishery Management Plan.

Photo: Toby Curtis.

Bay Scallop

North Carolina Distribution

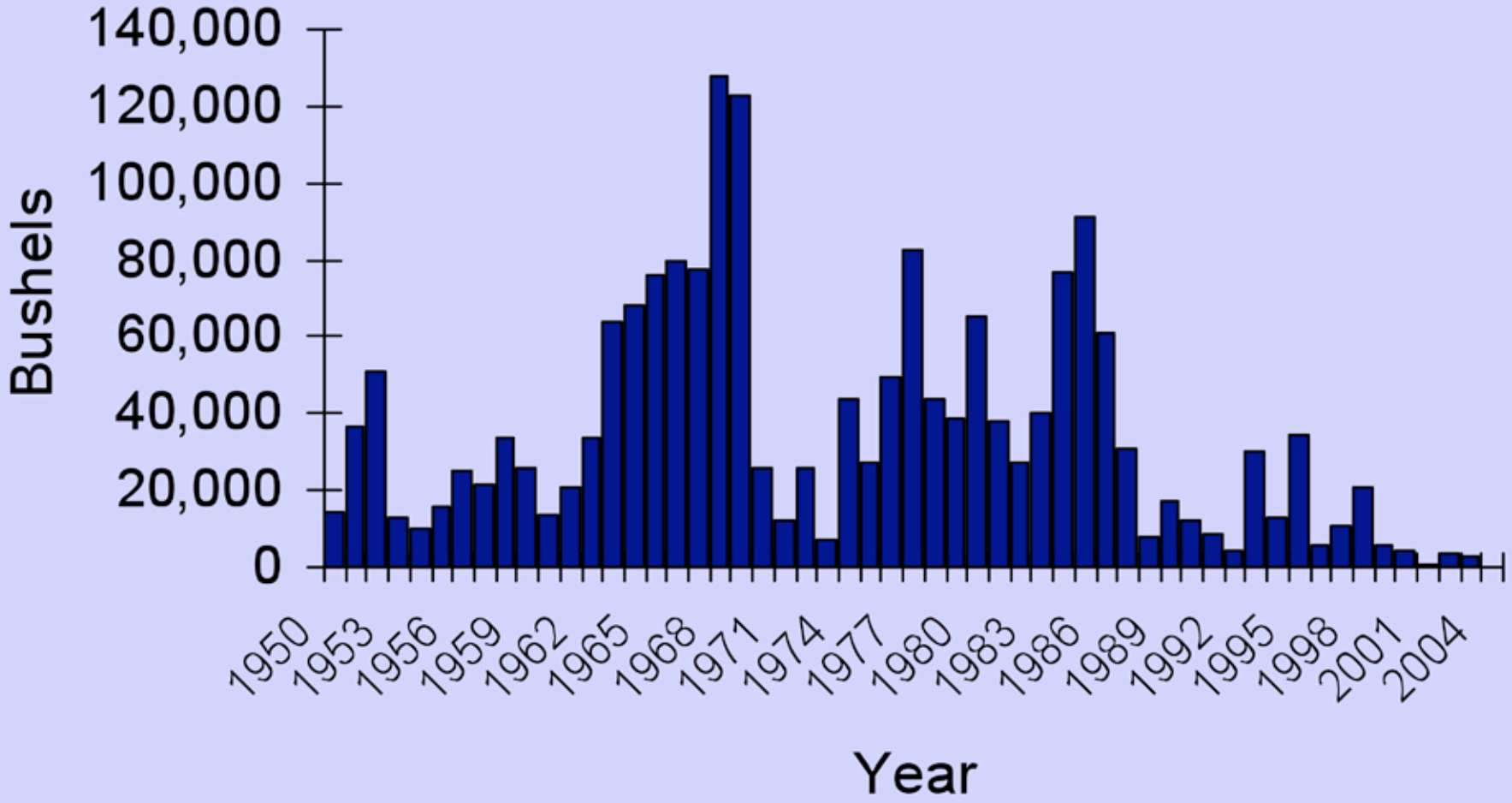


Map 4.2. Location of known of submerged aquatic vegetation (SAV) habitat in coastal North Carolina (from Ferguson and Wood 1994; Carraway and Priddy 1983). Note: absence of SAV beds in a given areas does not suggest actual presence/absence of SAV because surveys have not been conducted in all areas.

DMF Stock Status
CONCERN

- Annual crop
- Effected by environmental conditions
  - Climate
  - Predation
  - Red tide

Commercial bay scallop landings (bushels) of North Carolina, 1950-2004

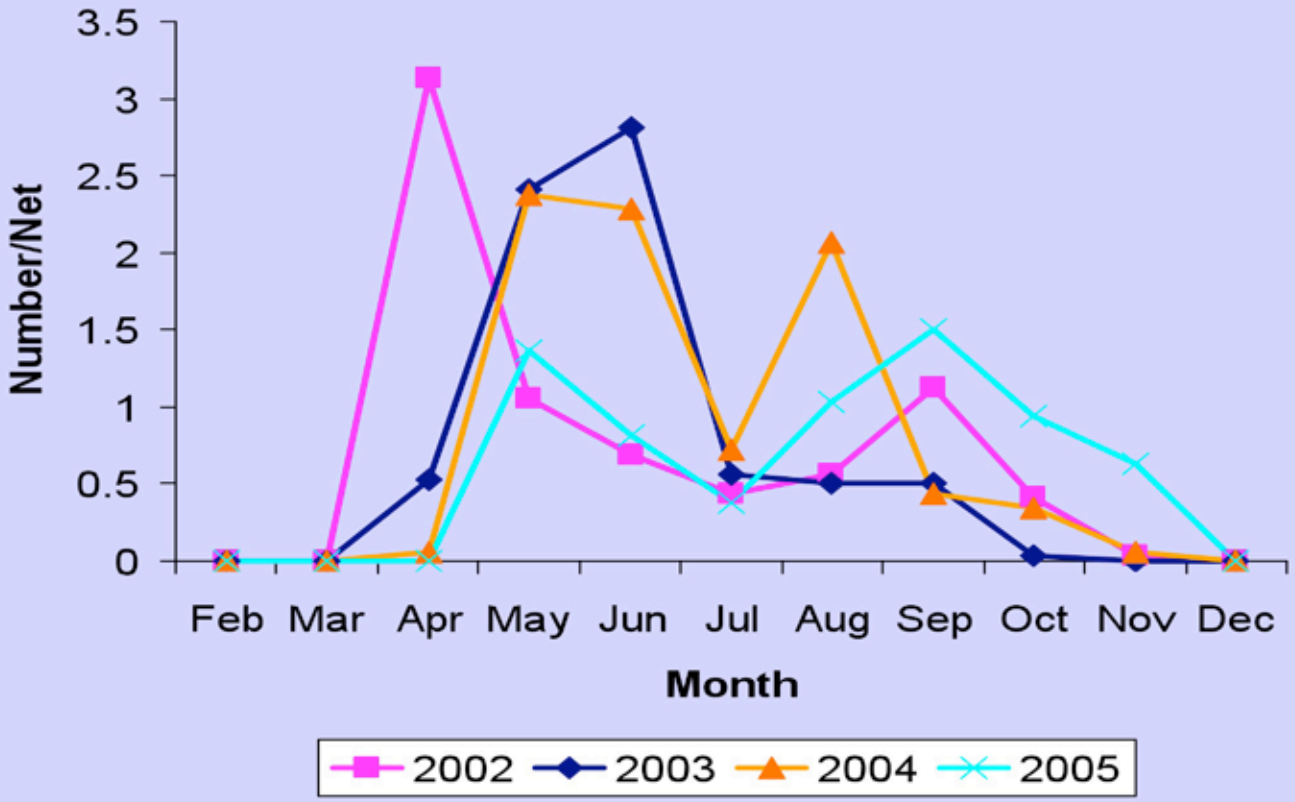




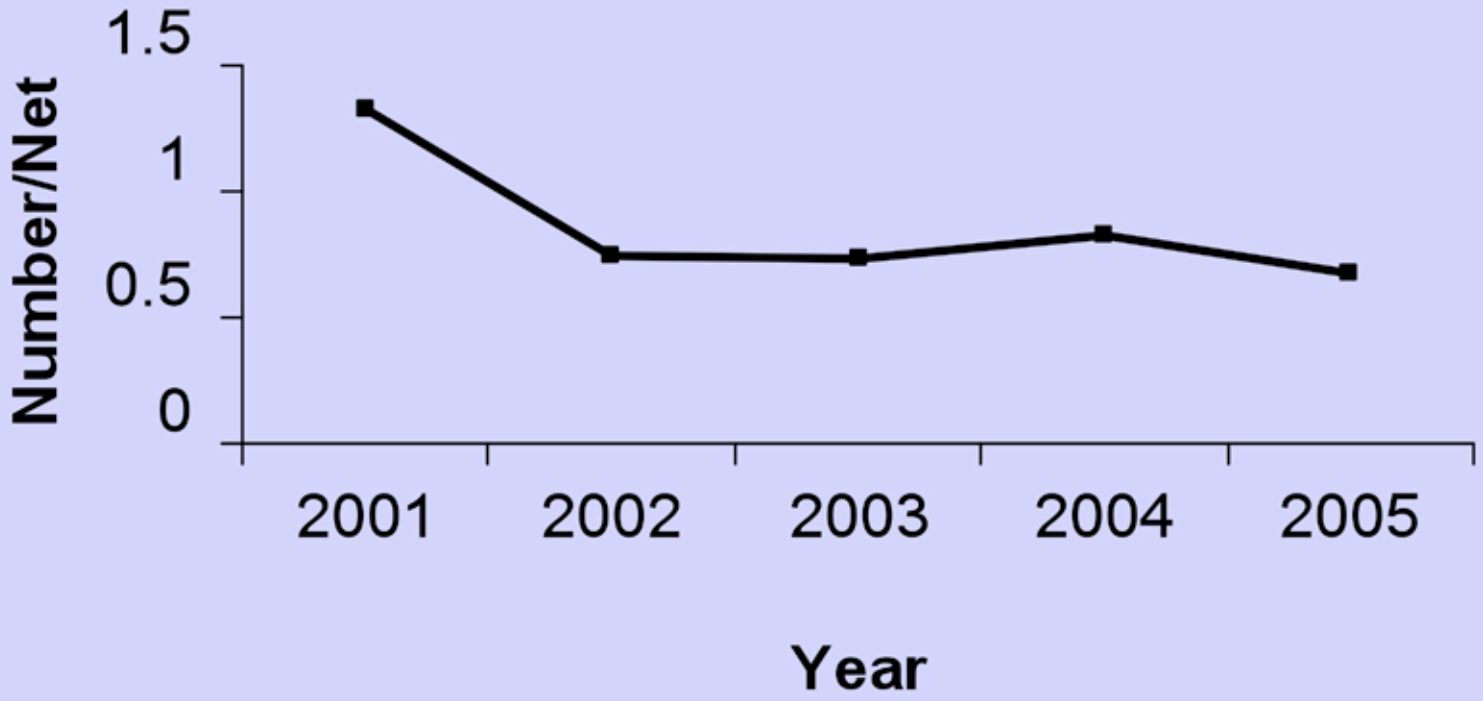




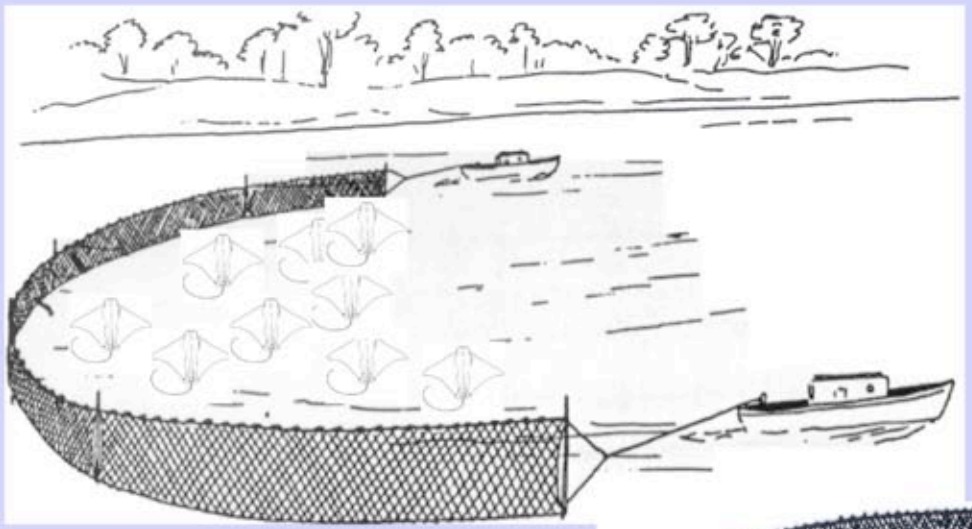

Monthly CPUE of Cownose Rays in Pamlico Sound

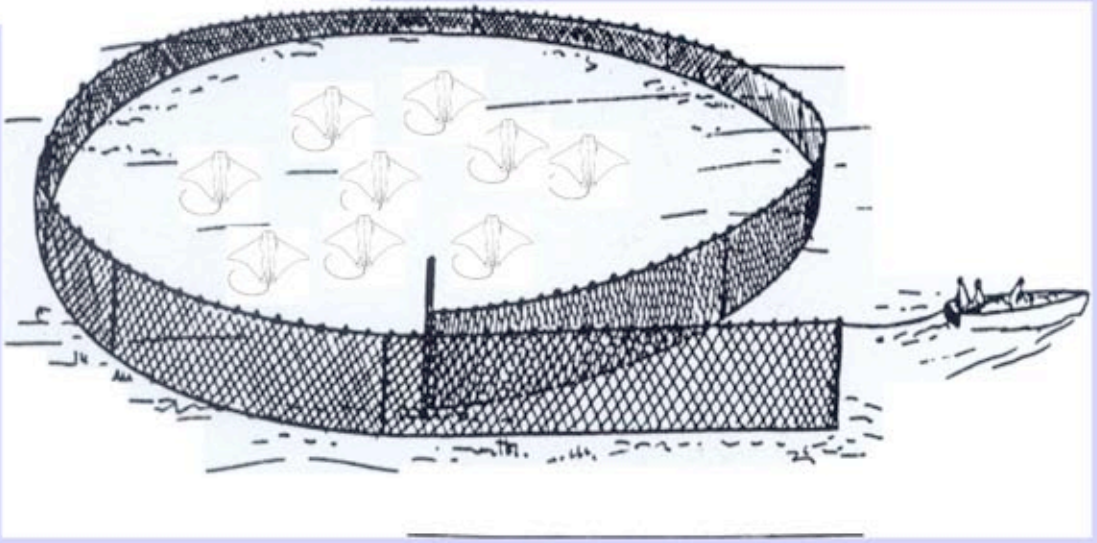


Yearly CPUE of Cownose Rays in Pamlico Sound



Otwell and Lanier 1978





Peterson et al. 2001

- Crashes of bay scallop populations before fall spawning
- Mortality rate increased as density increased
- Erected stockades to prevent predation
- Site specific habitat selection may be based on prey density

Powers and Gaskill 2005

- Surveyed Back, Core, and Bogue sounds
- 100% mortality in Core/Back sounds
- 20% mortality in Bogue Sound
- Rays selected areas with high densities of scallops


Goose Bay
Whitehurst Creek
Gibbs Creek
Mull
Davis Bay
Brooks Creek
Westmouth Bay
Henry Jones Creek
Hogpen Ba
Back Sound
Bald Hill Bay
Johnsons Bay
Lighthouse Bay
Blinds Hammock Bay
Image © 2006 DigitalGlobe
Image © 2006 TerraMetrics
Google

Management Options

- Construct fencing/stockades around most productive grass beds
- Transplant scallops from high density to low density areas
- Transplant scallops from high density to low density areas and protect by fencing/stockades
- Develop commercial and recreational cownose ray fishery

PDT Management Recommendations

Experimental or Pilot Program

- Construct fencing/stockades around most productive grass beds
- Transplant scallops from high density to low density areas
- Transplant scallops from high density to low density areas and protect by fencing/stockades

AC Management Recommendations

- Develop a cownose ray fishery
- Investigate markets for cownose rays
- Research approaches to control the cownose ray population

Research Recommendations

- Collect population information on cownose rays.
- Investigate uses of cownose rays
  - Food industry
  - Pet food industry
  - Supplement industry (human and pets)
- Investigate markets for cownose rays.
- Survey fishermen to determine 'best' methods of harvest for rays.

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- http://jrscience.wcp.muohio.edu
- www.oceanexplorer.noaa.gov
- http://mehp.vetmed.ucdavis.edu
- www.inlandreef.com
- http://pdubois.free.f

Cownose Ray Interactions in Maryland

Don Webster
University of Maryland
Sea Grant Extension
Wye Research and Education Center
P.O. Box 169
Queenstown, MD 21658-0169

Maryland has two areas of concern from Cownose Ray predation. While many of the rays enter the Chesapeake Bay, a smaller group has seasonal effects upon the coastal bays. With the advent of hard clam aquaculture in coastal areas, predation by rays has become a problem.

Historically, cownose rays had some minor predation effects on leased oyster grounds, mostly in the lower Chesapeake Bay. These were most pronounced when oysters were small and single rather than set heavily upon shell cultch. Recent large-scale oyster projects have included frequent sampling by several methods, including diver observation, with no noted predation by rays. All oysters in these projects are produced using spat on oyster shell.

The largest predation occurred upon soft and razor clam populations. From the start of the industry in the 1950s, harvesters noted heavy destruction of beds by cownose rays. During the late 1970s a project was funded by the Mid Atlantic Fishery Development Foundation to catch and market rays. Commercial harvesters were enlisted to report their occurrence, with specially outfitted catcher vessels dispatched to the area. Wings were removed at sea, and the resultant product used in market development by the Maryland Seafood Marketing Authority. The conclusion was that the populations were less than assumed and highly mobile and that markets for the product were hard to develop due to seasonality.

Hard clam growers use several methods in Maryland. Soft bags have the same problems encountered by their counterparts in Florida with rays being able to produce holes in the bags without additional protection. Predator nets seem to work well although rays are seen trying to find ways into them.

A discussion of concerns about the development of an uncontrolled directed fishery without concurrent expansion of knowledge base about the biological role and niche of the Cownose Ray resource is included.

Cownose Ray Interactions in Maryland

Don Webster
University of Maryland
Sea Grant Extension Program

Commercial Resource Effects

- Oysters
  - some private growers reported predation from rays during the 1970s - early 1980s
  - most in the Nanticoke area of the Eastern Shore planting oysters containing many singles
  - disease epizootic of early 80s wiped out most lower Shore private and public resources
  - not deemed significant threat to public reefs
  - spat on shell seemed to provide safety

Commercial Resource Effects

- Soft shell and razor clams
  - industry expanded from 1950s with advent of hydraulic escalator harvesters
  - CNRs frequently reported on clam beds
  - deemed to be a significant threat to resources
  - commercial watermen asked that control measures be instituted to prevent devastation of clam beds by what was assumed to be large numbers of CNR in the bay annually

Control Project

- 1978-79, Mid Atlantic Fisheries Development Foundation project award to
- Maryland Watermen's Association
- Vessels equipped with bottom trawls
- Commercial watermen note schools of CNR during work; radio location to shore stations
- Catching vessels would proceed to area, locate schools, and harvest

Control Project (cont'd)

- On-board primary processing of wings; overboard discharge of waste
- Marketing carried out with Maryland Seafood Marketing Authority
- Conclusions
  - hard to harvest using trawls
  - not as many CNR as thought due to their mobility
  - markets hard to develop for species
  - discarded as not being worth expanded effort

Other Reports of CNR in MD

- Nuclear Regulatory Commission report 2005
  - 80 - 100 CNR were found on entrainment screens at the Calvert Cliffs Nuclear Power Plant
  - believed to have died from anoxia
  - since anoxia is one of the largest problems in the Chesapeake Bay, could CNR have problems in coping with current conditions
  - what would be the effect on the overall resource from increased anoxia mortality

Hard Clam Growers in MD

- **Hard clam aquaculture is a new industry**
- **Limited to coastal bays by salinity profile**
- **Growout methods**
  - Soft bags as used in Florida have been tried with varying rates of success, depending on conditions
    - holes in bags noted from CNR predation
    - same problem as found in Cedar Key area of Florida
    - extra exclusion devices have been developed and used to deter CNR predation

Hard Clam Growers in MD

- **Growout methods**
  - Predator nets
    - CNR will work around edges of the nets if they are not well sealed with gravel bags
    - CNR investigate nets for any breaks
    - seem to always be looking for and trying new and innovative ways to breach predator controls in order to get to at the clams for their food

Internet Searches for CNR

- approximately 1.4 million ‘hits’ on recent search
- biological information included
- many dive sites include information, pictures, and descriptions of CNR and related rays
- many photographs of CNRs posted as both shellfish predators and interesting aquatic animals

Summary

- CNR are typical schooling opportunistic predators – they look for food and try to evolve methods to get it
- we have changed the populations of many species over the years because of commercial value or control as predators
- once depleted, populations are hard to restore, as we've seen with many species

Summary

- we need to better understand the role of CNRs before developing a large commercial fishery and building markets for them
- we are quite good at wiping out animals that are just inconvenient to us
- deterrence needs to be a key focus of our efforts while we determine what we can remove from the resource without harm

Summary

- CNR problem is multi-faceted
  - **deterrence:** finding methods and devices that can dissuade CNR from areas we do not want them, such as clam beds
  - **biological**: developing a better understanding of the role of the animal in the environment and the dynamics of the populations
  - **marketing:** product development to use the portion of the population available for harvest to gain the best return for the resource

Cownose Ray Threat to Aquaculture Development and Shellfish Restoration

James Wesson
Virginia Marine Resources Commission
2600 Washington Avenue
Newport News, VA 23607

Cownose rays have been a threat to wild oyster seed transplants on private beds for many years. Barbed wire and other deterrents were reportedly being used as far back as the 1950s. As the higher salinity areas of the Bay became unused because of the forward progression of MSX and Dermo, seed plants became more concentrated in lower salinity areas such as the upper Rappahannock and Potomac Rivers. Especially in the late 1980s, cownose ray impacts were reported more commonly. As oyster populations have continued to fall, so too have other shellfish populations that rays feed upon, such as the soft shell clam (*Mya*), hard clams (*Mercenaria*), and most recently, razor clams (*Tagelus*). Since the early 1990s, the occasional seed planting efforts to low salinity areas by private industry have been almost completely stymied by cownose ray predation. Since there appears to be no remedy or refuge for escaping ray predation, private wild seed planting has almost ceased.

Virginia's wild seed replenishment efforts have been equally unsuccessful, with much of the failure related to cownose rays. The result of this is that most of the replenishment efforts have been shell plants, both conventional two-dimensional projects and large three-dimensional sanctuary reef construction. Natural spatset attached to shell cultch appears less prone to ray damage.

In the late 1990s, "oyster gardening" became very popular with the public as a way to grow oysters at one's own pier. Initially, citizens grew cultchless oysters in small floating structures for home use. However, as the selective breeding programs began to produce strains of oysters with some disease tolerance, oyster gardening groups, and especially the Chesapeake Bay Foundation (CBF), began to encourage oyster gardening to produce oysters to place on three-dimensional reefs as broodstock. This effort became even larger when CBF initiated their own oyster farm in 2000, to produce cultchless oysters by aquaculture methods for restoration on Virginia's sanctuary reefs. Cultchless oysters were planted loose on many reefs throughout the Bay with the intent that they would jumpstart areas into a more dependable spatset using oysters that were selectively bred for disease resistance. Between 2000 and 2004, most of these cultchless oysters were placed on reefs in the spring or early summer, just prior to the schools of rays entering into the Bay. There were no direct stock assessment efforts to determine the fate of the cultchless oysters, and in many cases, small increases in localized spatset in adjacent areas were attributed to spawn from this oyster restoration effort. Quantitative surveys of the three-dimensional reefs conducted annually in the fall by a VIMS-VMRC team, found little evidence that these oysters survived on the reef as very few cultchless oysters or boxes were observed.

Broodstock supplementation with selected strains gained momentum as a possible restoration breakthrough, especially by the Army Corps of Engineers (ACOE). In 2004, a plan to "carpet bomb" a single tributary with cultchless, aquaculture-produced, genetically-selected oysters, was initiated

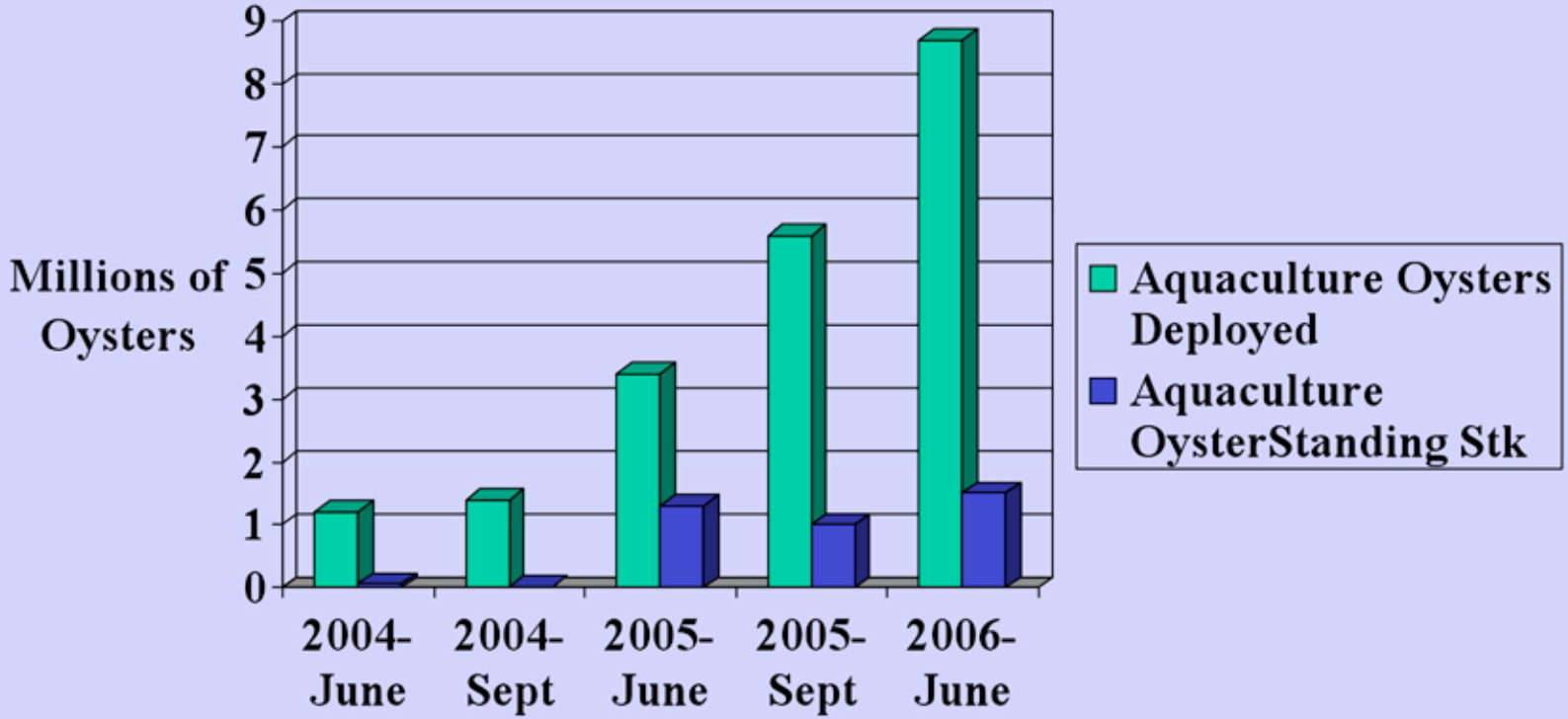
by the ACOE in the Great Wicomico River. Approximately 1.2 million cultchless oysters, (30-90 mm in shell length) were placed on the Shell Bar Reef in the Great Wicomico River in late May and early June. Planting efforts were monitored in mid-May, and cownose rays were visually observed immediately following the planting dates. A stock assessment survey found less than 5% of the deployed oysters. All planting was stopped, and a decision was made to erect net fences around the reefs that would protect the cultchless oysters. The fences were constructed early in 2005, and although there was some initial cownose ray intrusion, most of the oysters have been protected from the cownose rays. To date, approximately 7.6 million cultchless oysters have been deployed on the Shell Bar Reef in 2005 and 2006, and approximately 1.5 million (20%) cultchless oysters are currently present on the reef.

Most recently a project was initiated between CBF, the Nature Conservancy, VIMS, and VMRC to determine whether a heavier shell bed thickness could provide protection for cultchless oysters, and act as a deterrent for ray predation. In 2006, a one-half acre reef in the Piankatank River was recovered with 6 to 12 inches of fresh shells. Approximately 775,500 cultchless oysters (mean size 67 mm), which had been grown by the CBF oyster farm, were spread over the reef at a density of approximately 400 oysters per meter. The last of these cultchless oysters were deployed on May 17, 2006. The reef was quantitatively surveyed on May 18, 2006, and only 6% of the deployed oysters remained. Ray predation was entirely responsible for the loss of these oysters in less than 5 days.

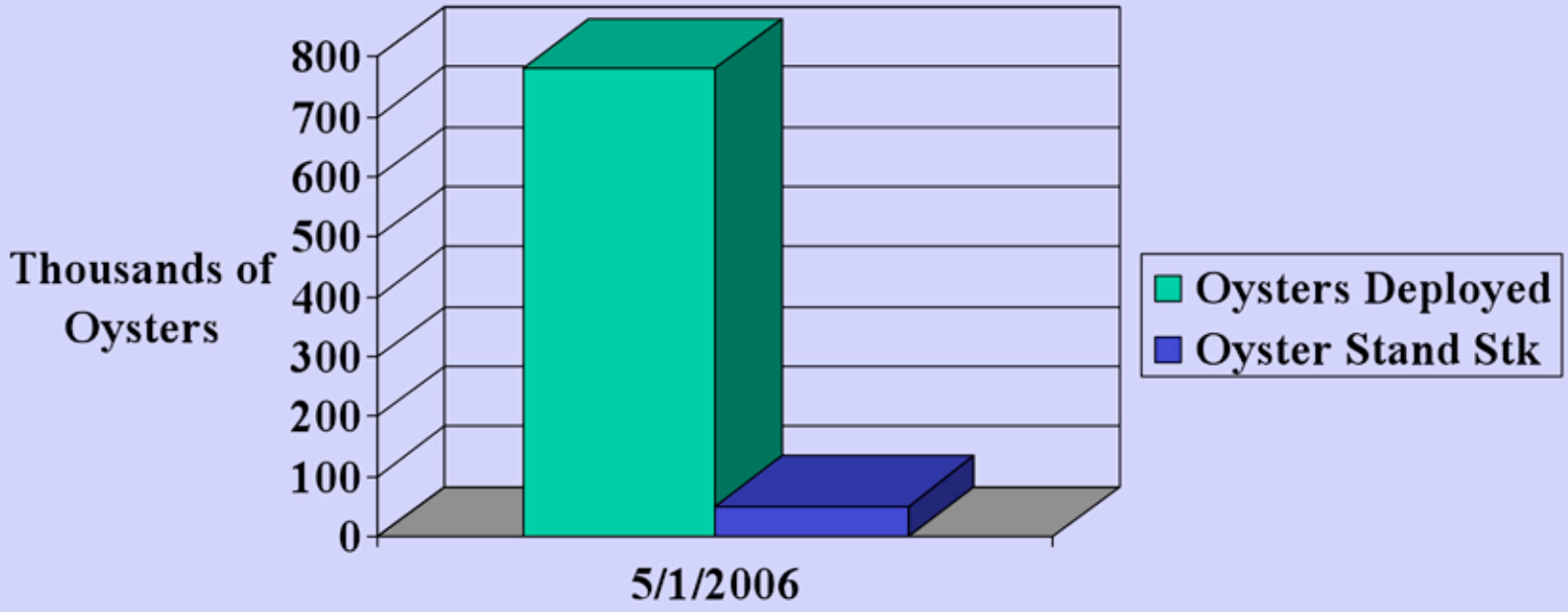
There is a new initiative in Virginia to remote set oyster larvae on shell and deploy the oysters as spat on shell in an effort to reduce cownose ray predation. Preliminary experiments appear promising, but oyster sets in 2005 were still quite small and data is limited.

In summary, at least for the time being, private oyster aquaculture will require methods of ray exclusion to have any chance of success. This significantly increases the cost of raising the product. Restoration activity for the State will remain focused on shellplanting, as the most cost effective method of producing oysters. Although periods of low salinity present the opportunity to move seed oysters for replenishment efforts, this is no longer cost effective because of the cownose ray predation.

Survival of Cultchless Oysters at Shell Bar Reef



Survival of Cultchless Oysters at Bland Point Reef



Spatial Structure at the Metapopulation and Habitat Levels: Relevance to Bivalve Restoration

Romuald N. Lipcius, Russell Burke, Rochelle D. Seitz, S. Schreiber, Harry V. Wang, Jian Shen, and Gamble "Mac" Sisson
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Gloucester Point, VA 23062

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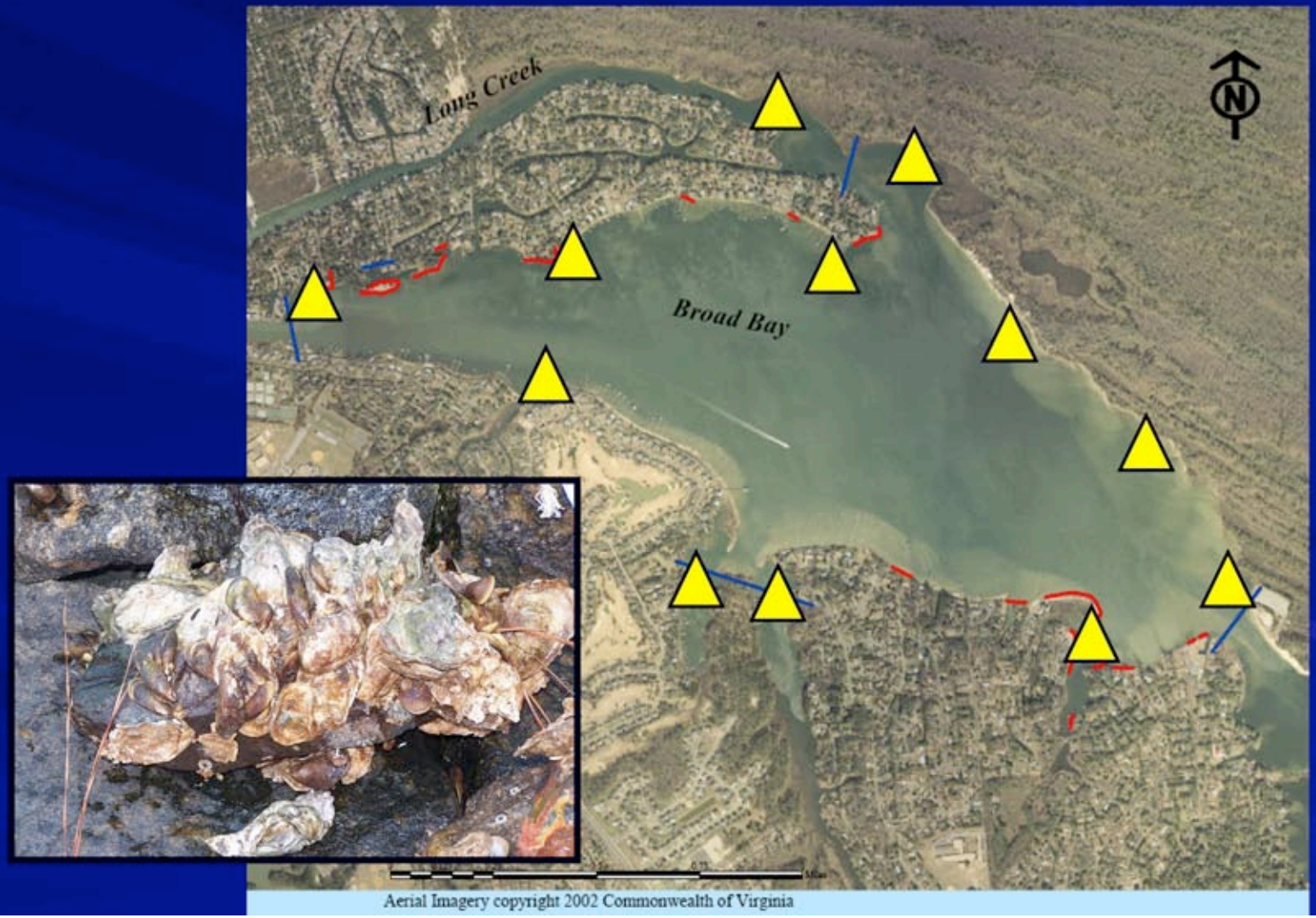
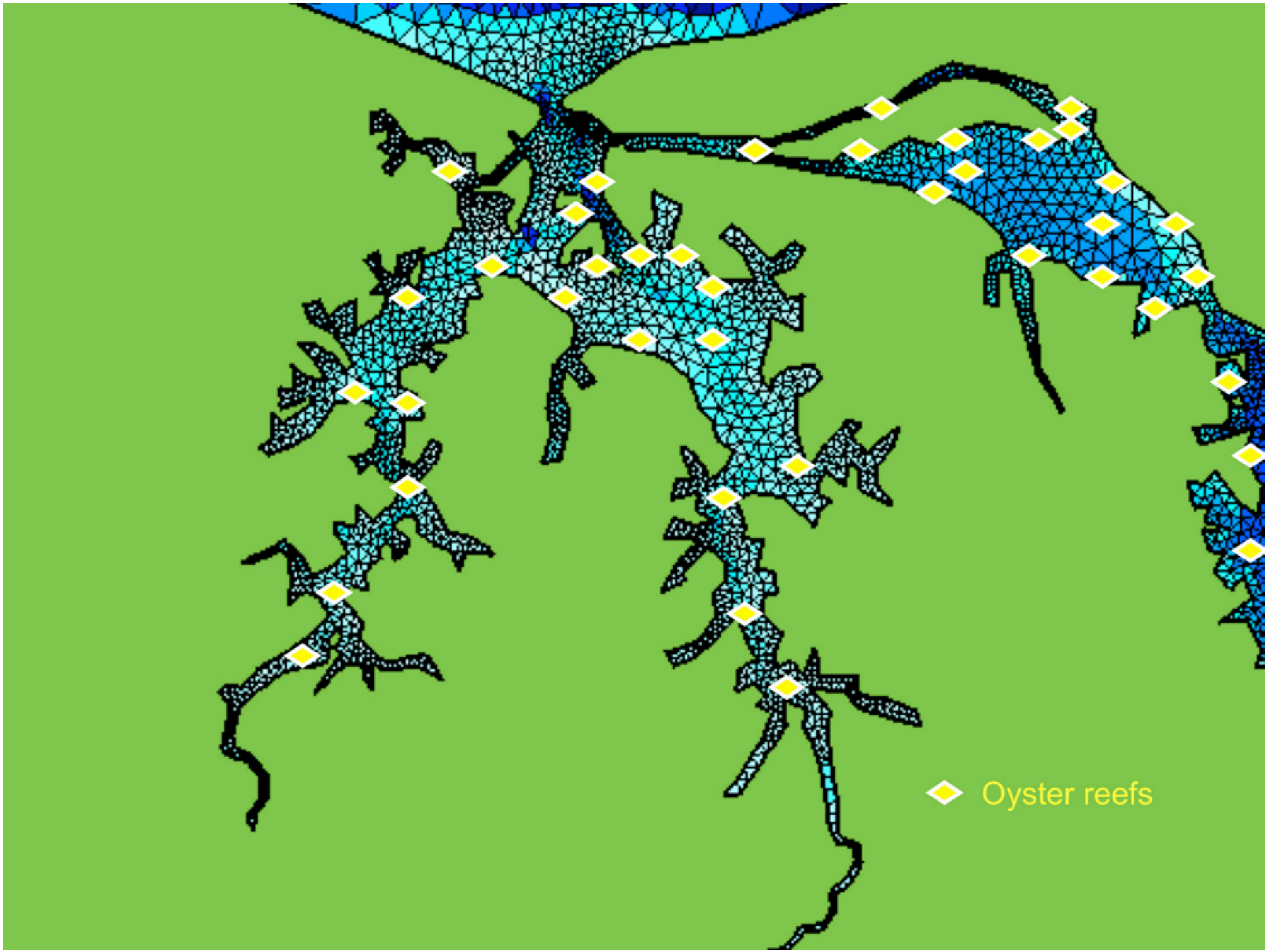
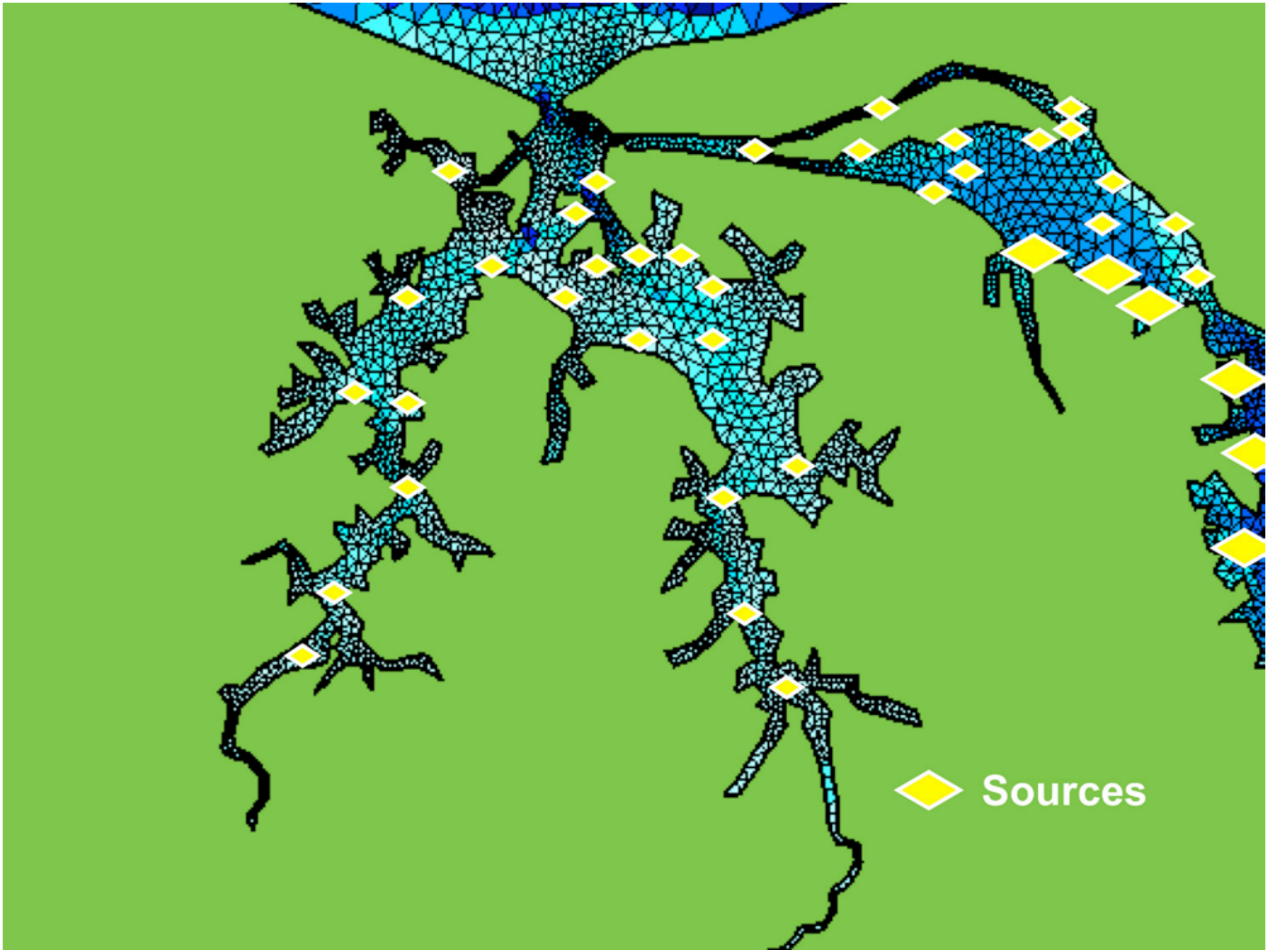
Spatial Structure at the Metapopulation and Habitat levels: Relevance to Bivalve Restoration

R. Lipcius, R. Burke, R. Seitz, S. Schreiber, H. Wang, J. Shen, M. Sisson
Virginia Institute of Marine Science, The College of William and Mary




Oyster reefs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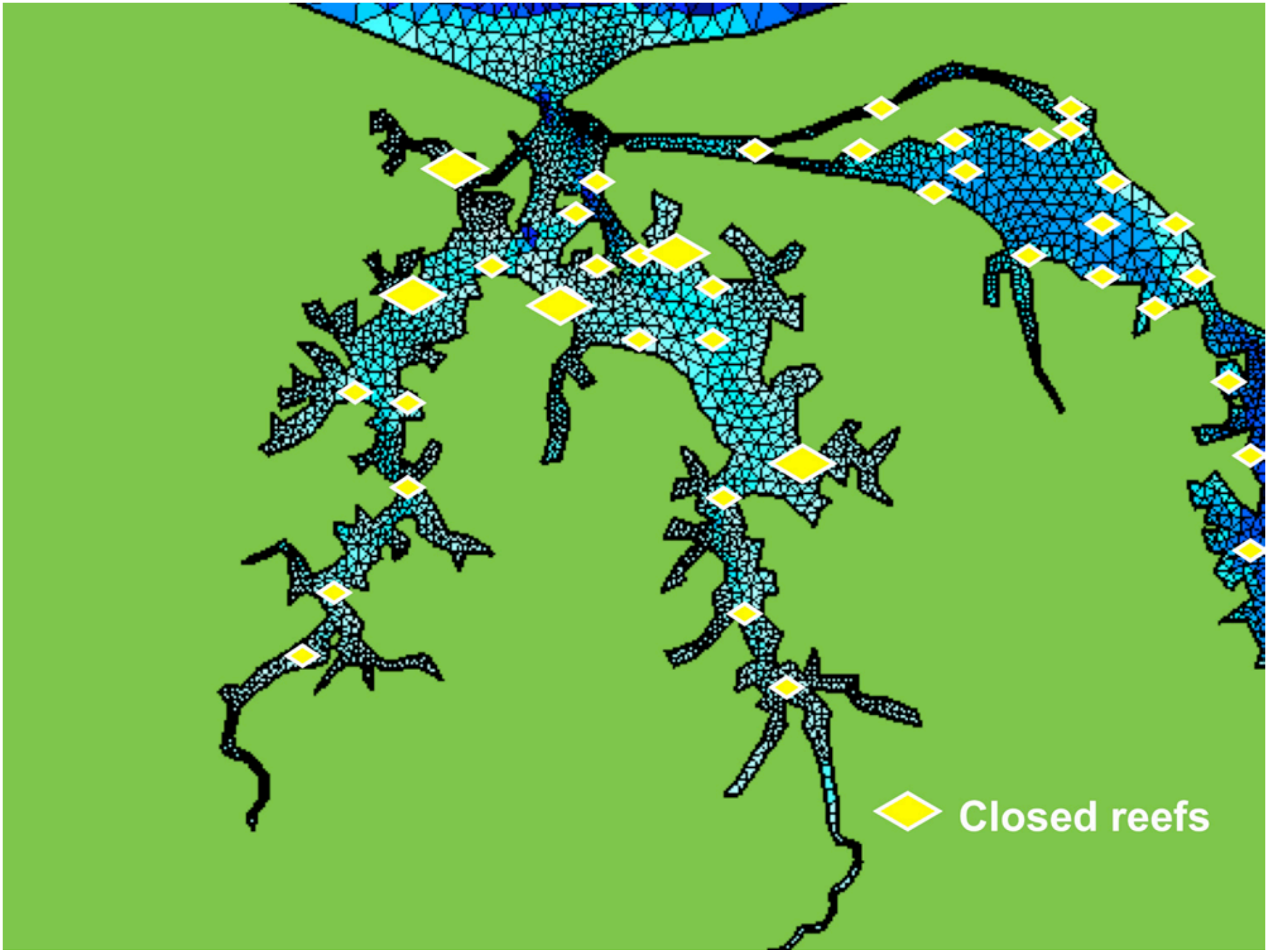
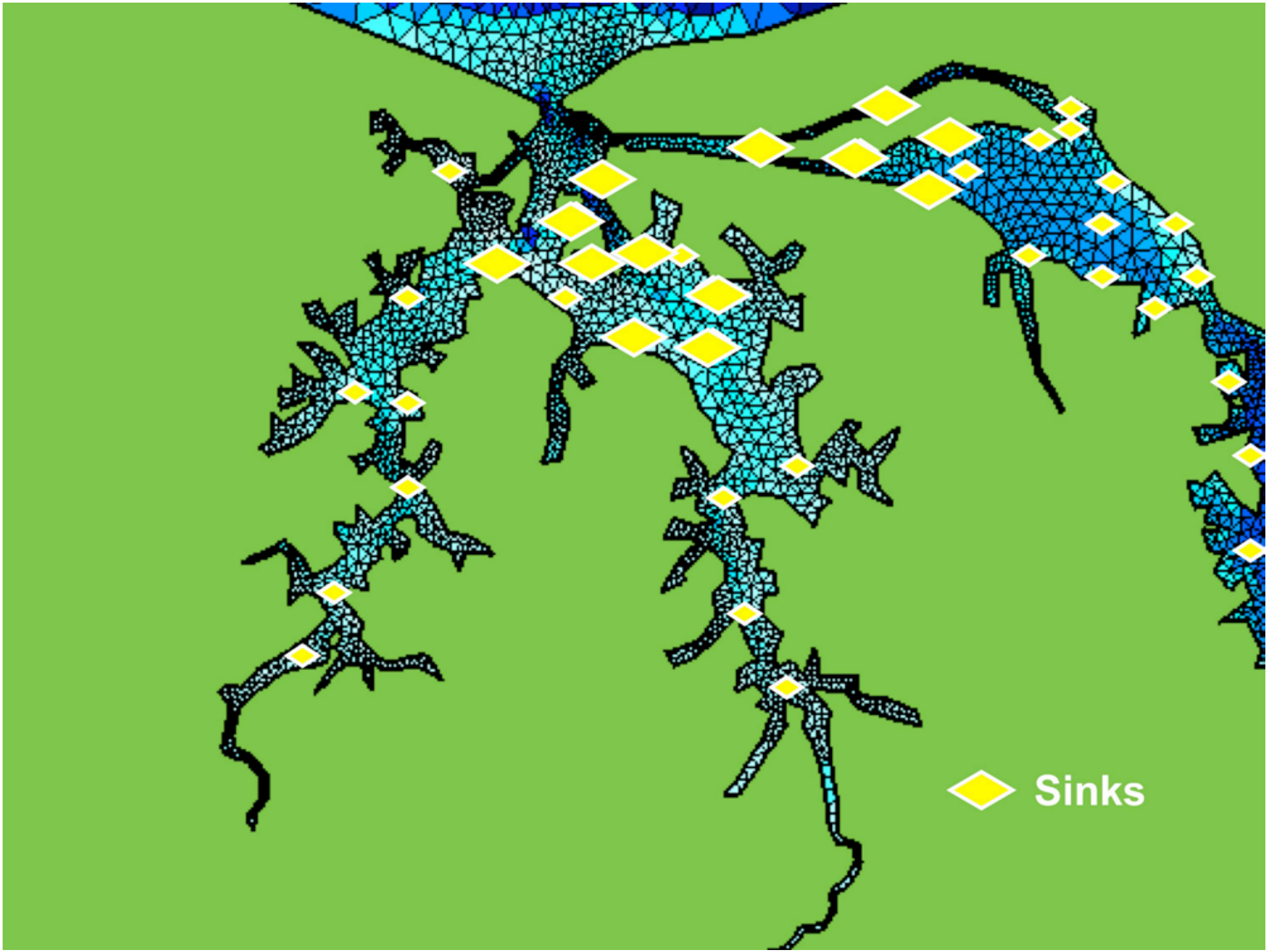
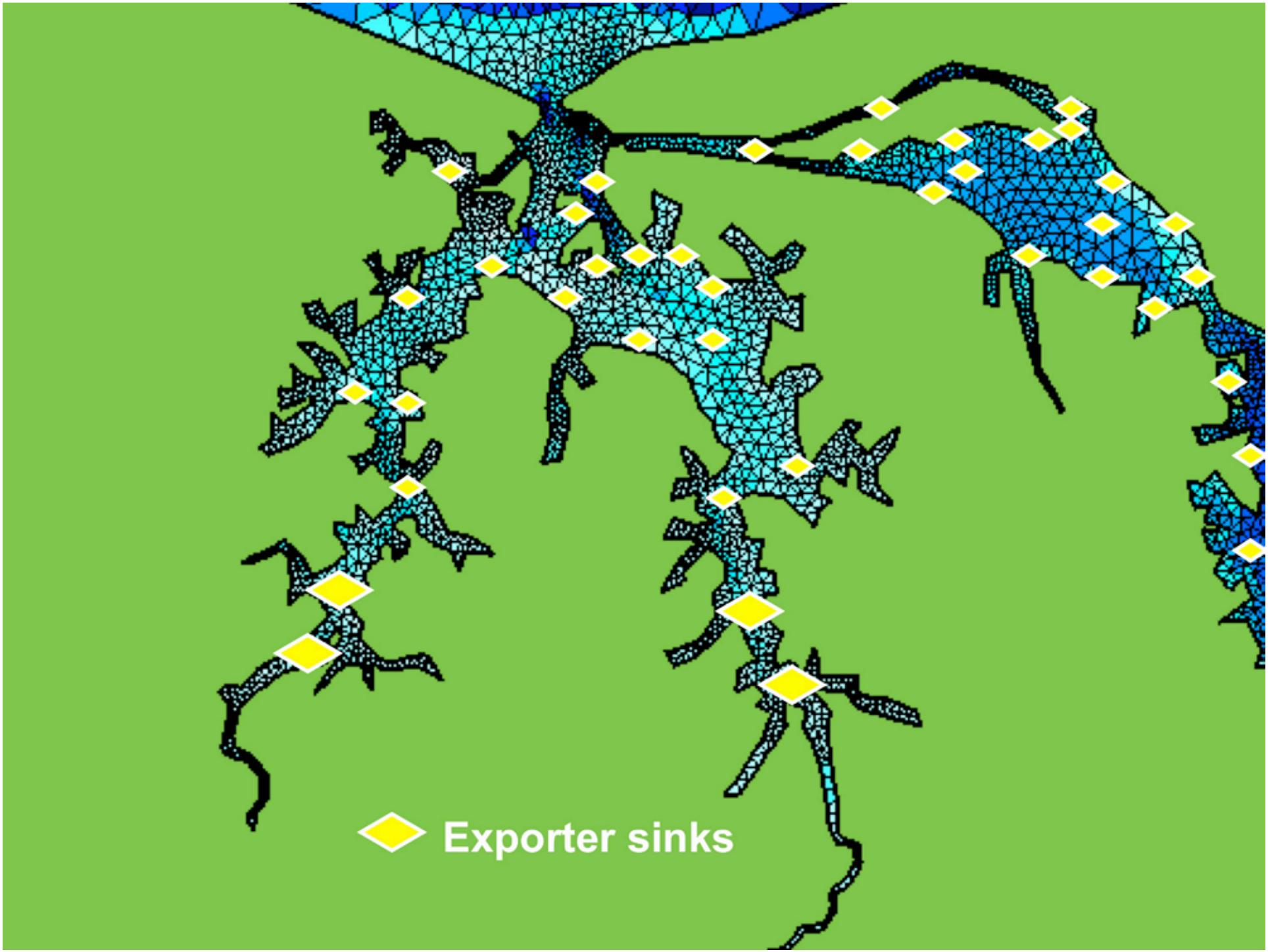
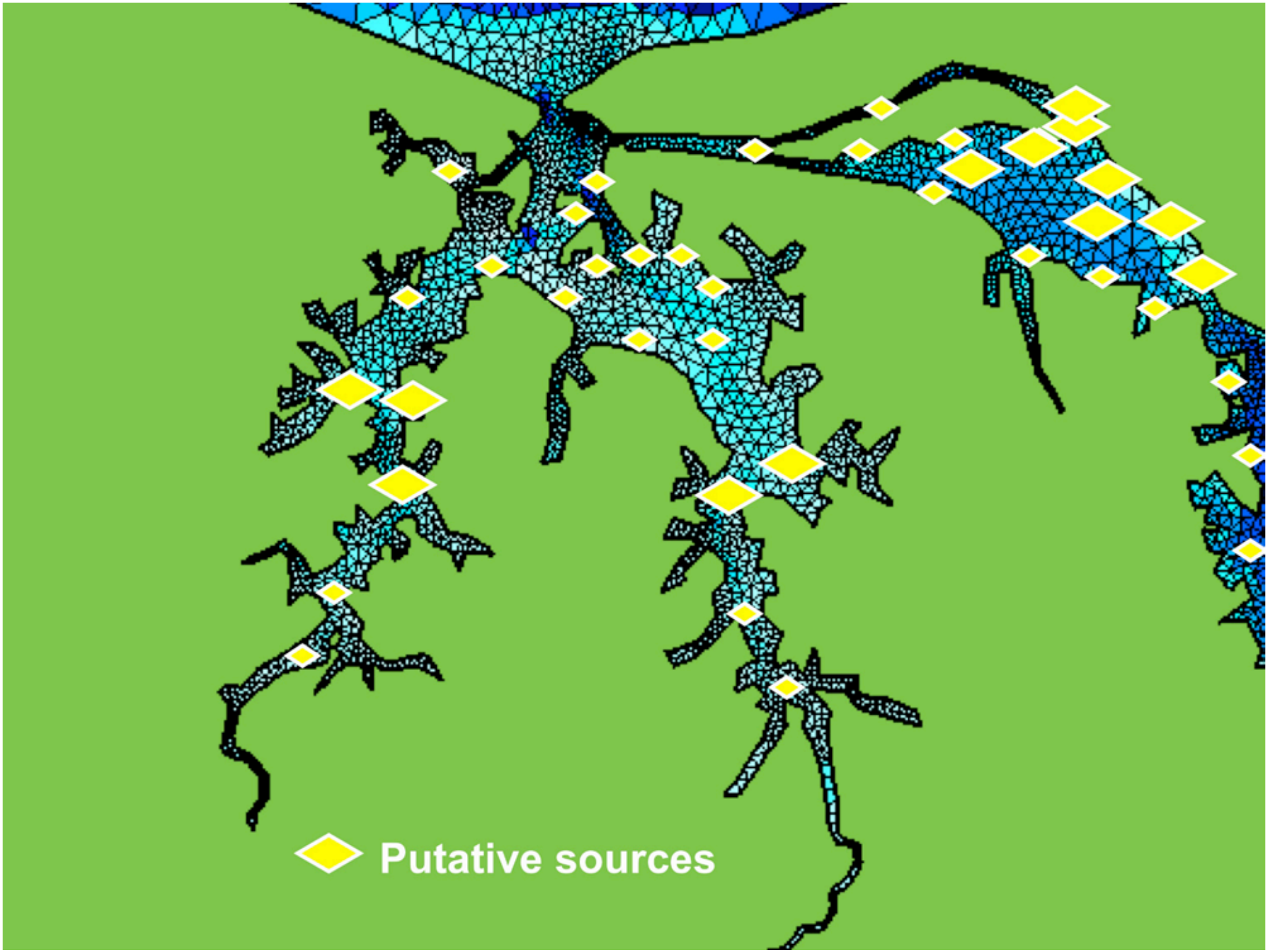

Closed reefs


Sinks

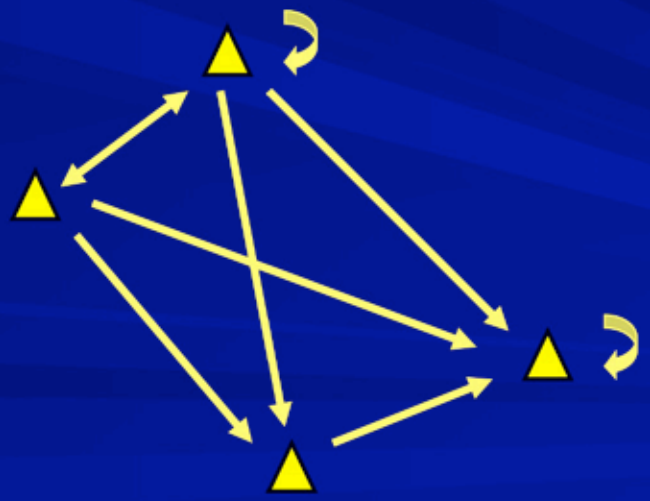

Exporter sinks


Putative sources

Metapopulation analysis conclusions:

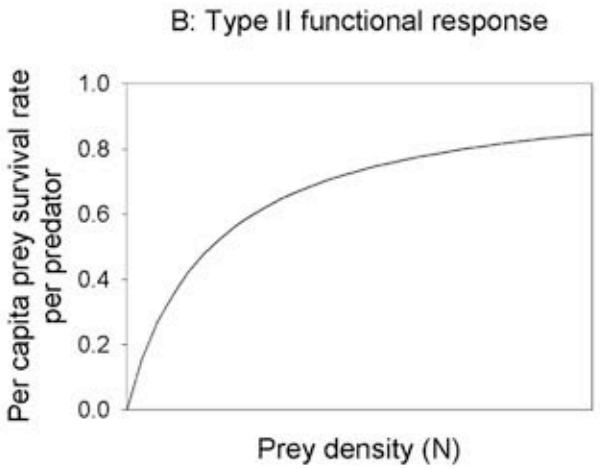
1. Source populations are distinct geographically and may be a small percentage of the metapopulation.

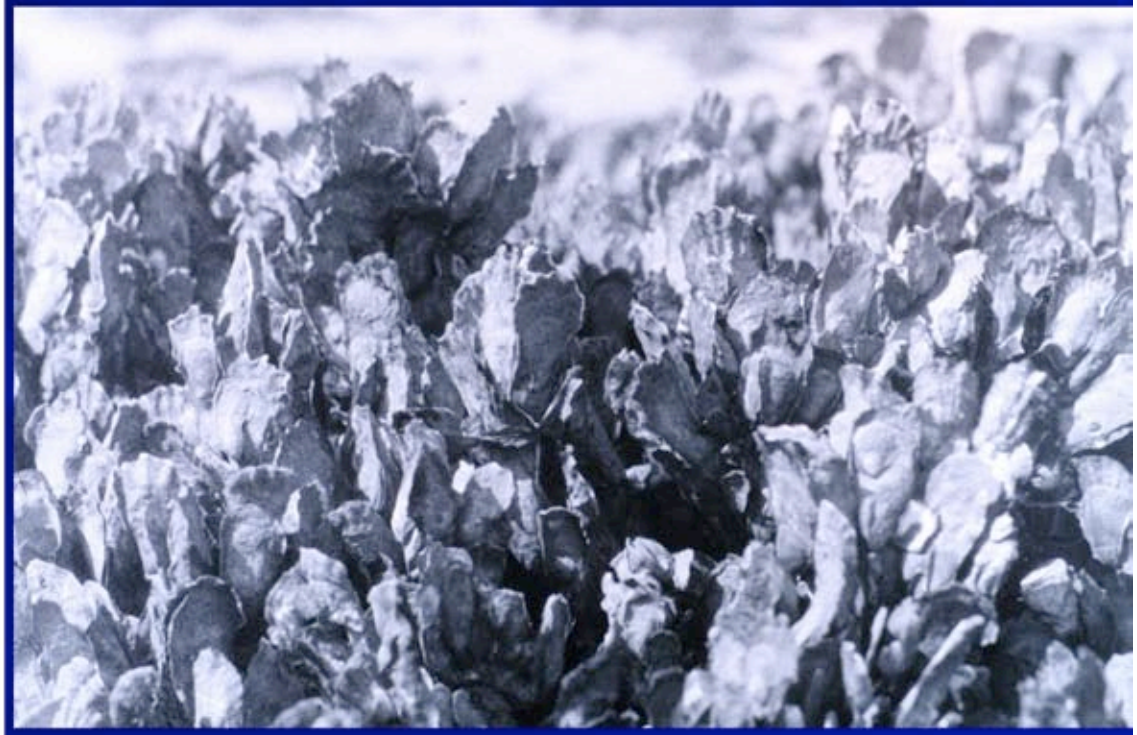
2. Optimal metapopulation growth and fisheries yield is attained by fully protecting source populations (i.e., sanctuaries) and allowing fishing in sink populations linked to the sources via larval dispersal.



PREDATOR-PREY DYNAMICS: INCORPORATING FACILITATION AND HABITAT STRUCTURE

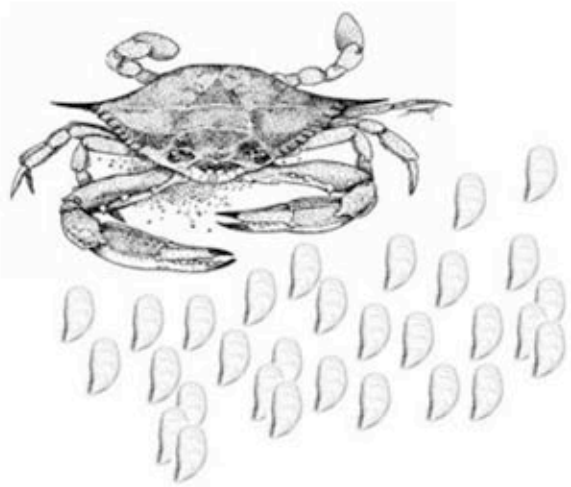
Disruption of Spatial Habitat Structure:



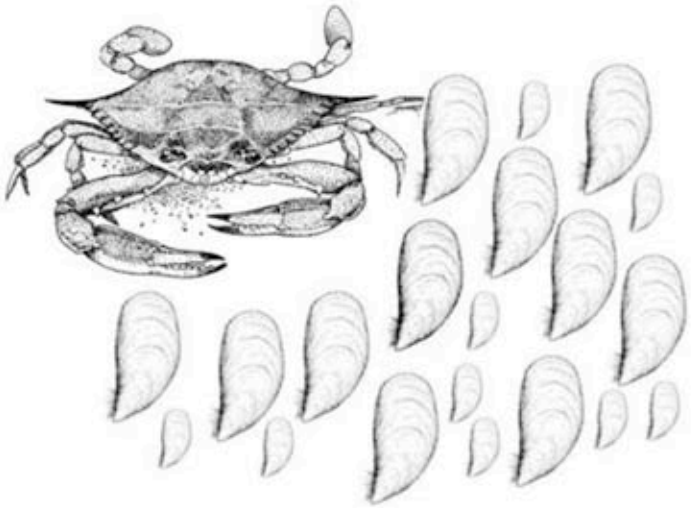


Facilitation in Predator-Prey Dynamics:

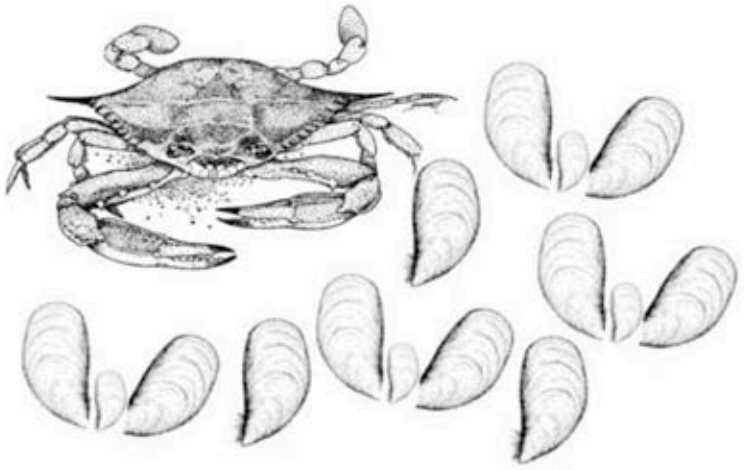
(a) High-Density Aggregation



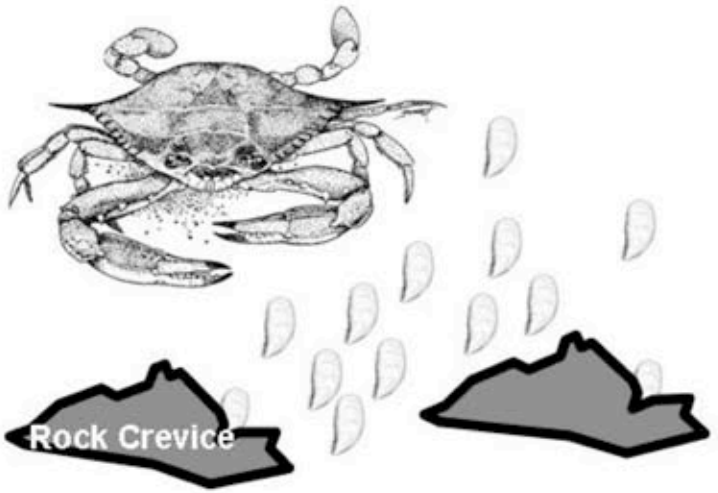
(b) Year-Class Facilitation



(c) Biotic Facilitation Refuge

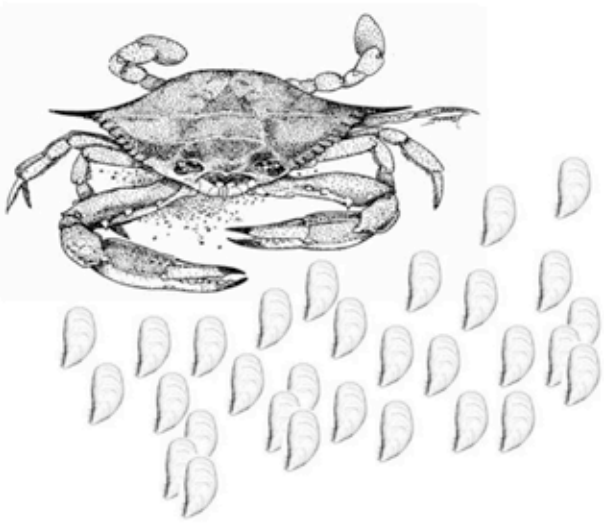


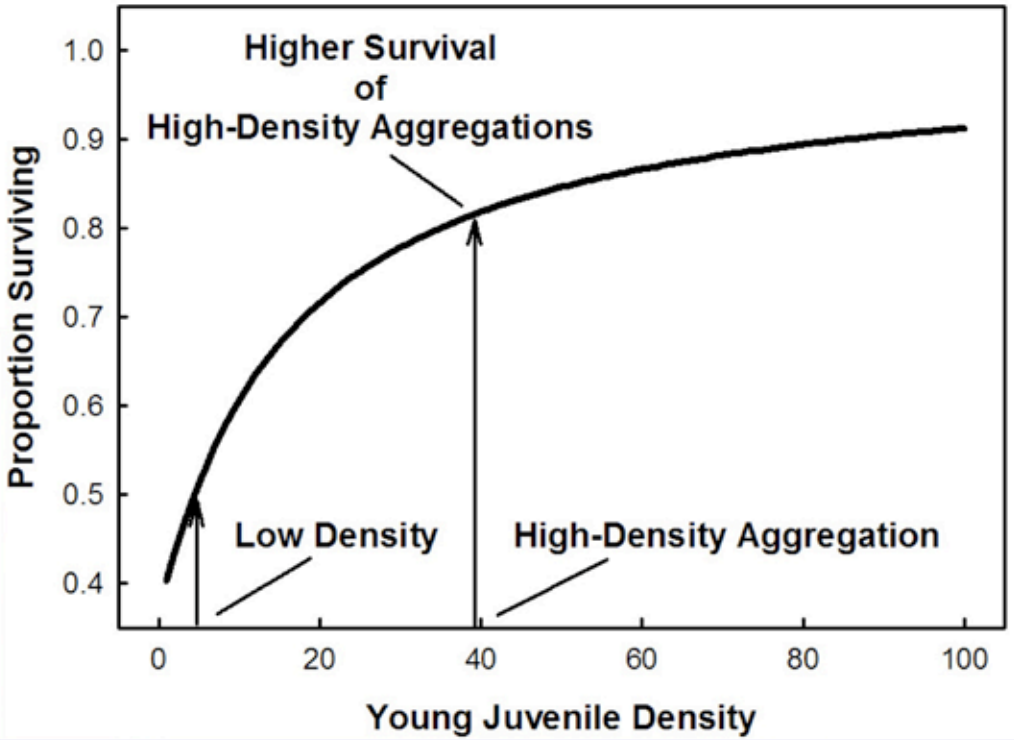
(d) Habitat Refuge



High-Density Aggregation:

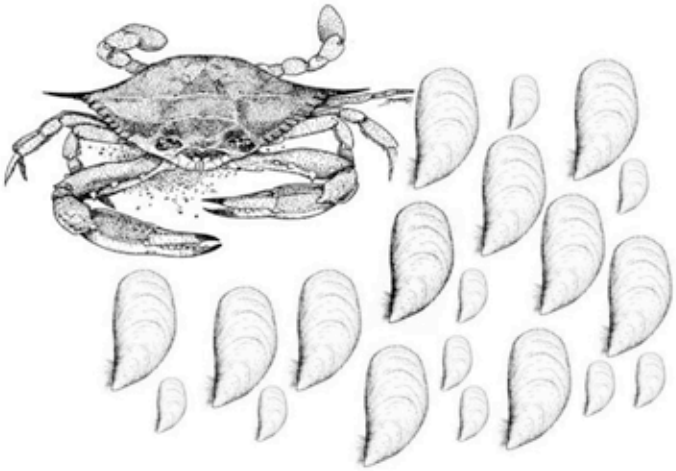
Facilitation: High-Density Aggregation

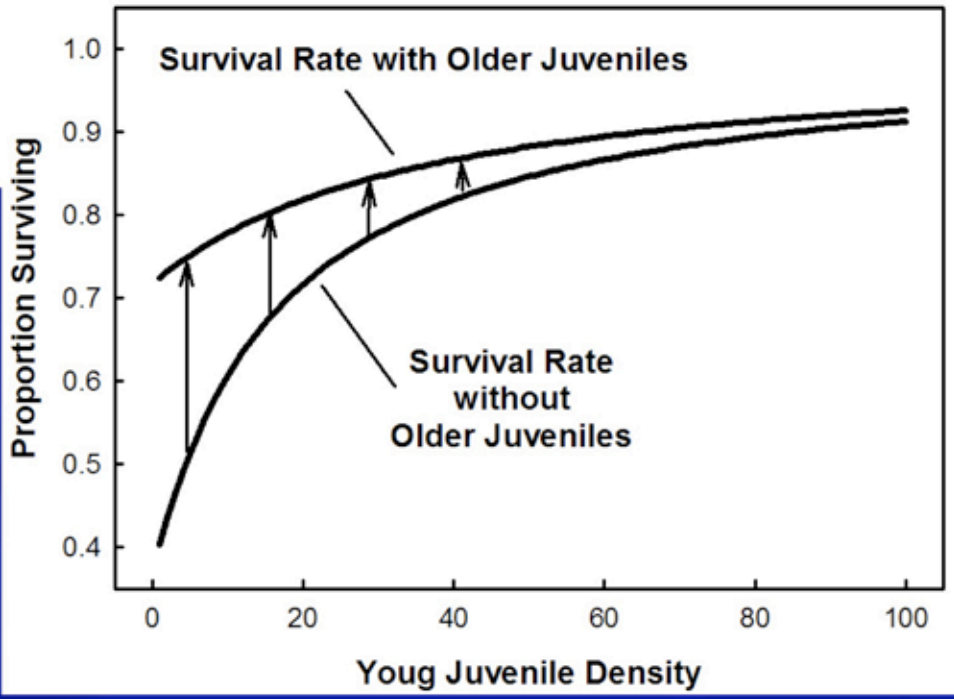




Year-Class Facilitation:

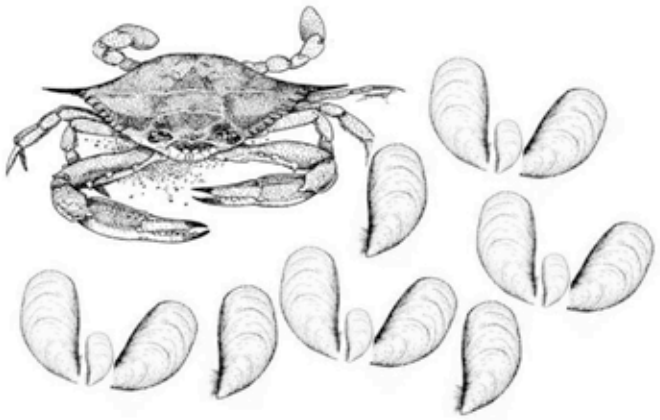
Facilitation: Older Year Class



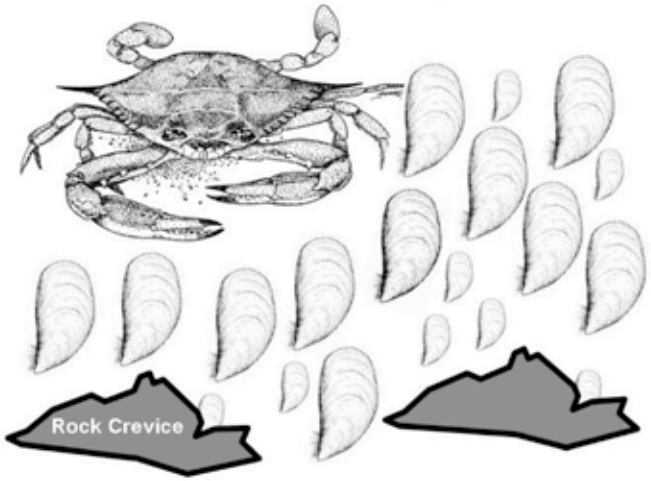


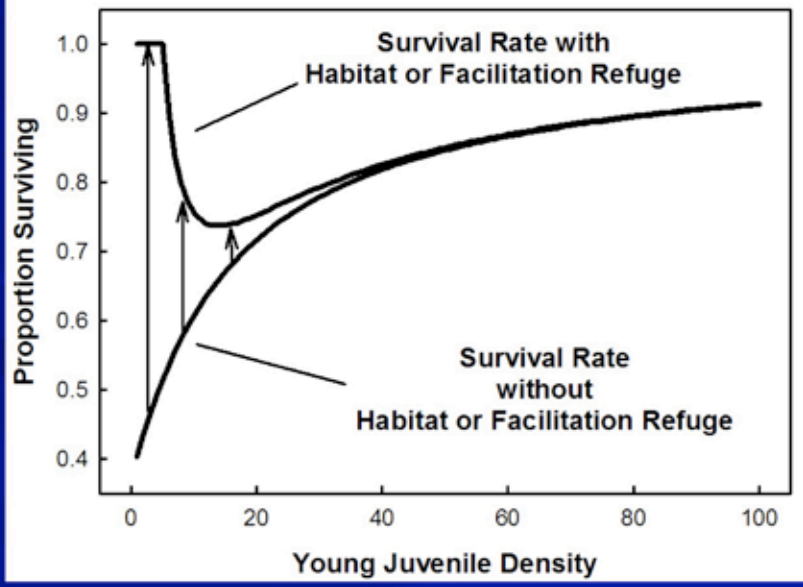
Refuge Facilitation:

Facilitation: Biotic Refuge



Habitat Refuge





Success of Alternative Oyster Reefs

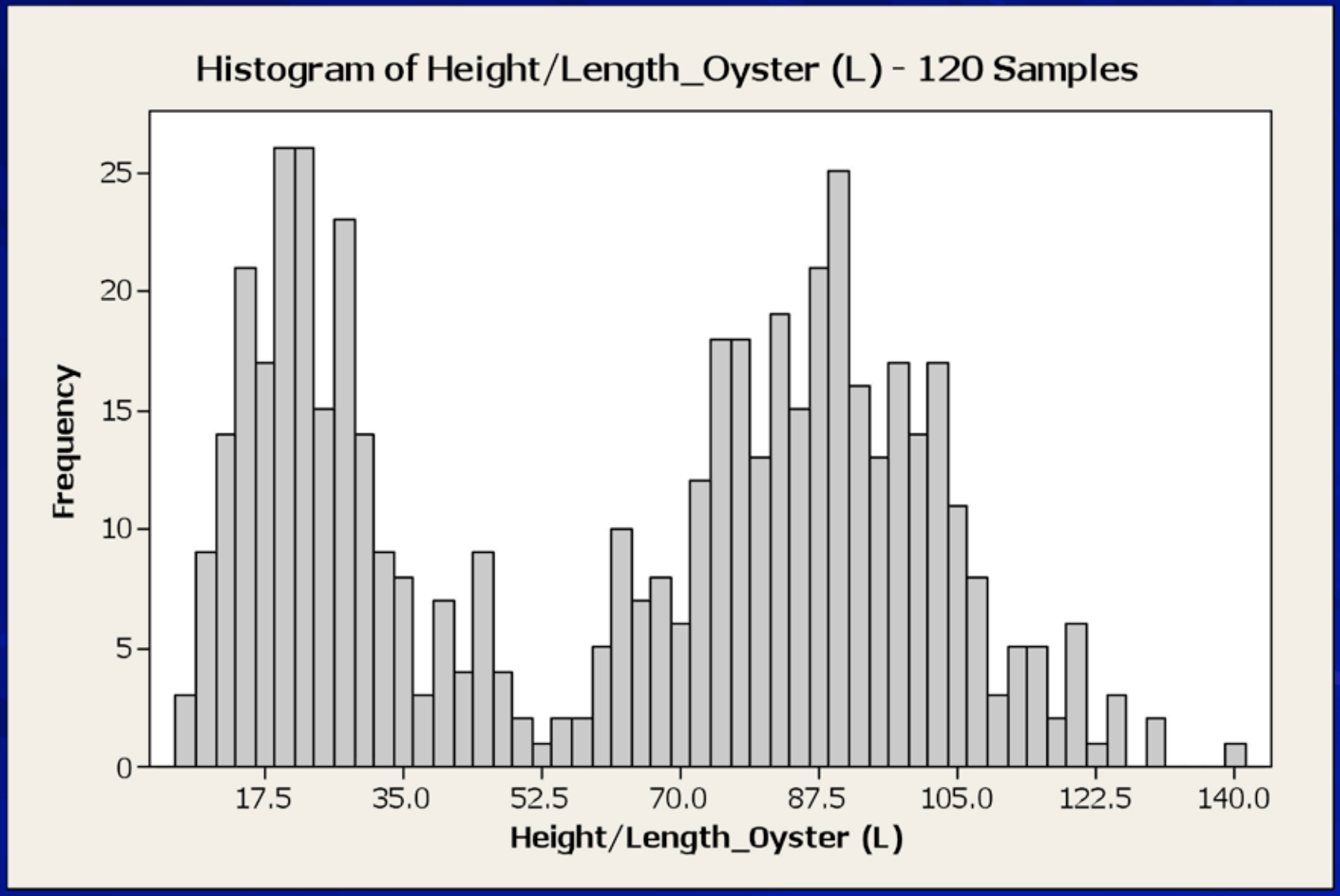
Rappahannock River

Lynnhaven Bay


Hole


Note the
Thickness
of Growth
on this
Concrete

Size Structure of Oysters



Results

Sampling Results	Per m^2 of Bottom
Surface Area	Oyster Density
7.2 m^2	**1085**
# of Mussels	Mussel Density
4281	**8617**
# of Oysters	Oyster Biomass*
523	1.643 kg
Bivalve Volume	Mussel Biomass*
40.33 L	0.666 kg
Sponge Volume	
13.58 L	

*Biomass derived from Tissue Dry Mass

Alternative Oyster Reefs: Rip-Rap (Justine Woodward M.S. Thesis)

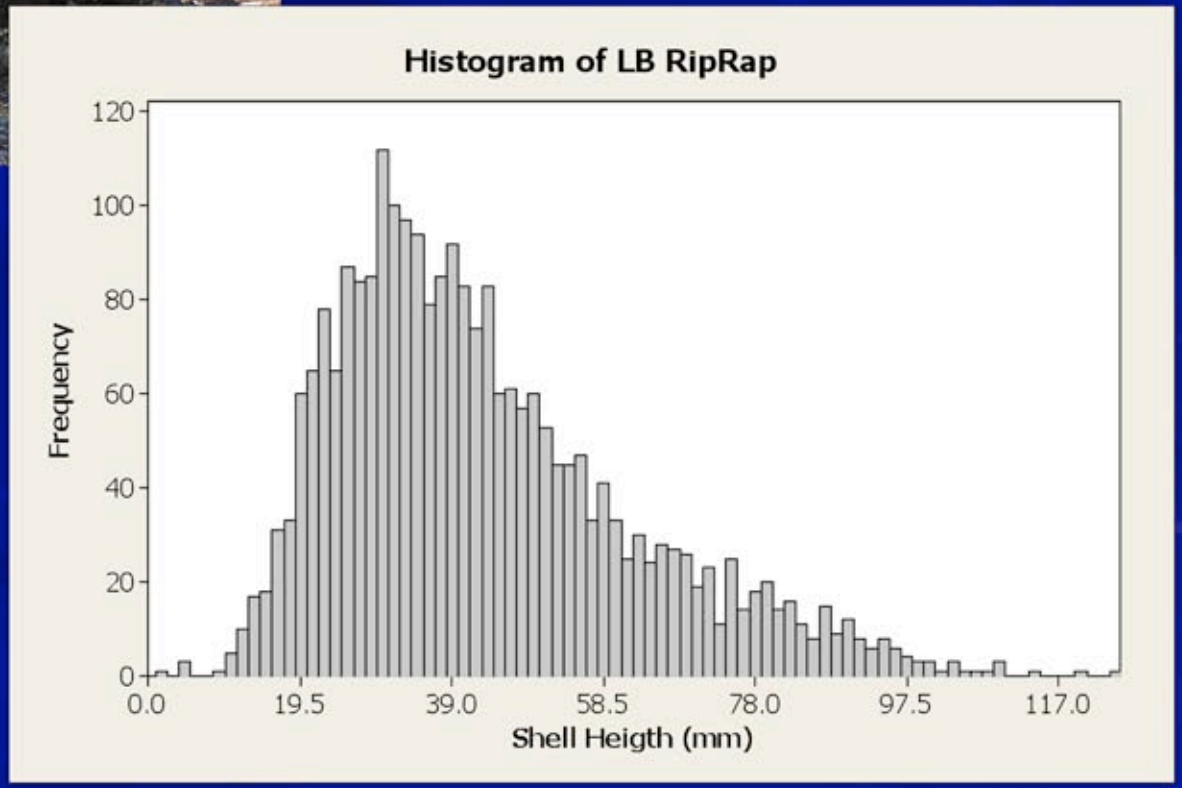
Alternative Oyster Reefs: Rip-Rap (Justine Woodward M.S. Thesis)

Alternative Oyster Reefs: Rip-Rap (Justine Woodward M.S. Thesis)

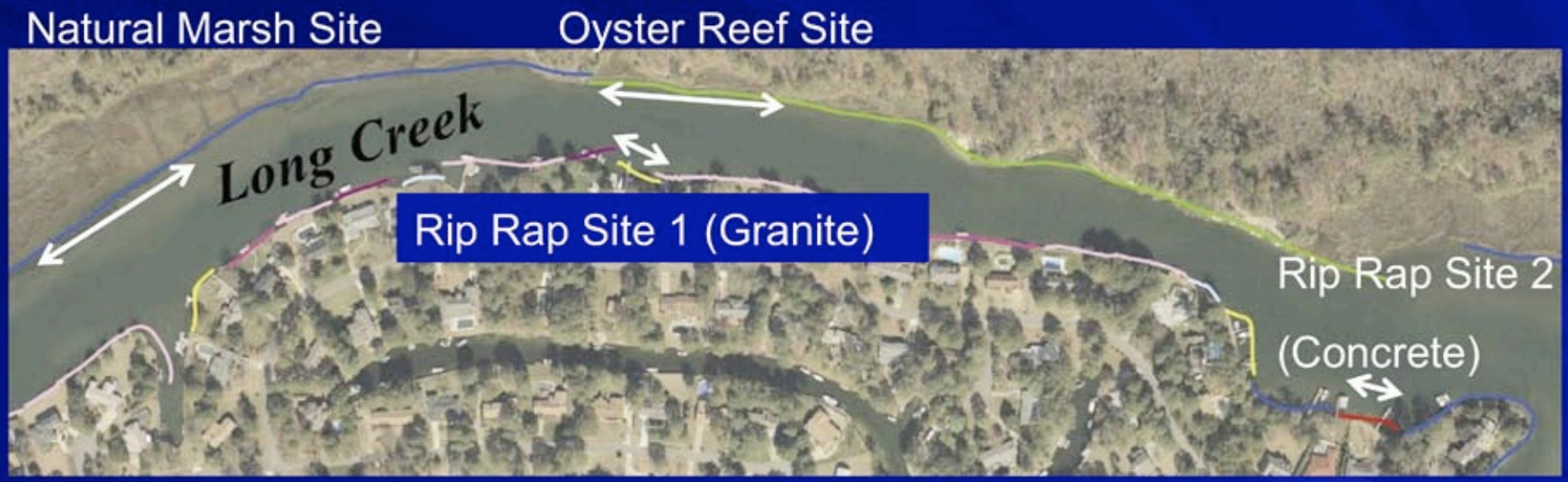
Average Density

770 oysters per m^2

95 % CI: 729-811 oysters per m^2



Long Creek Experiment



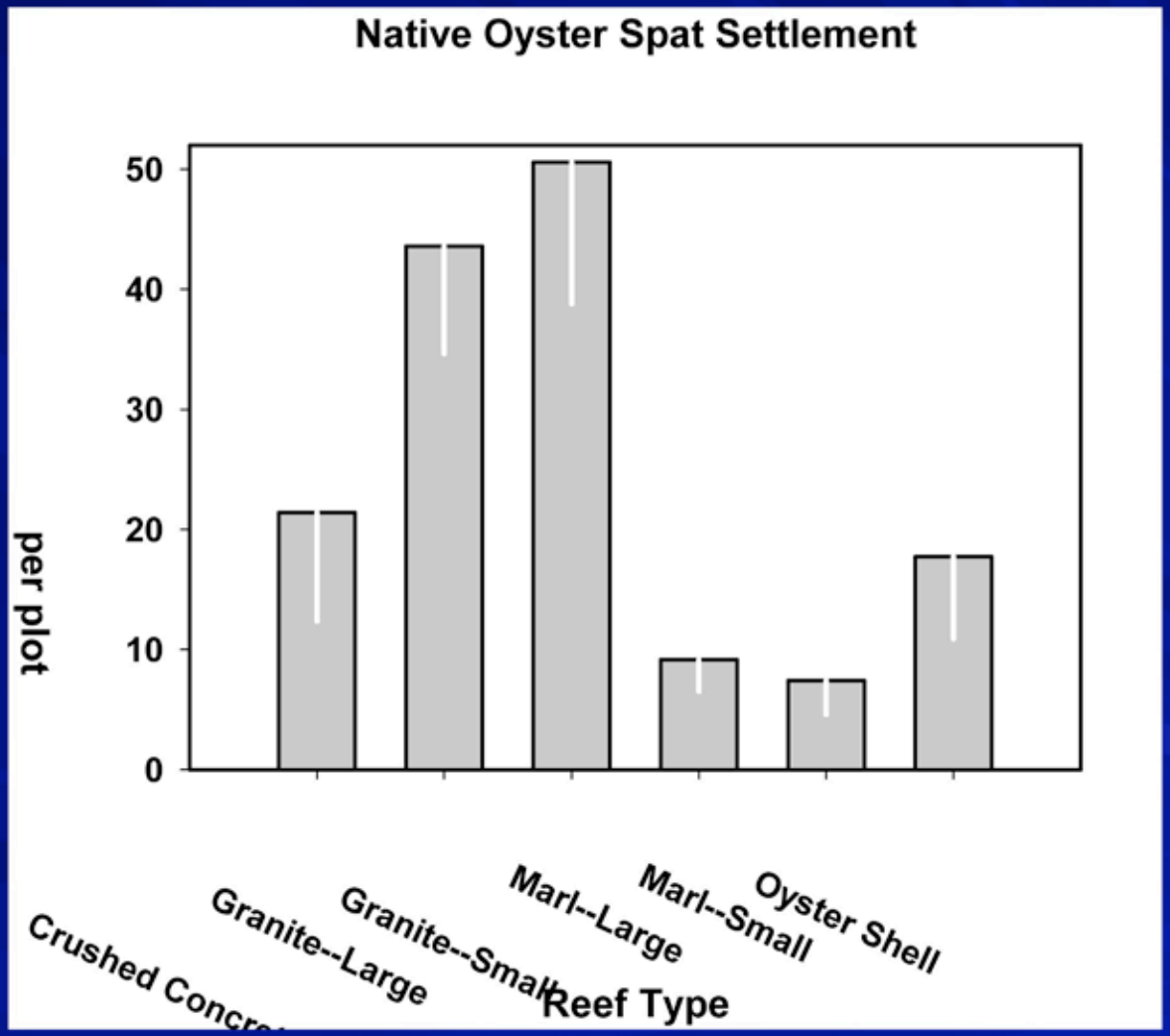
Oyster Shell

Limestone Marl (Lg/Sm)

Granite (Lg/Sm)

Demolished Concrete

Lynnhaven Spat Settlement Experiment:




Alternative
Native
Oyster
Reefs

Habitat structure conclusions:

1. Disruption or provision of habitat structure can have diverse and substantial effects on survival and metapopulation growth rate.

2. Alternative habitats characterized by complex structure have produced extremely high population densities of Eastern oyster (800-1100 m^{-2}) and hooked mussel (10,000 m^{-2}).

Panel Discussion: Commercial Shellfish Growers

Mike Peirson
Cherrystone Aqua-Farms
P.O. Box 347
Cheriton, VA 23316

It's good to see that the things we see everyday researchers are confirming. Sometimes it seems cownose rays are smarter than they look. They seem to learn stuff and remember stuff from year to year. They are major trouble for our growers. We are a big clam grower, if you don't know us. We plant 100 million seed a year that we grow up to market size. We have staff that plants about 30 percent and the other 70 is grown by contract growers, in a situation similar to the way they grow chickens. We have the hatchery, we supply the seed to them, and they bring it back to us at market size.

About 10 days ago is when the first round of cownose ray came into the Bay. For those of you who know the Eastern Shore, we are on the lower Chesapeake Bay, from about seven miles to about 20 miles north of the mouth of the Bay. This is on the Eastern Shore so there are no rivers, these are all tidal creeks. Cownose rays are always a nuisance, but there are certain conditions and certain techniques that you have to use to keep them from becoming a disaster to us. The first round that comes in is hungry. They have been swimming from Florida and so they are hungry when they come in and they are looking for soft clams. Hard clams are an extra bonus, but they are looking for soft clams.

What our growers are reporting you can see in the photo. That's typical on the grounds we have, they are just cratered by cownose ray. All of our clams are under net—quarter inch mesh net. We often have to change out our nets after about a year due to fouling. We have these street sweeper-like machines to clean nets, but if the nets are fouled from underneath and fouled to a mat, they will suffocate the clams, so we have to get the nets changed. You want to do that out of ray season, because if you do it during ray season, they see clean nets as no nets at all, and they come into them. Nets that are fouled with a normal amount of seaweed and things, rays don't seem to bother nearly as much.

One of our major growers who plants 12 million clams a year just changed out 150 nets. At 50,000 seed per net, that's 7 ½ million all together. Rays came in looking for soft clams and the grower would find craters 3 feet in diameter under the net with the soft clam in the bottom still under the net because they couldn't get at them through the net. But the damage that was done wasn't that they ate the clams, but that they piled sand all over the nets suffocating the clams underneath, unless you can get to them fast enough to save them. They were finding as much as 6 inches of sand piled on the nets. The normal street sweeper that we use wasn't cutting it. The sand was too deep to cut through. They actually had to get big pumps and use the hoses to shoot water parallel to the surface of the net to try to wash the sand out to a low enough level so they could pick up the net through the sand. This all happened in a day or two and we are looking at the yield from those nets at our typical 70% yield would be about $750,000. So just one grower had an

opportunity to lose $750,000 in a matter of days. He spent ten days cleaning nets and as soon as he got all the nets cleaned he would have to go back and start all over until the rays dispersed. So that is the worst case scenario.

They are there all summer. Some areas are worse than others. There are actually some areas that we have considered abandoning. Jeff Conway, my field manager, was going to come with me today, but the maintenance on his beds got to be in a critical stage and he told me the day before yesterday that he wasn't going to be able to make it. He made a list of costs associated with the extra maintenance caused by cownose rays. The bulk of the damage is not due to the eating of the clams by the rays but by the piling of sand on the nets from their activity, unless the net is damaged by the rays or others. If a boater cuts through a bed and his outboard cuts our net open you don't even bother to try and replace it because by the time you get inshore and back out again with a new net the clams are gone. There is no point trying to save an uncovered bed during ray season. The Rays also root up SAV's in the aisles between the beds. A lot of the debris that we are getting on top of the nets is the rooted up SAV. Jeff now has a full time maintenance crew whose job is to maintain the beds. And about 80% of the maintenance they do is due to cownose rays.

Talk about the big brains, big brains for a fish. The rays seem to be learning and remembering. In the spring in some years we get a recruitment of *Mytilus*, blue mussels, and it's not every year. Conditions have to be right. In the shallows where we plant clams, the mussels usually will die in mid June because it is too hot. But until they die they can be quite a problem. They will form mats three, four, five, six feet in diameter, solid mats on the nets, and they will suffocate the clams underneath, plus they are filter feeders and so they are competing with the clams for food. The cownose rays usually come in to our growing area in May and clean off the nets for us by eating the mussels on top and so are a help to us. But it is sort of like a Tootsie Roll Pop to the ray. It's eating the hard candy outside, the mussels, but then it finds a creamy center in the middle, that's our clams. And, they will actually grab the nets and twist and spin until they twist a hole into the net. They don't rip the net, but they make a hole only a couple inches in diameter that they twist out of the net. They can consume all the clams in about a three foot circle by making a crater that serves as a funnel, and as they suck the clams out of the hole more clams tumble down the crater wall to the hole. We don't know if they teach each other this behavior or if they remember this from year to year. But there are a lot of them doing this. This behavior causes a loss from the clams that are eaten, from the clams that are suffocated by the sand that gets piled on the net and from crab damage that may occur from crabs getting through the hole in the net.

With cost of plastic going up, net replacement is very expensive. Cleaning the nets of silt and sand from the rays' feeding activity is one of the major problems in areas that are already planted, but as you saw in the picture of the craters in the shallows of our grounds, much of our ground is in this condition in the Spring. You can't replant over that ground until it has time to smooth over by the action of the tides. So this can take areas out of productivity seasonally.

Jeff is a good one to talk to. He knows first hand what the cownose rays are all about. The only current method we have to protect our clams is clam netting but you have to maintain it religiously to keep it clear.

Margaret Ransone
Bevans Oyster Company
1090 Skipjack Road
Kinsale, VA 22488

I should have gone first, I'm not sure if I have much of a story after Mike's. But, of course we are devastated in the Chesapeake Bay with the oyster end of what the rays have done to us.

We have a lot of private ground in the Chesapeake Bay so what we have done throughout the years is plant seed on our private ground. Our last major seed planting was in 2004. We planted in the Spring of 2004—about 15 thousand bushels in tributaries of the Potomac River. And that seed came from the James River and the Piankatank. After about two weeks, we checked the oysters and about five days later everything was gone, they attacked the James River a little quicker then they did the Piankatank. The James River was I guess a little more singled out where the seed had some more cultch in it. So, my father made the decision to buy Delaware Bay seed, because that was a little more cultch and seems to be a little tighter. They seemed to attack that as well. So, we made the decision in 2005 that we were not going to suffer that loss again and went full force into aquaculture.

So, we planted one million oysters and that's what we are moving forward into now. This year because of the weather pattern we did plant wild seed that all came from the James River in Rappahannock River. What we did was actually cover the seed in chicken wire. So we will keep our fingers crossed—the rays have entered the areas now. They actually came into town a little earlier than expected. We usually see them in the end of May or the first part of June. They came in the second week of May this year, they entered. Everything we have in the water is covered, it is either in a cage, bag, or it is covered by chicken wire.

We are not quite sure what they are feeding on—I've had a couple people tell me that there are soft shell clams that they are finding—but they are there and they are feeding. We do have footage.

We are looking at this as a possible bait product. The core, if we can process the wings for food maybe we can use the core as a bait product for other fisheries. The rays are causing destruction. Certainly we don't want to do anything that is going to diminish their existence. But, it would be nice to utilize them in some form and also help in all the efforts that we are trying to accomplish to restore the oysters, to restore the scallops, to restore the clams, and help watermen. We all are on the same page, as far as developing a fishery and trying to utilize the species in some form.

Christopher Scales: (New Jersey clam grower)

I am a commercial clam grower, and a gill net fisherman from New Jersey. Historically there have always been rays around us. We think they come through late June early July most years. Generally they get a lot a notoriety in the news because the swimmers see them. They take a couple days or sometimes a couple of weeks just one after the other coming by right in the surf where people swim.

There is a small commercial fishery for them in New Jersey. It is kind of a grey area and kind of hush hush. But for the most part they are used for lobster bait, and I think in New England they are also used for lobster bait. Occasionally you will see them on the market—the big markets in New York. I haven't personally seen them in Philadelphia. There are a number of men who would like to fish for them. We think that maybe the pound nets would do the best way to go. There are a couple of pound netters—most in the Sandy Hook area—where one guy says he has to shut his operation down because he catches around two hundred boxes a night, which is around 20 thousand pounds a night if he leaves his nets set up, and it is too much labor and damage for him to deal with.

I kind of apologize. I had hoped to attend this whole thing, but I am busy covering up the clam bed, because the rays are on their way. We have probably six major shell fisheries in New Jersey, three hard clam fisheries, and bay scallops, oysters, and surf clams. We are pretty sure the rays demolish the bay scallops when they come in. No one really knows that. We have had pretty good sets bay scallops for the last couple of years. We don't typically have a lot of bay scallops every year. We don't know how they affect our oyster fishery. The surf clam fishery, the stocks have kind of collapsed off of New Jersey. Biologists in New Jersey tell us that it is the warm temperature. Maybe it is a little bit more than that. Maybe the rays are running out of food and they are working on the sea plants. There's a lot of big time dredge guys that need to steam far offshore to catch their surf clams now. That is the largest clam fishery in New Jersey.

There's a lot of speculation although no real proof that the rays have something to do with the problems they are experiencing with the fisheries right now. A couple guys say they have caught the characteristic crushed shells in their dredges. I haven't seen it. Possibly it is affecting the surf clam fisheries. Most definitely, definitely it is affecting the hard shell fisheries. The clam growers have known about it forever or since we have started growing clams.

The two best stories I can tell is a guy, John Maxwell, a pretty big clam grower in New Jersey. He's been doing it for quite awhile. We never really had a problem with the rays or we didn't realize we had a problem. One year just about July 5 he went out to get his premium market clams as they were all 2-3 years old they were regular harvest and there was nothing there. This was 45 screens, which is the equivalent of about at 20 cents a clam it is equivalent to about $100,000. This happened in about a couple of weeks.

I did witness rays cross one of our bays where we do a lot of our clamming. We went across this one lot and the whole surface of the water got foggy. I asked the guy who owned the lot what was there and he was watching it. Another fellow asked him "are your clams covered up there"? He said "no." I think what he meant was that it wasn't a problem anymore because he knew that there wasn't going to be anything left.

It also sufficiently affects our relay fisheries. There is a fishery in New Jersey where clams are caught in semi-polluted water and transplanted to clear water. They were taken to a depuration plant. It affects the fisheries in two ways. One is where they take the clams to the transplant lots. They didn't think they had to put a cover on it and for years and years they got away with it. But one year they didn't, and consequently probably 60% of the guys are no longer relaying. And the ones who survived are selling to the plant. These guys were making good money. They were making $80-$100 thousand a year for about 7 or 8 months of work. Well not anymore. They were ruined. We told them they should have covered their stuff but no one believed us. It also affects the major place for the relay clams. The rays have a great time there. They love that place. That's one of the places where that fisherman thinks he can catch a lot of them. It's a hot spot for rays anyway. So the relay did collapse.

We think the ray population is increasing every year just by the amount of rays that have come through. We're growing clams in the back bays (back shallow bays) pretty much as a migration or when a mess of rays come in every year like I said in late June or early July. They have their way with any clams they find that are uncovered or easy to get at. I don't know if they eat crabs or not. Either they run out of food or the sharks show up and then they're gone. We get a few rays that stick around all year but most of them are stingrays, which are a different critter. We think the population has gone way up. I don't know if the rays are learning or they are becoming progressively hungrier. They are going to more extreme measures every year to get the clams. They are working the isle in between the pots and like Mike said they have ways of getting under screens and tearing them up. We don't know if that is learned behavior. Some people think it is. Other people just think they're hungry, and would go to more extreme measures to get to food. They certainly go for the easiest meals first. If there is stress—clams either planted too densely or have stressed out at the bottom for some reason—they go for them.

They don't seem to like little tiny baby clams. They like the ones that we like (the little necks and the top necks) and they will eat the chowders, too. I didn't believe they would but they will. I found out the hard way on that. It also affects the wild fisheries. In some good ways and some bad ways. They certainly work wild clam beds that are too dense. They make sure that our wild clam populations are not too high. They also, I guess you saw pictures before of clam beds with lots of holes and just totally torn up. They leave our best wild sea catching reefs torn apart. We don't know if that's good or bad. Maybe that's good. Maybe it provides a better habitat. We don't know. It certainly affects the whole food chain of back bays. There's a humongous number of filter feeders and every year the rays come thru and wipe them out. I guess they don't wipe them out completely because they always come back.

There are quite a few places that we could grow clams in New Jersey without any kind of predator screens if it wasn't for the rays. I think I touched on where the rays are being shipped. There are a couple of limited Asian markets within the larger cities in the Northeast. We're hoping that there is a more potential for bait fishing. I believe they are used for shark bait by some of the offshore guys.

Does anyone have any questions? I hate to admit that I know very little about the surf clam fishery. I also couldn't find too many guys that really wanted to fish for the rays. I really don't know how to answer your question. New Jersey is really good about shutting fisheries down but they're not real good about opening them up. The governor has the power to shut a fishery down on an emergency basis but he doesn't have the ability to open a fishery on an emergency basis. It would take years, I think, for us to really get a fishery through the legislature.

Discussion Summary: Development of a Ray Fishery, Research and Extension Needs

Robert Fisher
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A lengthy discussion was conducted by all stakeholders in attendance covering many parts of the cownose ray issue. An audio recording of the discussion was made, but was too low quality to be transcribed into this document. Instead the following narrative touches on questions and issues raised by the workshop participants.

As the result of the presentations given over the course of the two-day workshop, a better understanding of cownose ray issues has been established. This was evidenced by the nature of discussion topics, which gravitated away from the basic pre-workshop "why can't we just fish them all up?" line of questions to "how can we responsibly manage this situation?" The harvesting of rays to support a ray fishery at various levels of effort was not viewed as an obstacle, since traditional fisheries in the Bay (haul seine and pound net) are effective means of capturing rays. The group was sensitive to ray biological constraints and the lack of ray population information, and resulting discussions focused on reducing ray-shellfish interaction (predator control/repellent measures) and on how fishery data can be gathered to support population estimates.

Predatory controls discussed included methods of stiffening the mesh netting that covers clam beds, staking or fencing growout areas, using sonic booms to repel rays, and the study of other ray repellents. The use of a thicker strand of twine in the construction of clam mesh net would stiffen the netting and make it harder for the rays to tear it and get access to clams. The application of a net coating to serve the same purpose was also mentioned; however, regulations governing the addition of this material were under review at the time. The effectiveness on a commercial scale of staking (driving wooden stakes into the ground at a certain spacing) was questioned. Problems mentioned with this method included the height of stakes in the water column (the creation of navigational hazards as well as the ability of rays to go over stakes on incoming tides) and the shear number of stakes that would be needed to encircle a commercial plot at sufficient intervals (~18 inches apart). Some participants commented on ray behavior around bamboo poles driven at corners of clam beds used to mark boundaries and help secure netting. The rays were reported to not eat clams that were within two feet from the poles, thus resulting in some fisherman putting poles throughout their clam beds to help reduce ray predation. The effectiveness of sonic blasts to disperse rays from shellfish grounds was also questioned. Mike Oesterling of VIMS commented that sonic cannons, shot into the air as well as underwater, had been tried in the past and that the shock wave quickly caused the rays to go away (as along with all other fish in the area) but that

they would come right back. These conclusions lead into a discussion of chemical repellents.

A question was posed about using dead rays to ward off feeding rays, mimicking the observation by local watermen in the crab fishery that dead crabs seem to keep live crabs from entering their pots. Bob Fisher of VIMS commented that there may be a chemical component released by dead animals that acts as a cue to living animals of the same species. He recounted his work with the commercial whelk fishery (in which he has been working to find an alternative bait to replace horseshoe crabs) where he experimented using crushed whelk as bait to attract whelk. The crushed whelk bait was used in traps randomly placed within a commercial trap line, with the other traps baited with horseshoe crabs. Upon retrieval of traps, not a single whelk was caught in traps baited with the crushed whelk, while the other traps caught whelk. Fisher also described his recent contact with a group studying shark repellents (Shark Defense, LLC Oakridge, NJ) and subsequent collaborative research trials to be conducted at VIMS that summer (2006). Shark Defense was featured on National Geographic's Shark Week, in which chemical repellents were demonstrated to effectively repel multiple species of sharks. These chemical (semiochemical) repellents are derived from decaying shark tissue. Fisher sent ray flesh to Shark Defense for the production of a repellent to be tested on rays. In addition, the use of rare earth magnets (Neodymium-Iron-Boride permanent magnet) and electropositive metal alloys (ingots of Cerium-Lanthanum Mischmetal and Neodymium-Praseodymium Mischmetal were also going to be tested for ray repellency effect. The magnetic field generated by these specific magnets causes irritation within the sensory organ of elasmobranchs, which results in the animal actively avoiding the field. The objective of these experiments was to determine if shark repellent technologies could be exploited to control cownose ray behavior. An initial repellency study using Neodymium-Iron-Boride permanent magnet and Cerium-Lanthanum Mischmetal was performed in October 2006 at VIMS. Results of this preliminary study demonstrate a level of desirable repellent effect on adult cownose rays. This report is included as an appendage to this document.

The workshop concluded with a discussion of ways to obtain adequate ray samples to build on the biological assessment database. Some specific questions about ray biology were recognized as priorities, including: What proportion of the whole Atlantic cownose ray population comes into the Chesapeake Bay and is subjected to a ray fishery?; Is the ray population exploding?; How are cownose rays distributed around the Bay (due to social structure, by sex, age, or size)?; And, how many offspring do females produce per year and when? Limiting factors in securing rays to address these questions included lack of fishery-independent sampling methods, limited access to areas not commercially fished, incomplete cooperation of watermen, and the lack of research funding opportunities.

Closing Remarks

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The objective of the Regional Workshop on Cownose Ray Issues was to bring together, for the first time, representatives from academia, industry, and regulatory groups in the Mid-Atlantic region concerned with the various cownose ray issues. The participants were tasked with reviewing historic events, providing information on current activities, and assessing future needs. Fifty-two people attended the workshop, representing four different states. The workshop helped shed light on a regional problem facing many commercial shellfish stakeholders and on the need for responsible management of the cownose ray resource in light of a potential fishery. Representatives from academia helped educate industry members and regulatory personnel about the biological constraints of cownose ray as a species, while industry representatives educated academic and regulatory personnel about the negative economic impacts of ray-shellfish interactions.

The overall conclusions of the workshop were that shellfish-ray interactions are an important regional issue, that little information exists on cownose ray population dynamics, and that a cownose ray fishery has potential if educational and marketing efforts are strengthened. The need for biological assessment information on the ray population was proposed as an important component in the process of establishing a ray fishery, with VASG proposing to continue their research and extension efforts. Consumer education on ray products and markets for human consumption were also identified as prerequisites for successfully establishing a fishery, with the Virginia Marine Products Board and VASG proposing to continue their respective efforts.

An important benefit resulting from this workshop was the proposal to go forward investigating the potential for a ray fishery in a concerted effort, as a collaboration between industry, academia, marketing groups, and regulatory agencies. The impact of such a collaboration will be a higher likelihood that if a ray fishery is established, in addition to providing a supplemental fishery for many displaced watermen and potentially lessening ray predation on shellfish, it will also be a sustainable fishery.

In summary, this workshop provided a means to educate all on past and present efforts dealing with cownose ray issues, so we know where we came from, and can come to a consensus about where we are going.

APPENDIX 1: Newspaper Coverage

Chefs cook up solution for rays: Creatures' appetite for destruction leads to ideas to limit damage

BY LAWRENCE LATANE III
TIMES-DISPATCH STAFF WRITER
Jun 2, 2006

YORKTOWN -- Chef John T. Maxwell hopes to save the Chesapeake Bay -- one ray fajita at a time.

That's cow-nosed ray, or Chesapeake ray, as state seafood lobbyists have taken to calling the 20-pound bat-winged creatures that swim into the bay each spring with a destructive appetite for oysters.

Maxwell doesn't care what name is used as long as the public begins thinking of them in terms of being sautÈed or fried.

During a presentation yesterday titled "Chesapeake Ray: An Ecological Menu Choice," Maxwell shed his own view on the suddenly controversial creature.

"It's a little bit chewy to be marketed as fish," he said, "and it's hard to market it as meat because it's a little bit fishy."

But Maxwell, a well-known Richmond-area chef and culinary teacher at J. Sargeant Reynolds Community College, said he remains undaunted. The chefs he has met and introduced to ray during the past year at conferences and trade shows all over the world "didn't have any trouble with it at all."

"Every chef's goal is to create the next big thing," Maxwell continued in his talk at a Virginia Sea Grant Marine Advisory Program forum. "And if we can make ray the next big thing, we can market ray."

Marketing rays may be the only solution to what appears to be a growing problem in the bay, where state and federal agencies and private oyster growers are trying to restore the estuary's dwindling oyster population.

Until recently, the effects of long-term over fishing and a pair of potent disease-causing parasites posed the biggest hurdles to oyster restoration. Now, rays are emerging as a particularly troubling threat.

Case in point: Two weeks ago, rays gobbled up an estimated 90 percent of the 775,000 oysters conservation groups had just stocked in the Piankatank River. Rays helped themselves to a similar Army Corps of Engineers restoration project in the Great Wicomico River about two years earlier.

Scientists, watermen and researchers will wrap up their second day of presentations on the cow-nosed ray today at the conference. Bob Fisher, a sea grant adviser who hosted the program, hopes a fishery can be developed for rays that can allow for a sustainable harvest to check their numbers.

Rays have always migrated to the Chesapeake Bay from wintering grounds off Florida and South America to calve and eat shellfish. What's new is that heavy fishing pressure on their main enemies -- sharks -- apparently has allowed the ray population to mushroom.

"Ray numbers have increased 6 percent a year over the past 30 years,"

University of North Carolina biologist Pete Peterson said during a meeting break yesterday.

He fears that the growing ray population, once it reduces the oyster population enough, will next turn to uprooting underwater grass beds in their search for burrowing clams.

"We are at the precipice of a sea change in the community structures and ecological functionings delivered by our estuaries," he said, because of the rays' effects on shellfish and submerged vegetation.

Oysters and underwater grasses are considered keystone species in the bay and in the sounds because of their central ecological roles in maintaining water quality and supporting a vibrant food web, Peterson said.

He is not optimistic that a big enough market can be found to control ray numbers.

As he spoke, Maxwell lighted a flame under a cast iron skillet and browned a slab of ray wing for a dish called Chesapeake ray fajitas. The three or four dozen people in the audience picked up plastic plates and waited in line.

Contact staff writer Lawrence Latane III at llatane@timesdispatch.com or (804) 333-3461.

Cownose rays ruin oyster restoration efforts: Virginia seeks to create a retail market for the rays, which have stalled oyster restoration efforts with their appetite for shellfish

BY FRED CARROLL
June 4, 2006

Reprinted with permission of the Daily Press. Article was also picked up by the Associated Press.

YORK -- When most of the big sharks disappeared, few natural predators remained in the Atlantic Ocean to thin the schools of cownose rays migrating in late spring from southern Florida into the Chesapeake Bay.

When most of the soft clams savored by hungry rays disappeared, more and more rays flapped their wings, churned the muck on bay area bottoms and ate the oysters and other shellfish they exposed.

Marine scientists suspect such a cycle has worsened over 30 years or so.

Now, though, the rays might have finally attracted the sustained attention of the ultimate predator: humans.

Scientists, regulators and commercial seafood reps met in Yorktown this past week at a workshop sponsored by Virginia Sea Grant to reinvigorate efforts to create a retail market for ray wings and filets.

"I find a ray of hope for this project - finally," said Shirley Estes, of the Virginia Marine Products Board.

A commercial ray harvest could protect delicate attempts to restore pollution-filtering oysters, lessen damage to ecologically valuable seagrass beds and create jobs in a shrunken fishing industry.

Virginia seafood officials are exploring the possibility of exporting ray wings to South Korea - which imports $18 million worth of frozen ray annually.

They're also planning to test market ray wings - which are generally well

reviewed in taste samplings - in American restaurants under the more appetizing name of Chesapeake rays.

Past attempts to sell ray meat have floundered amid buyer indifference, high processing costs and difficulties in landing them.

Without a retail market, rays will seemingly continue to increase unabated in number - undermining efforts to rebuild oyster reefs and improve the bay's water quality.

One trawl survey done between Delaware and North Carolina estimates that the ray population has grown by 6 percent annually for 30 years.

In the late 1980s, scientists at the Virginia Institute of Marine Science studied a school that covered more than 1,100 acres and included about 5 million rays.

(The school was so large that scientists could not include it in its entirety in a single aerial photo.)

Named for their distinctive heads, cownose rays fly through the water on wings sometimes mistaken for shark dorsal fins. They protect themselves with a poisonous stinger and grind shellfish inside their powerful mouths.

Rays have long drawn the curses of bay oystermen - who have sought help getting rid of them since the 1970s.

Just two weeks ago, rays ruined an oyster restoration effort on the Piankatank River - eating most of about 750,000 oysters. Organizers had poured an extra layer of shells atop the oyster reef specifically to fend off the rays.

"We knew we were going to lose some, but we lost 94 percent in just five days," said Jim Wesson, oyster expert for the Virginia Marine Resources Commission. "Now they're getting to the oysters even before the diseases."

Wesson considers rays the biggest obstacle to restoration work because oysters today have been bred to resist two disease-causing parasites that - along with overfishing - contributed to the mollusks' near-extinction.

An abundance of rays pose similar problems elsewhere, including off the West Coast and Japan.

Pete Peterson, a biologist with the North Carolina Institute of Marine Sciences, said rays gobbled up bay scallops and essentially shuttered that industry in North Carolina.

"We are at the tip of an ecological crisis," Peterson said. "There's a good chance we're looking at an ecosystem-based case of bad management worldwide."

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