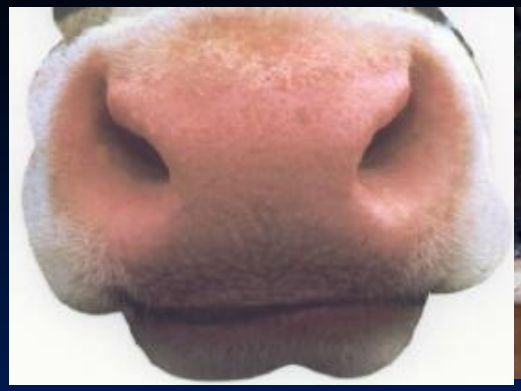
Historical concern over shellfish predation by cownose rays
Update on cownose ray feeding biomechanics

Dean Grubbs, Ph.D
Associate Research Professor
Associate Director of Research
Florida State University Coastal and Marine Lab

Rhinoptera bonasus

Rhino = Greek for “snout”

ptero = Greek for “wing”



BONASUS

http://enluminure.livejournal.com/1486.html
https://en.wikipedia.org/wiki/Bonnacon#/media/File:Bonnacon.jpg

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

Pliny the Elder [1st century CE]: The bonasus when attacked 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.

HISTORICAL PERSPECTIVE:

John Smith's 1608 exploration of the Chesapeake Bay.
Smith's crew "...Our Captain sporting himself by nailing them [rays] 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."

Mitchell (1815)
Cownose rays "are detested by people who live near the shores by reason of the damage they do to the clams (*Mya arenaria*)"

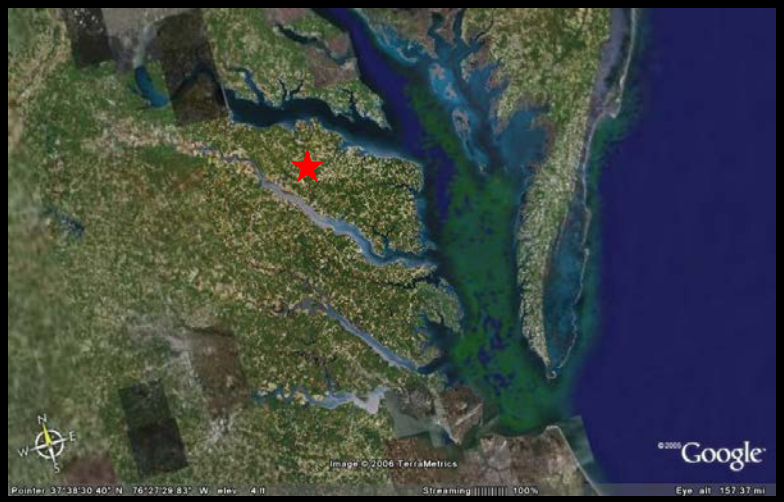
Joseph (1961) Copeia.
Cited unusual catches of cownose rays in pound nets in 1960.
Fishermen polled could not "recall such concentrations in the past".

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

Jim Bourdon: elasmo.com

Cownose ray: most common ray teeth in the Pungo River (North Carolina). Miocene - 5-23 million years old

Common in Nanjemoy sediments
Stafford County, Virginia
Early Eocene (Ypresian) –
~50-55 million years old



ELASMO.COM

The Life and Times of Long Dead Sharks

HOME LEE-CREEK FAUNAS GENERA BATOIDS TOPICS REFERENCES

FAUNAS
LEE CREEK
BELGRADE
CASTLE HAYNE
NANJEMOY
AQUIA
BLACK CREEK

Genera from the Fossil Record

Rhinoptera spp — Cenozoic Rhinopterids

The Cownose rays — Upr Palaeocene - Recent

ORDER: Myliobatiformes COMPAGNO, 1973
FAMILY: Rhinopteridae JORDAN & EVERMANN, 1896

Jim Bourdon © 1997 - 2007

In the Western North Atlantic, they tend to become common in the Ypresian and appear to have maintained a healthy presence into recent times. Kent (1999:45-46) reported *R. sherboni* form the Ypresian of Virginia. Muller (1999:64-65) included:

- *R. sp* Piney Pt Fm , (Lutetian) VA
- *R. aff bonasus* from the Belgrade, Calvert, Choptank & Pungo River Fms (Oligo-Miocene)
- *R. aff brasiliensis* MULLER 1835 from the Old Church, Belgrade, Calvert, Choptank & Pungo River Fms (Oligo-Miocene) of VA & NC

Purdy et al (2001:95) consider the teeth found in Pungo River (units 1-5) as *Rhinoptera sp.*

more → images

Selandian Ypresian Ypresian Lutetian Lutetian Bartonian

Fig. 4 ? *Rhinoptera sp* — medial tooth
Piscatway Mbr, Aquia Fm (Selandian), MD

Jim Bourdon: elasmo.com

Cownose ray: most common ray teeth in the Pungo River (North Carolina). Miocene - 5-23 million years old

Commo
Stafford
Early E

Cownose Rays are not aliens that recently invaded the East Coast of the US

ELASMO.COM

The Life and Times of Long Dead Sharks

HOME LEE-CREEK FAUNAS GENERA BATOIDS TOPICS REFERENCES

FAUNAS
LEE CREEK
BELGRADE
CASTLE HAYNE
NANJEMOY
AQUIA
BLACK CREEK

Genera from the Fossil Record

***Rhinoptera spp* — Cenozoic Rhinopterids**

The Cownose rays — Upr Palaeocene - Recent

ORDER: Myliobatiformes COMPAGNO, 1973
FAMILY: Rhinopteridae JORDAN & EVERMANN, 1896

Jim Bourdon © 1997 - 2007

esian and
1999:45-46)
ncluded:

Fms (Oligo-

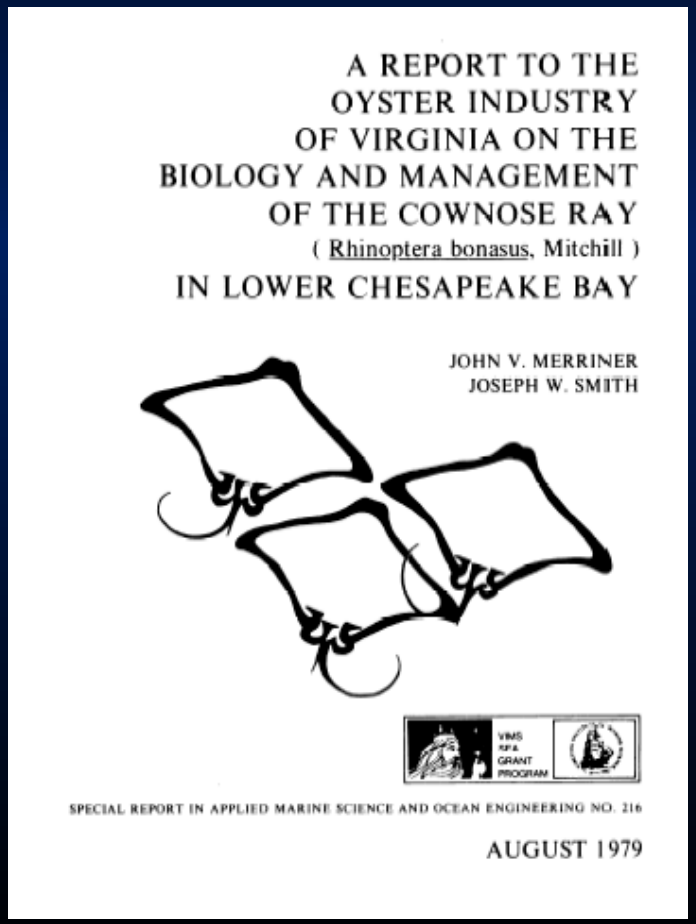
t, Choptank &

) as

utetian Lutetian Bartonian

— medial tooth
Selandian), MD

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



Merriner and Smith (1979)

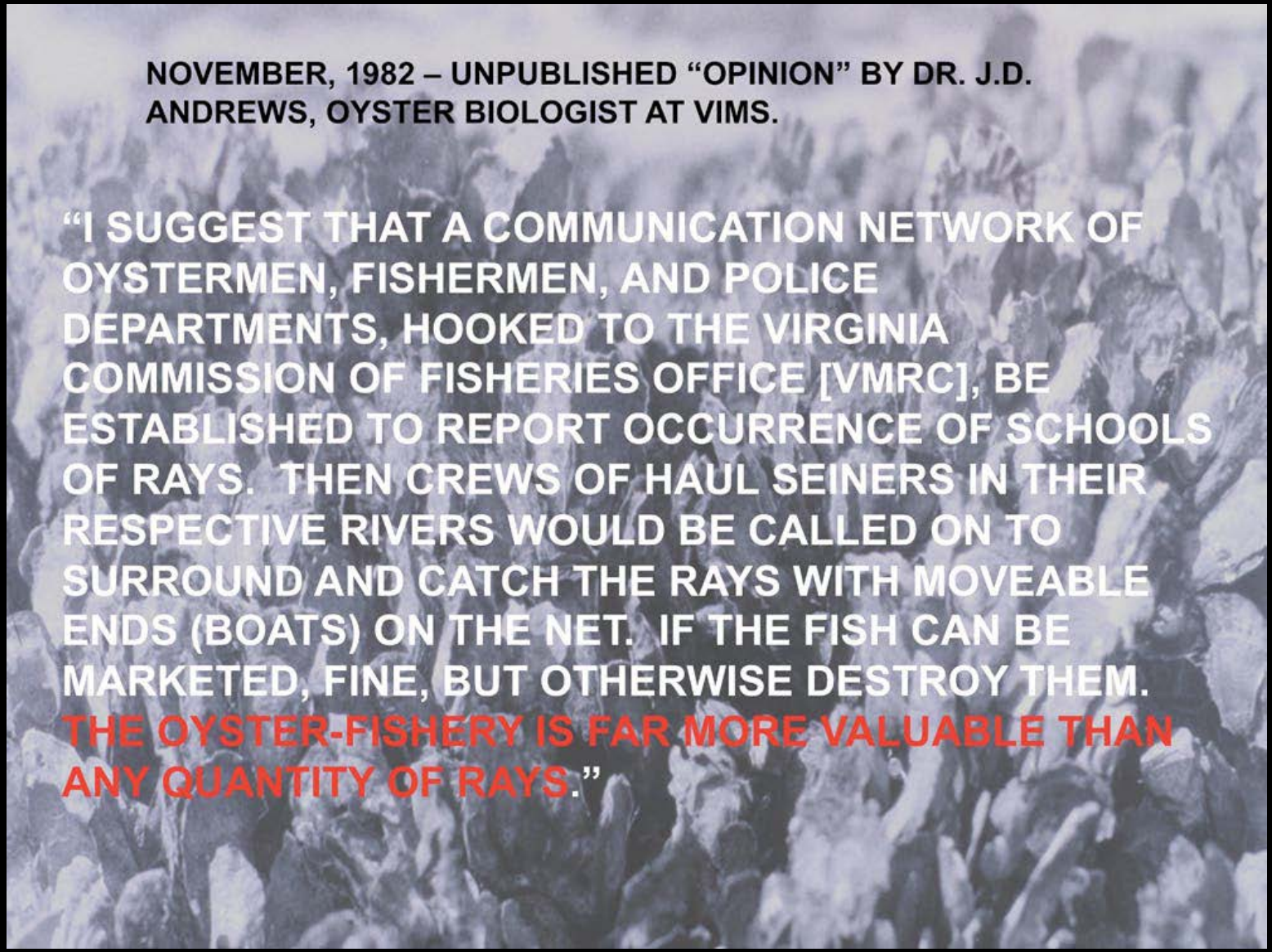
Reported substantial losses to seed and harvestable oyster beds in Virginia due to cownose ray predation.

Recommendations:

1) Fences to protect planted oyster bottom
2) Develop a fishery for cownose rays
3) Directed fishery should begin after July 15 to allow births
4) Develop sportfishing derbies for cownose rays
5) Add cownose ray to the list of citable fishes maintained by the Virginia Saltwater Fishing Tournament

Otwell and Lanier (1978)

Also reported losses of bay scallops in North Carolina to cownose rays. Proposed a fishery and tried to develop a market.

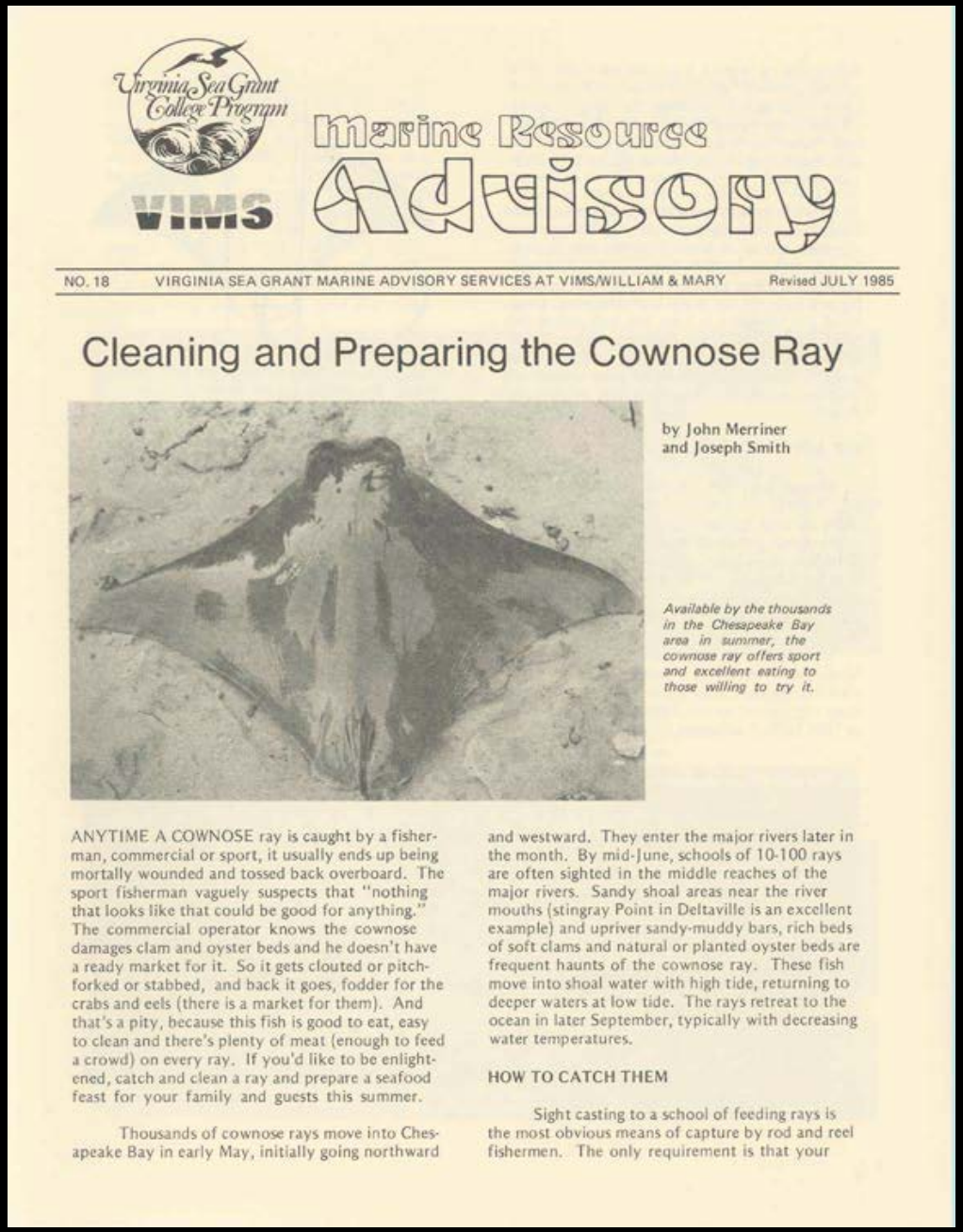


Slide directly from Oesterling, M. 2006. A History of Cownose Ray Interactions in Virginia. VIMS Marine Resource Report 2009-6

In 1984, oyster growers from the Rappahannock River requested VMRC and Virginia Seagrant Marine Advisory Services revisit the cownose ray issue.

Claimed 1983 was worse year for planted oyster loss in history.

1989: Oystermen lobbied Consgressman Bateman who in turn requested the Virginia Seagrant Marine Advisory Services refocus on cownose issues.



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.

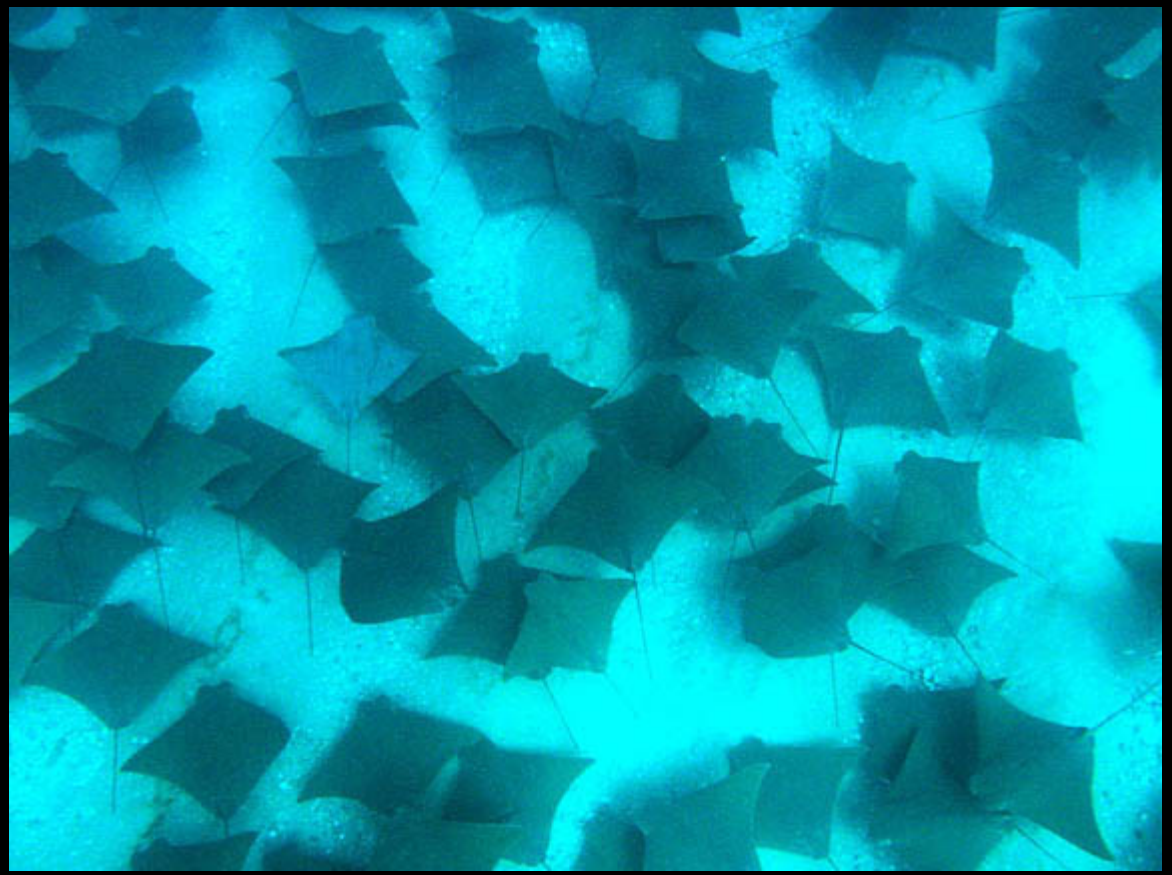
HOW TO CATCH THEM

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

Blaylock 1993

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



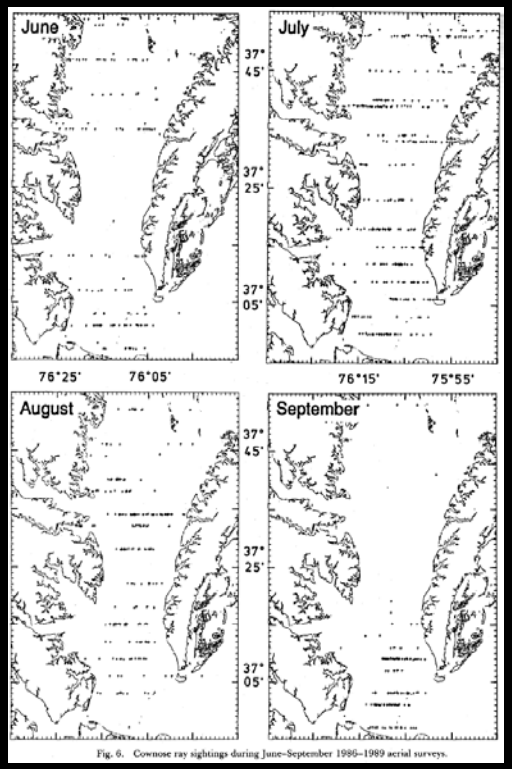
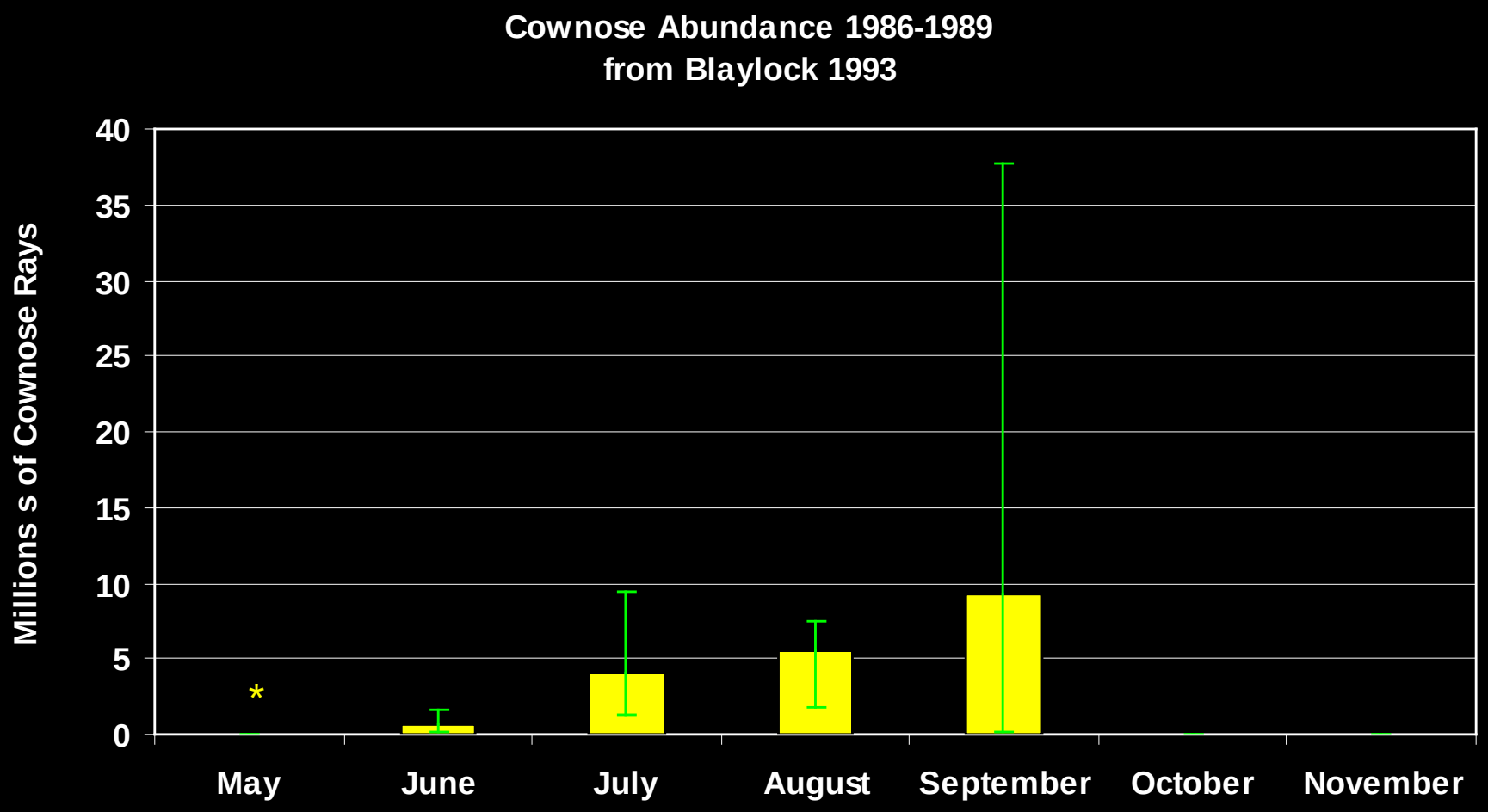


Fig. 6. Cownose ray sightings during June–September 1986–1989 aerial surveys.

Blaylock estimated



Watermen: Cownose Ray Nothing But Trouble For Bay

Threat To Clam, Oyster Population

February 22, 1993 | By MARK DI VINCENZO Daily Press

Watermen smile when they talk about killing them.

Scientists struggle to name one redeeming value possessed by them

``They're no good whatsoever for the Chesapeake Bay,'' says S. Lake Cowart Jr., a Northumberland County oyster grower and seafood dealer.

In the 1950s and 1960s, bay watermen used fewer and fewer nets to catch fish. This was good news for cownose rays because they find it difficult to escape nets. Watermen who find rays in their nets often stab and kill them with hooks, called gaffs, and dump them overboard, where blue crabs feast on ray carcasses.

By the mid-1970s, with fewer watermen killing rays and with overharvesting, pollution and diseases thinning clam and oyster populations, the Virginia Institute of Marine Scienc
purpose. They suggested they be caught, processed an
pork chops or chicken.

1998: At the request of the oyster industry, the Cownose Ray Working Group through Virginia Seagrant Marine Advisory Service was resurrected

They've tried to scare them with blasts from propane ga
didn't go anywhere." They've covered oyster beds with
away at the oysters. They've pounded sharp stakes - sh
milk jugs with marbles to create noise to scare the rays.

Scientists warn that killing cownose rays will not rejuven
and clams are on the decline," says John R. McConaug
and oysters in the long run."

Regional Workshop on Cownose Ray Issues Identifying Research and Extension Needs

Yorktown, VA
June 1-2, 2006

Sea Grant
Virginia

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

8 talks on cownose ray interactions with bivalve fisheries

Workshop Agenda

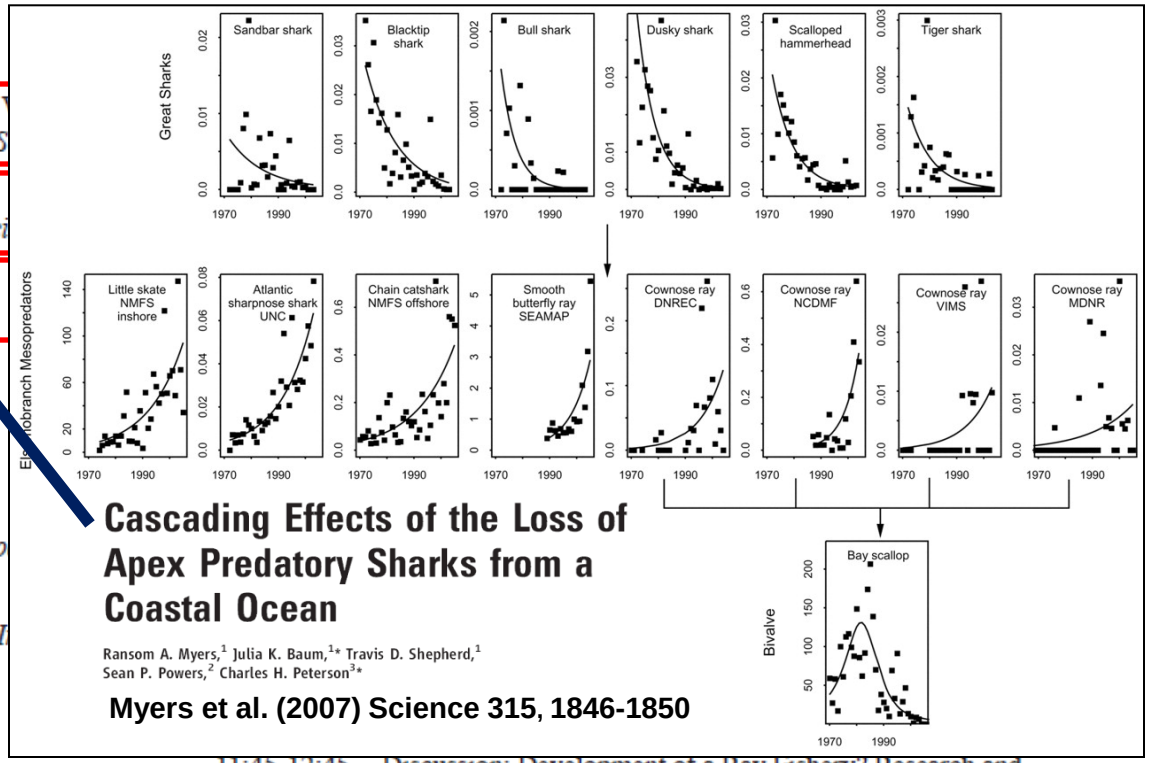
Freight Shed, Yorktown, VA June 1-2, 2006
Hosted by Virginia Sea Grant Marine Advisory Program

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 *Mike Oesterling, Virginia Sea Grant, VIMS*
1:10-1:40	Impact of Rays on Bay Scallops *Pete Peterson, UNC Institute of Marine Sci*
1:40-2:10	North Carolina Ray Projects *Bob Hines, North Carolina Sea Gra*
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 Bo*
3:40-4:10	Ray Domestic Market Efforts *Chef John Maxwell, CEC, AAC, Culinary I*
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*
11:45-12:45	Discussion: Development of a Ray Fishery? Research and Extension Needs? *Moderator; Bob Fisher*
12:45	Adjourn



Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean

Ransom A. Myers,[1] Julia K. Baum,[1]* Travis D. Shepherd,[1] Sean P. Powers,[2] Charles H. Peterson[3]*

Myers et al. (2007) Science 315, 1846-1850

8 talks on cownose ray interactions with bivalve fisheries

Workshop Agenda

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

June 1, 2006

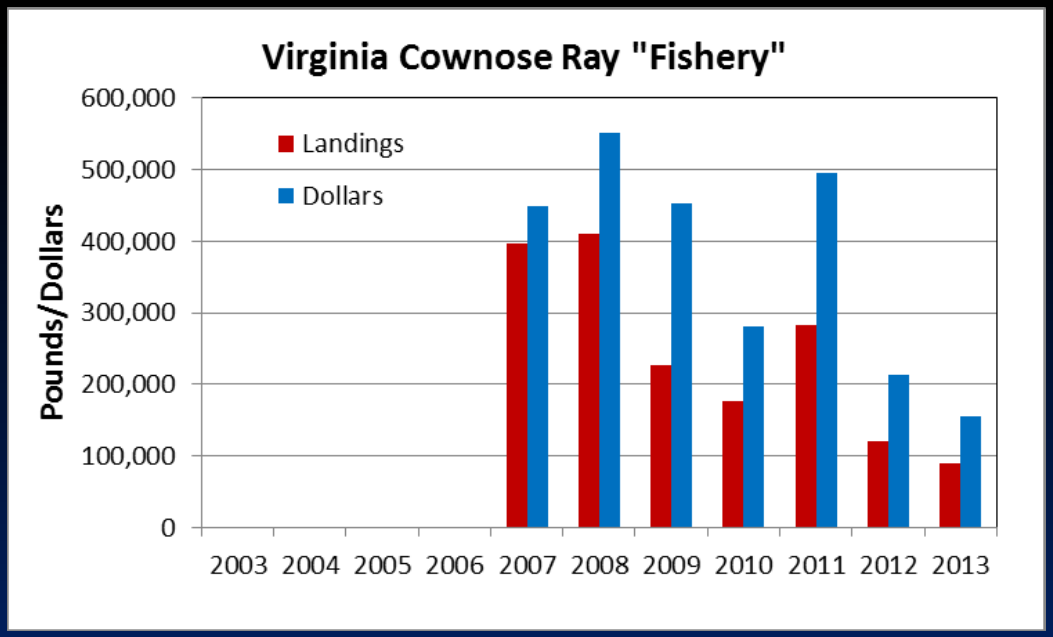
12:00-12:30	Registration
12:30-12:40	Welcome, Purpose of Workshop *Bob Fisher, Virginia Sea Grant, VIMS*
12:40-1:10	A History of Cownose Ray Interactions in Virginia *Mike Oesterling, Virginia Sea Grant, VIMS*
1:10-1:40	Impact of Rays on Bay Scallops *Pete Peterson, UNC Institute of Marine Science*
1:40-2:10	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

5 Talks on cownose ray market and fishery development

1 Talk on cownose ray biology and the need for caution in developing a fishery

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



Does not include commercial discards or recreational mortality (e.g. ray derbies)

2008 = 186 MT

Data from Virginia Marine Resources Commission's commercial landings bulletins
http://www.mrc.state.va.us/landings_bulletins.shtm

RESOLUTION REGARDING ATLANTIC COWNOSE RAYS

American Elasmobranch Society
July 2010
Providence, Rhode Island

WHEREAS the fishing industry along the East Coast, particularly in Virginia and Maryland, is aggressively promoting targeted fishing, new markets, and eradication programs for cownose rays *(Rhinoptera bonasus)* through state governments, seafood shows, the media, and their "eat a ray, save the bay" initiative (which suggests cownose ray consumption is good for the environment);

WHEREAS cownose rays are among the least fecund marine vertebrates, with females maturing around age eight and usually producing just one pup per year after an 11 month gestation period;

WHEREAS large scale removal of a similar South American species, *Rhinoptera brasiliensis,* led rapidly to population depletion followed by an IUCN categorization as *Endangered*;

WHEREAS there have been no assessments of East coast cownose ray population status or sustainable catch levels;

WHEREAS there are no limits on cownose ray fishing and no concrete plans for managing the fishery;

THEREFORE BE IT RESOLVED *that the American Elasmobranch Society urges Atlantic states where cownose rays are being landed, particularly Virginia and Maryland, to immediately impose precautionary cownose ray catch limits and initiate development of a population assessment and science-based interstate management plan, as a matter of priority.*

Trophic Relationships

- ***Are cownose rays significant natural predators of commercial bivalves?***

Location	Primary Diet
Chesapeake Bay (1970's)	Softshell clams, small bivalves
Chesapeake Bay (current)	Small non-commercial bivalves, crustaceans, fishes
North Carolina	Bay scallops (70%)
Tampa Bay	Cumaceans and polychaetes
Gulf of Mexico	Amphipods, polychaetes, echinoderms, non-commercial bivalves

Smith and Merriner (1985), Powers and Gaskill (2003), Collins et al. (2007), Craig et al. (2010), Ajemian and Powers (2011), Fisher et al. (in prep)

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%

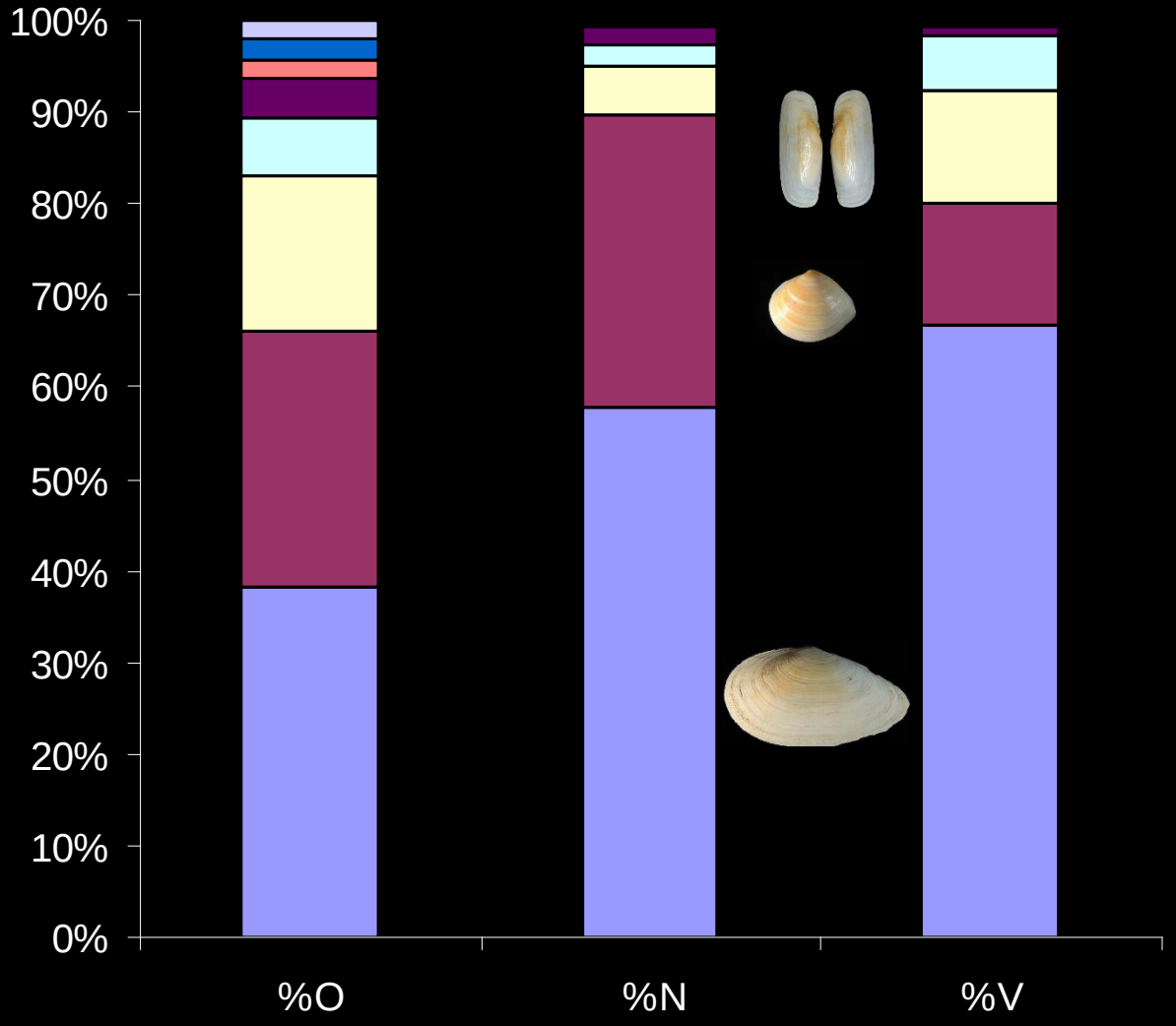
Mya arenaria (soft shell clam), 45%

Tagelus plebeus (stout razor clam), 20%

Macoma balthica (Baltic macoma),

Smith and Merriner 1985

N=40, Caught in and just outside of York River



- Unidentified Teleosts
- Unidentified Shellfish
- Oyster
- Ribbed Mussel
- Hard Clam
- Stout Razor Clam
- Baltic Macoma
- Soft Clam

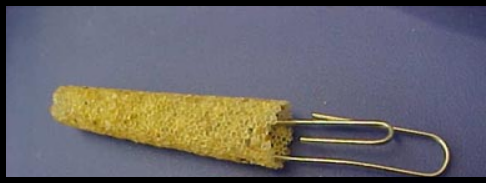
Smith and Merriner 1985

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).

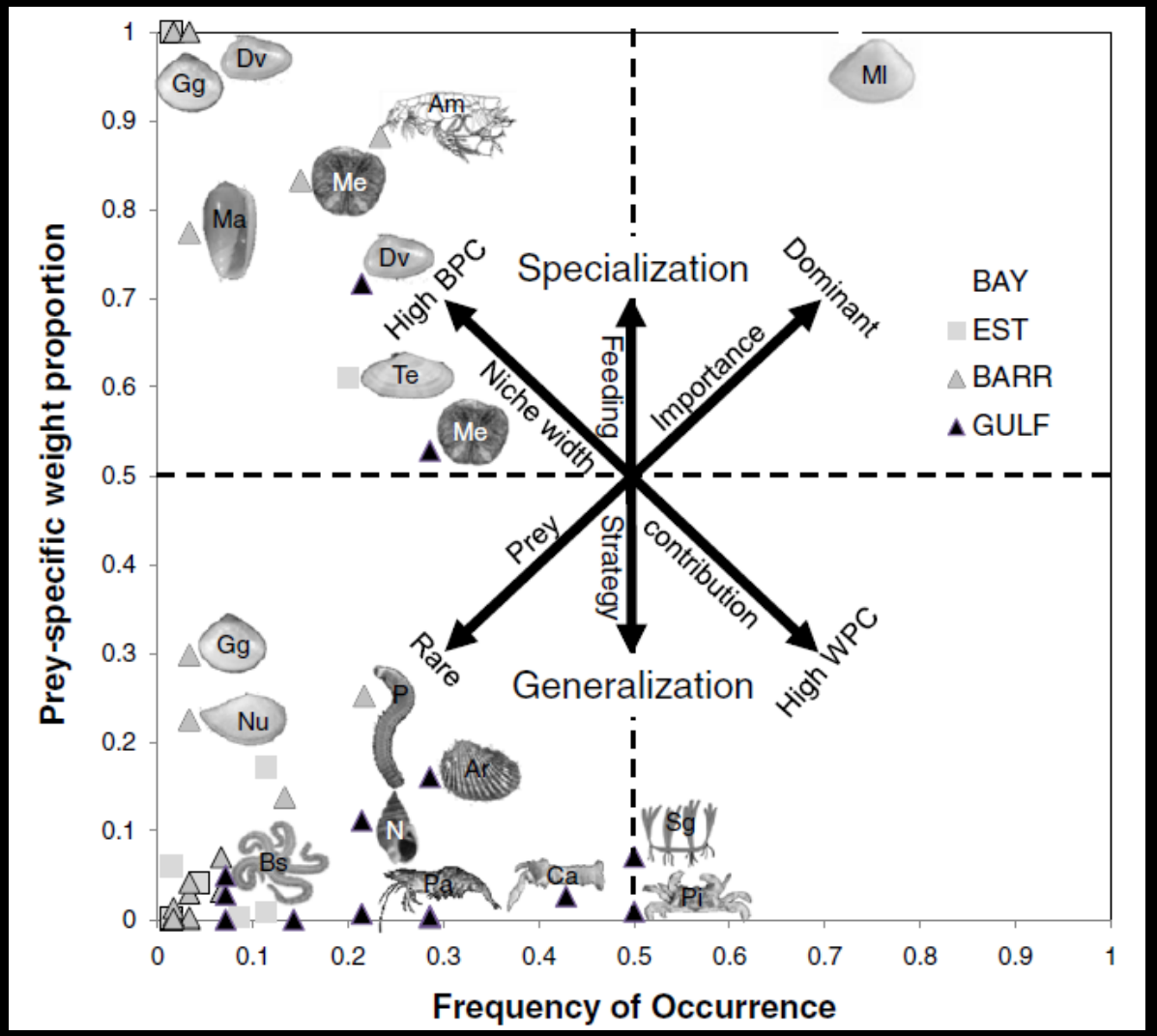
All cumaceans and polychaetes within ray stomachs were intact, indicating capture through suction feeding.

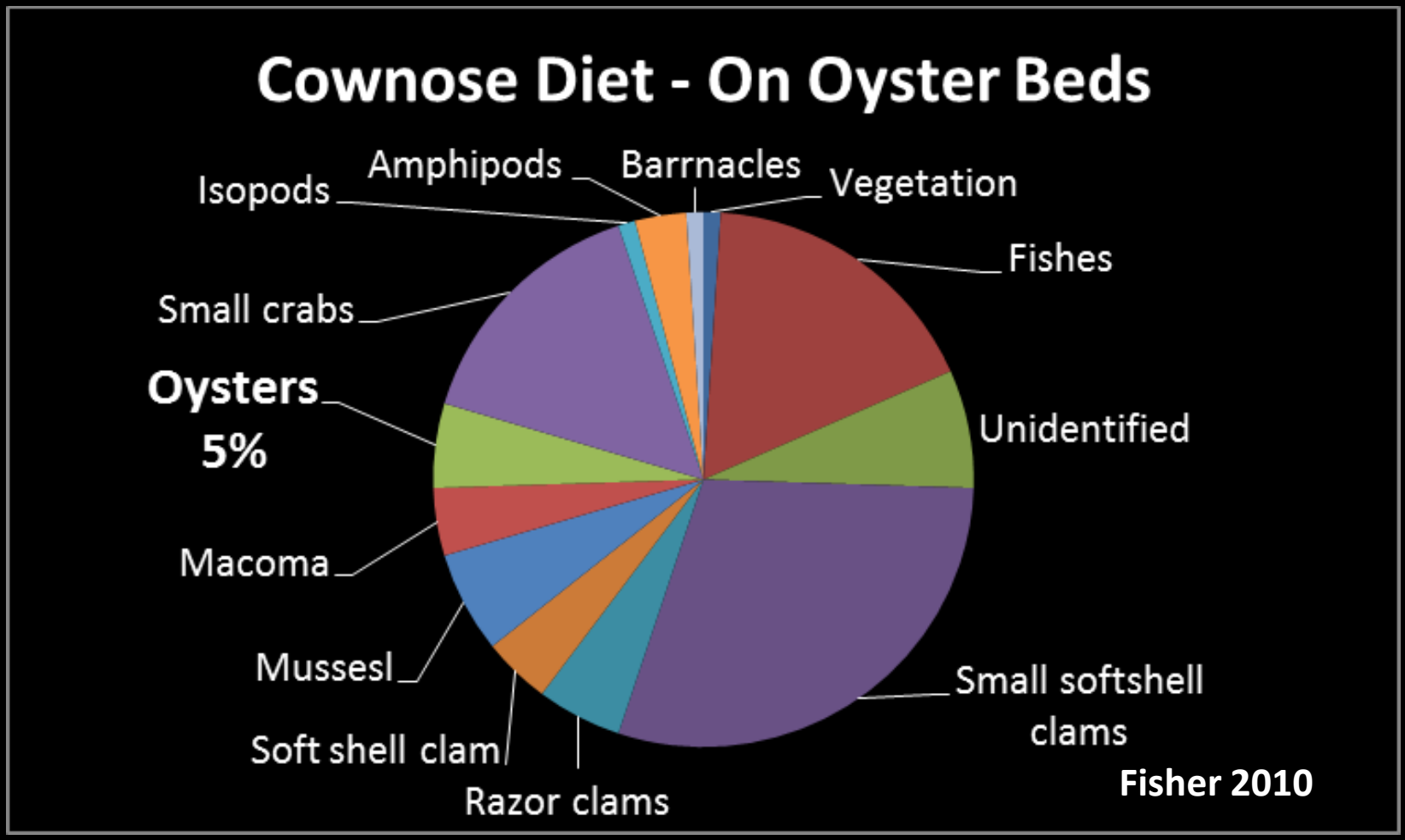
All larger, hard prey showed evidence of crushing (fractured and broken shells).

Ajemian and Powers 2012

Gulf of Mexico: N=201 Cownose rays

Dominant prey:
amphipods
polychaetes
Echinoderms
non-commercial bivalves





No evidence of significant predation on oysters and hard clams except on "seeded" beds (i.e. on-bottom aquaculture)

Cownose collected from commercial oyster grounds in Chesapeake Bay: oysters=5% of diet, small weak-shelled bivalves and crustaceans dominated (Fisher 2010 – Report to NOAA NA07NMF4570324)

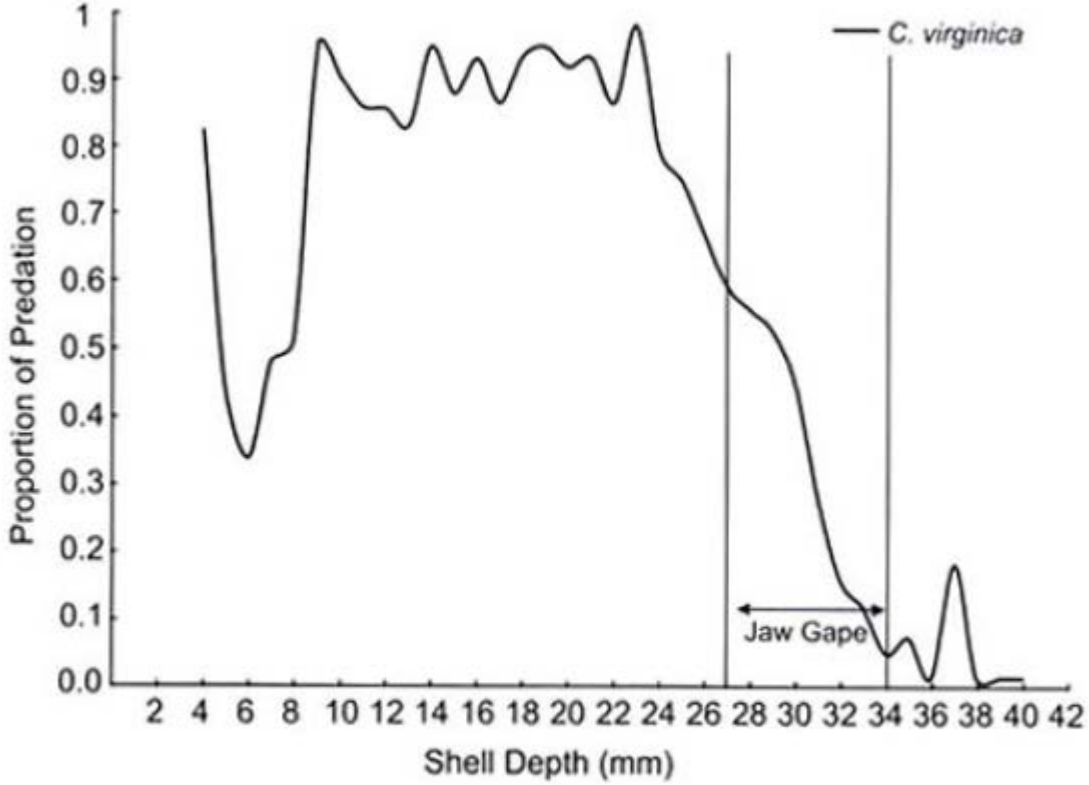
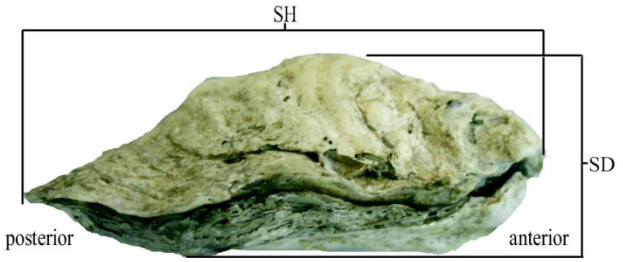
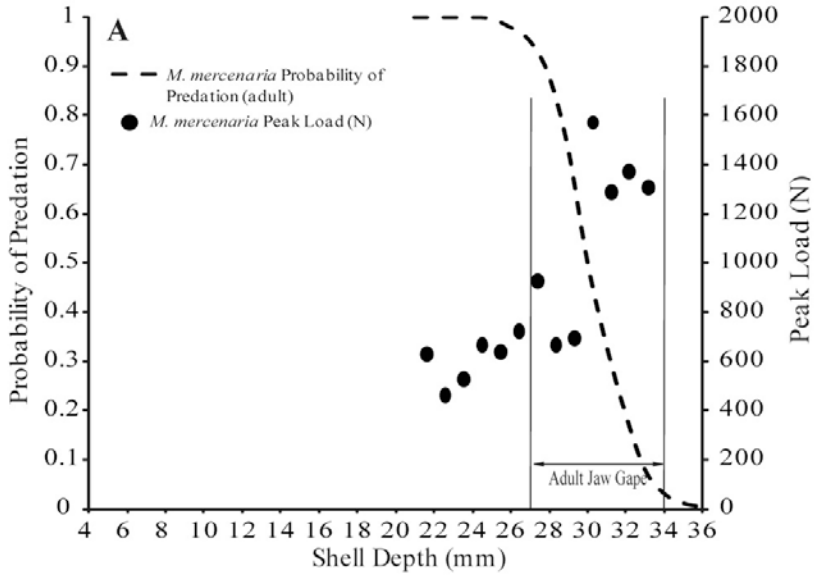


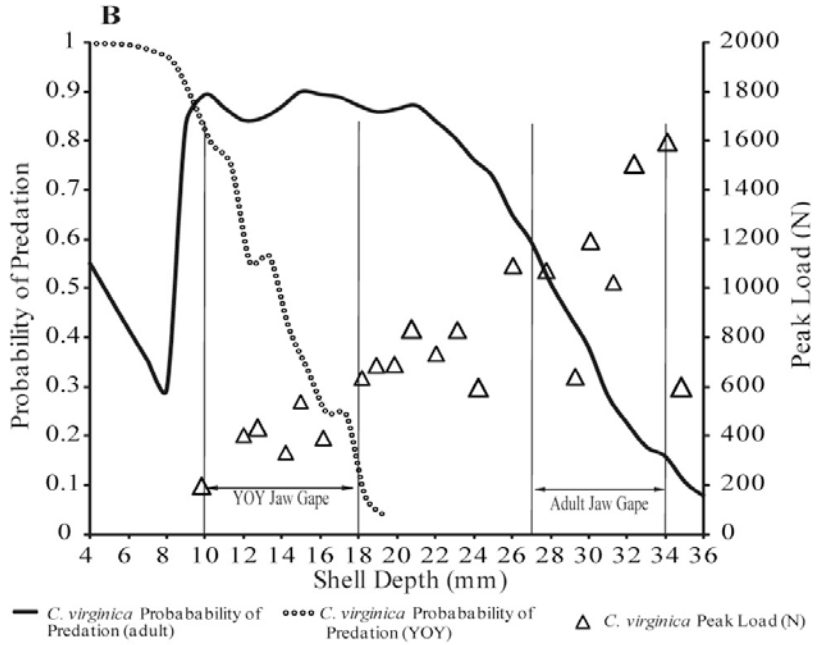
Figure 3. Proportion of *C. virginica* eaten as a function of shell depth in comingled trials. Vertical lines represent the range in maximum jaw gape for adult rays used in predation trials.



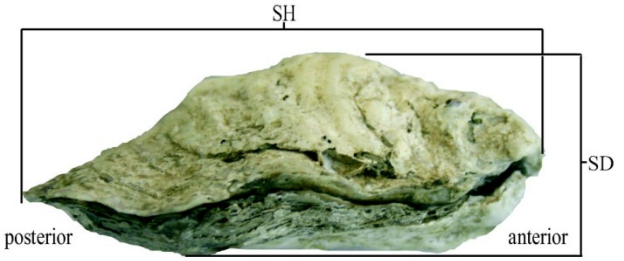
Fisher, R.A., G.C. Call, R.D. Grubbs. 2011.
J. Shellfish Research 30(1): 187-196.



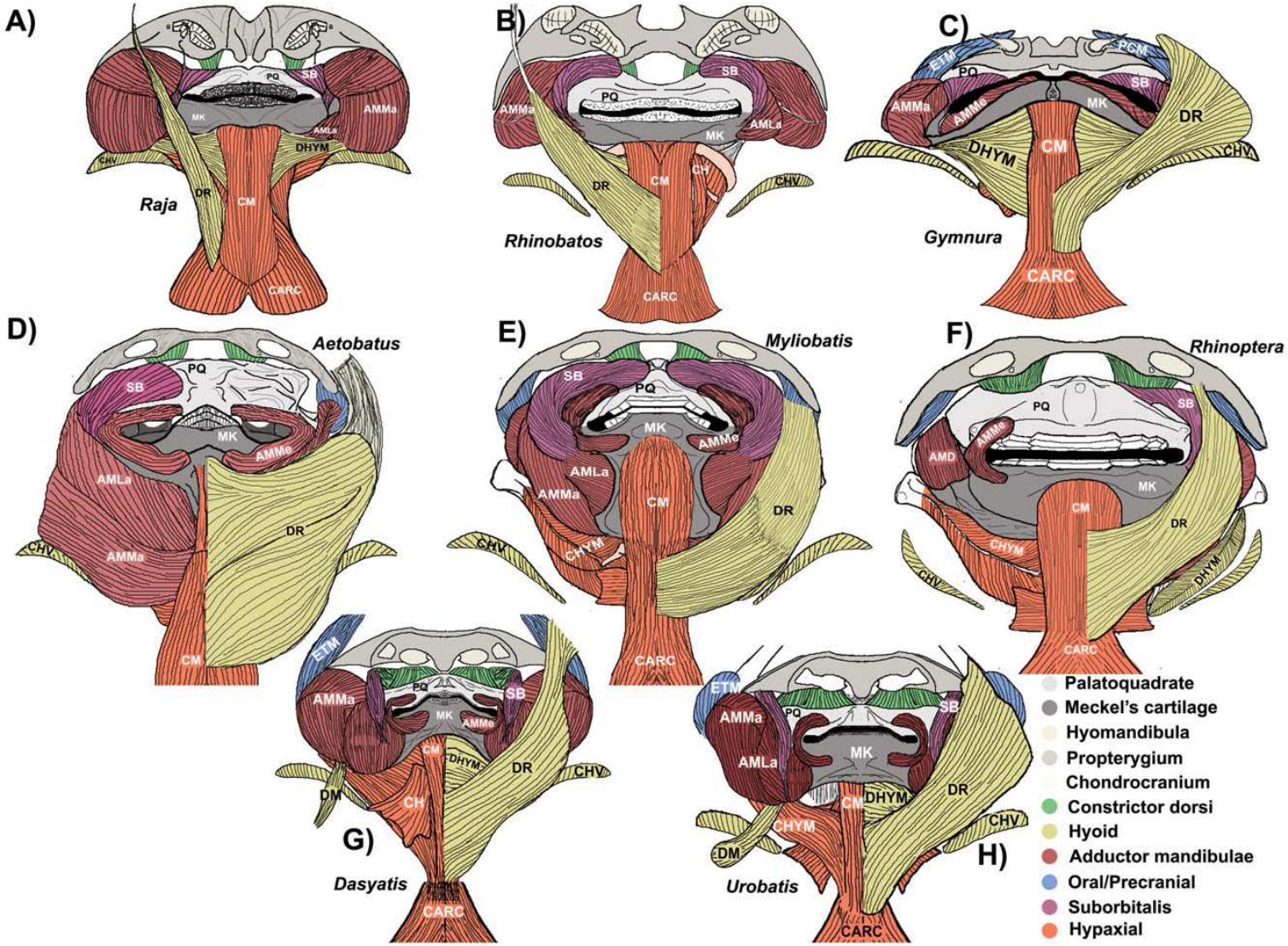
(A)Probability of predation and peak load of *M. mercenaria* as a function of shell depth



(B) Probability of predations and peak load of *C. virginica* and as a function of shell depth.



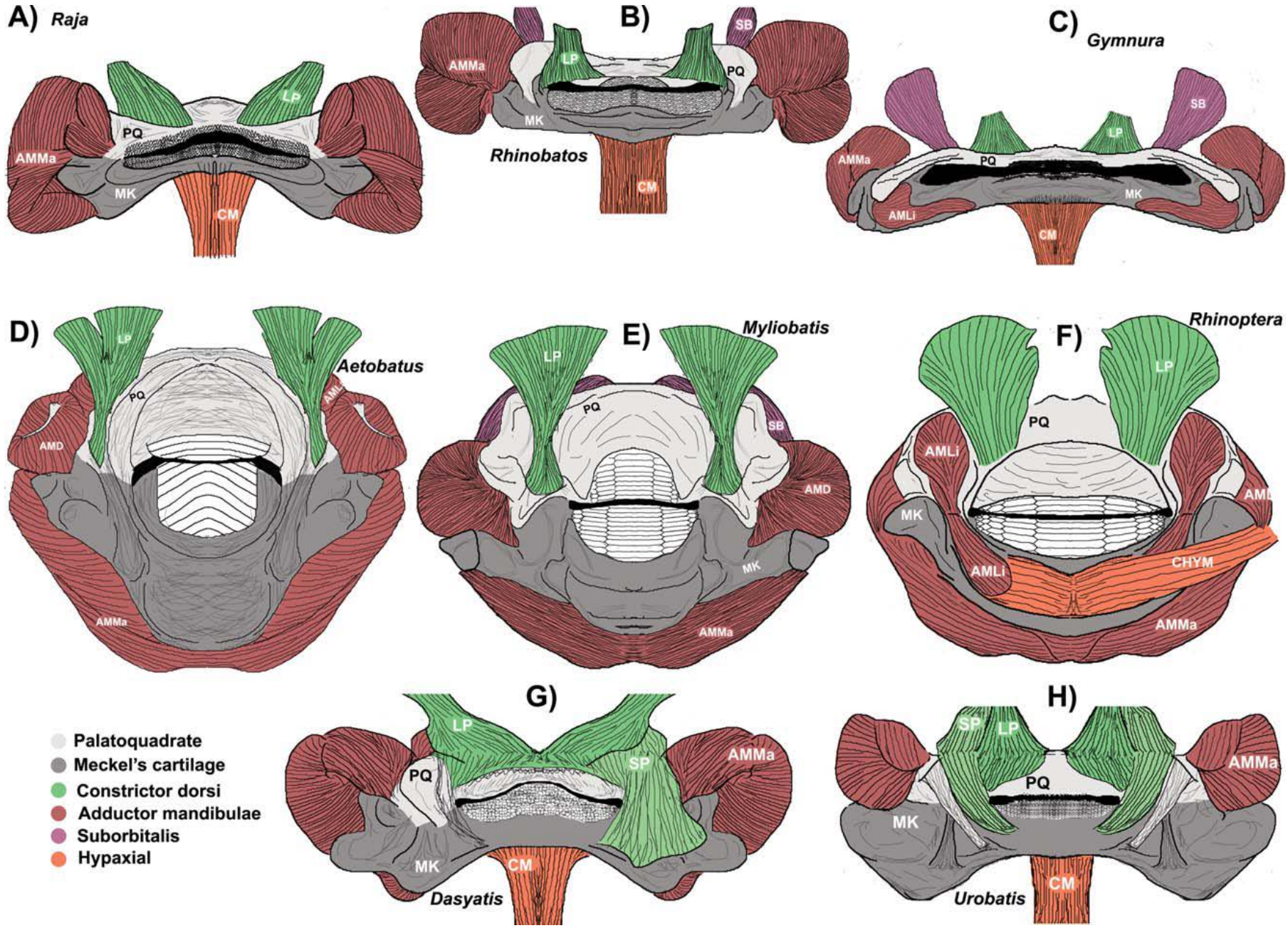
Fisher, R.A., G.C. Call, R.D. Grubbs. 2011. J. Shellfish Research 30(1): 187-196.



Myological Variability in a Decoupled Skeletal System: Batoid Cranial Anatomy

Matthew A. Kolmann,[1]* Daniel R. Huber,[2] Mason N. Dean,[3] and R. Dean Grubbs[1]

Kolmann et al. 2014 – Journal of Morphology



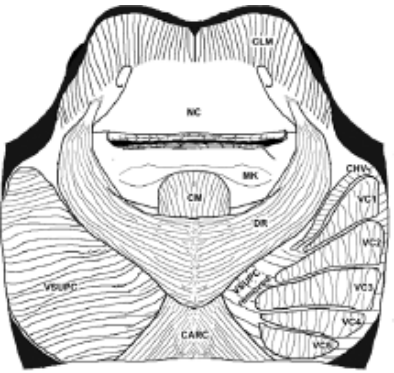
Kolmann et al. 2014 – Journal of Morphology

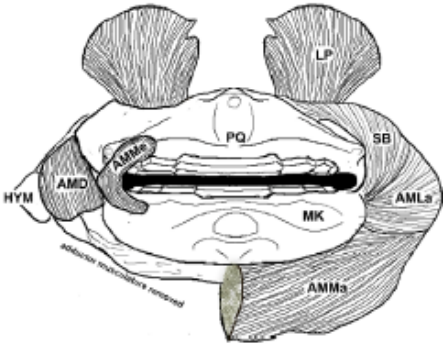
Journal of Anatomy

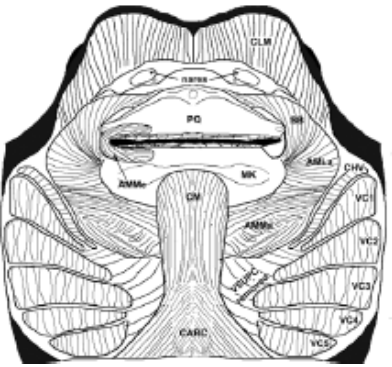
J. Anat. (2015) doi: 10.1111/joa.12342

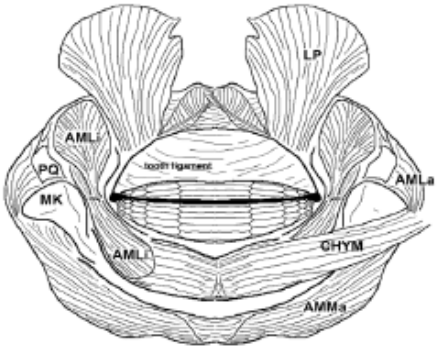
Feeding biomechanics of the cownose ray, *Rhinoptera bonasus*, over ontogeny

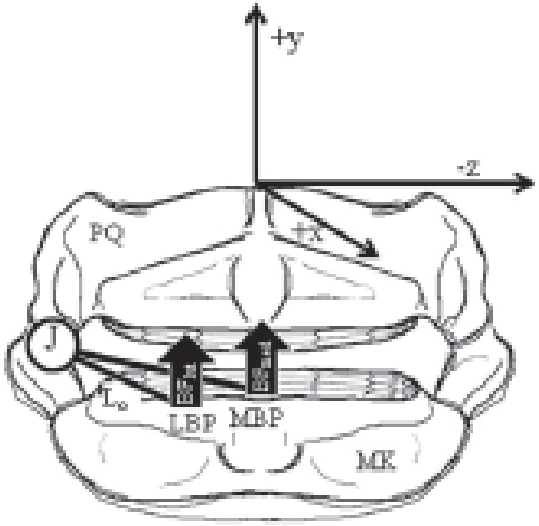
Matthew A. Kolmann,[1] Daniel R. Huber,[2] Philip J. Motta[3] and R. Dean Grubbs[4]

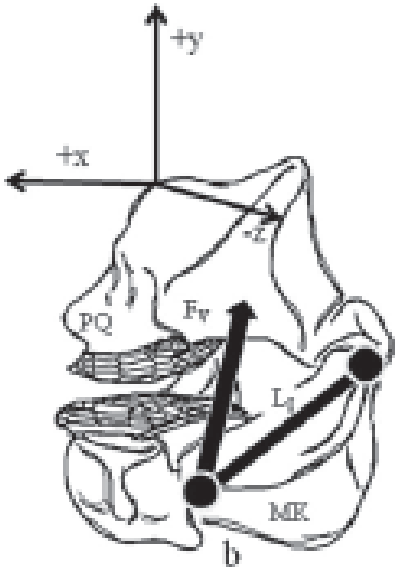












Kolmann et al. 2015 – Journal of Anatomy

Journal of Anatomy

J. Anat. (2015) doi: 10.1111/joa.12342

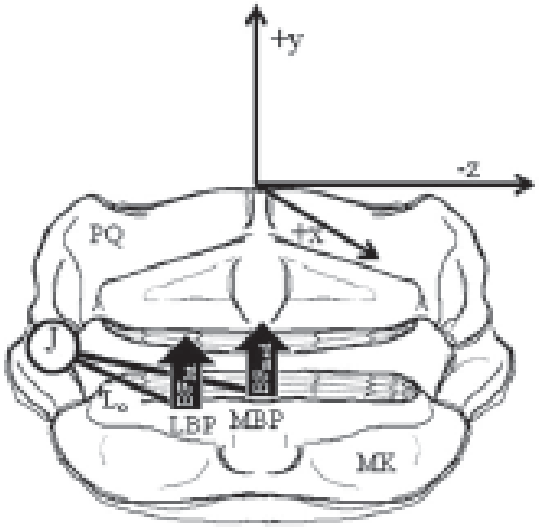
Feeding biomechanics of the cownose ray, *Rhinoptera bonasus*, over ontogeny

Matthew A. Kolmann,[1] Daniel R. Huber,[2] Philip J. Motta[3] and R. Dean Grubbs[4]

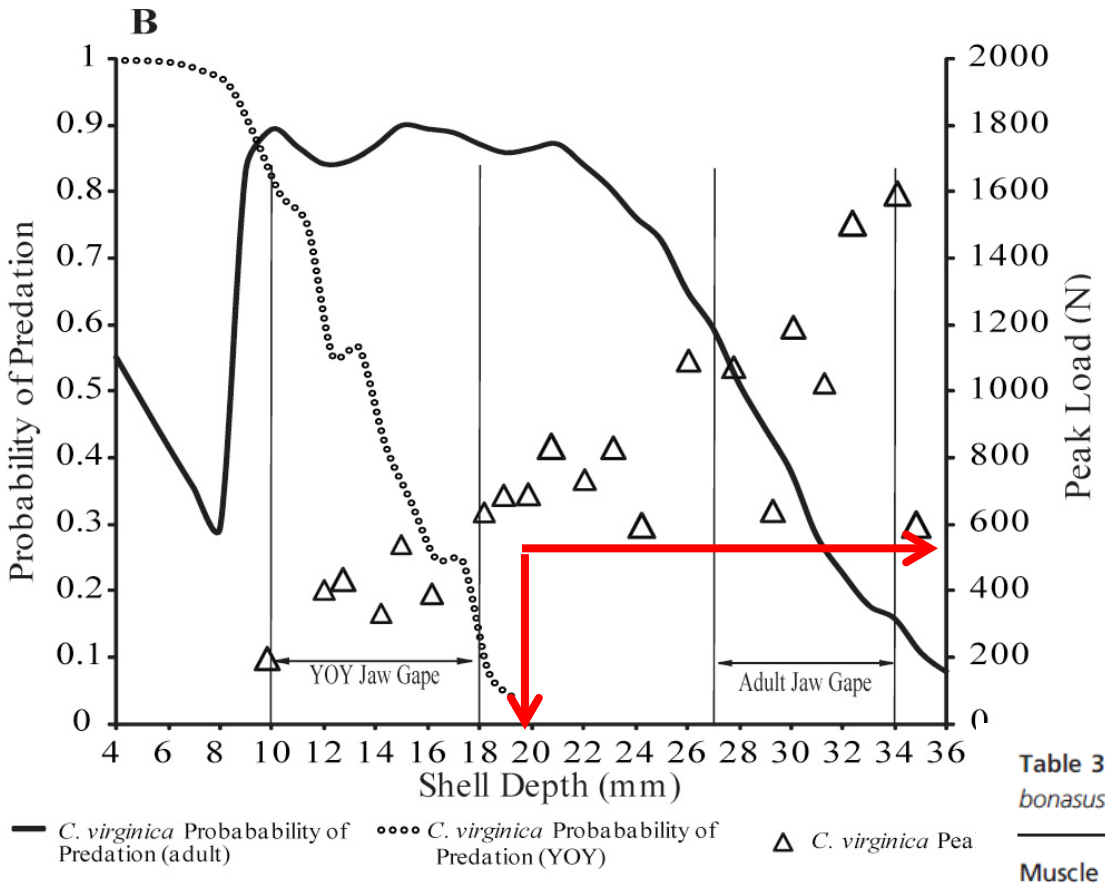
Table 3 Descriptive statistics for bite force scenarios in *Rhinoptera bonasus*.

Muscle division	Medial (N)	Lateral (N)
Class 3 without fibrocartilage	144.0 ± 0.09	146.9 ± 0.03
	25.3–336.1	25.3–362.1
Class 3 with fibrocartilage	194.8 ± 0.64	199.8 ± 0.65
	25.3–480.2	25.3–520.2
Measured bite force	201.7 ± 0.24	
	50.8–561.1	

Values are the mean ± SEM. Range from smallest individual to largest.

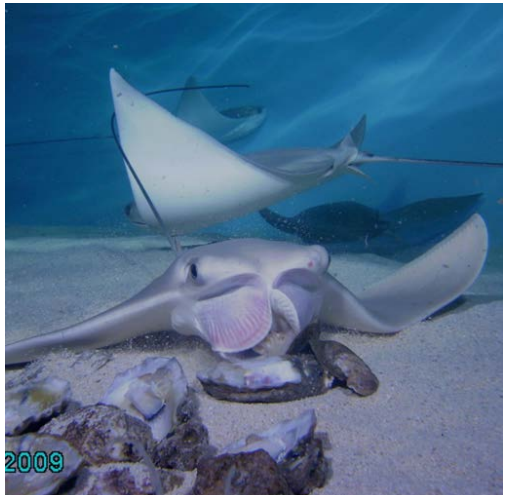


Kolmann et al. 2015 – Journal of Anatomy



(B) Probability of predations and peak load of *C. virginica* and as a function of shell depth.

Fisher, R.A., G.C. Call, R.D. Grubbs. 2011. J. Shellfish Research 30(1): 187-196.



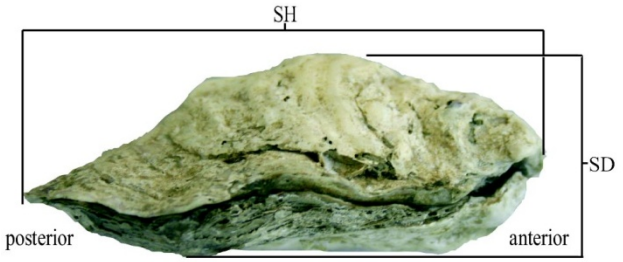
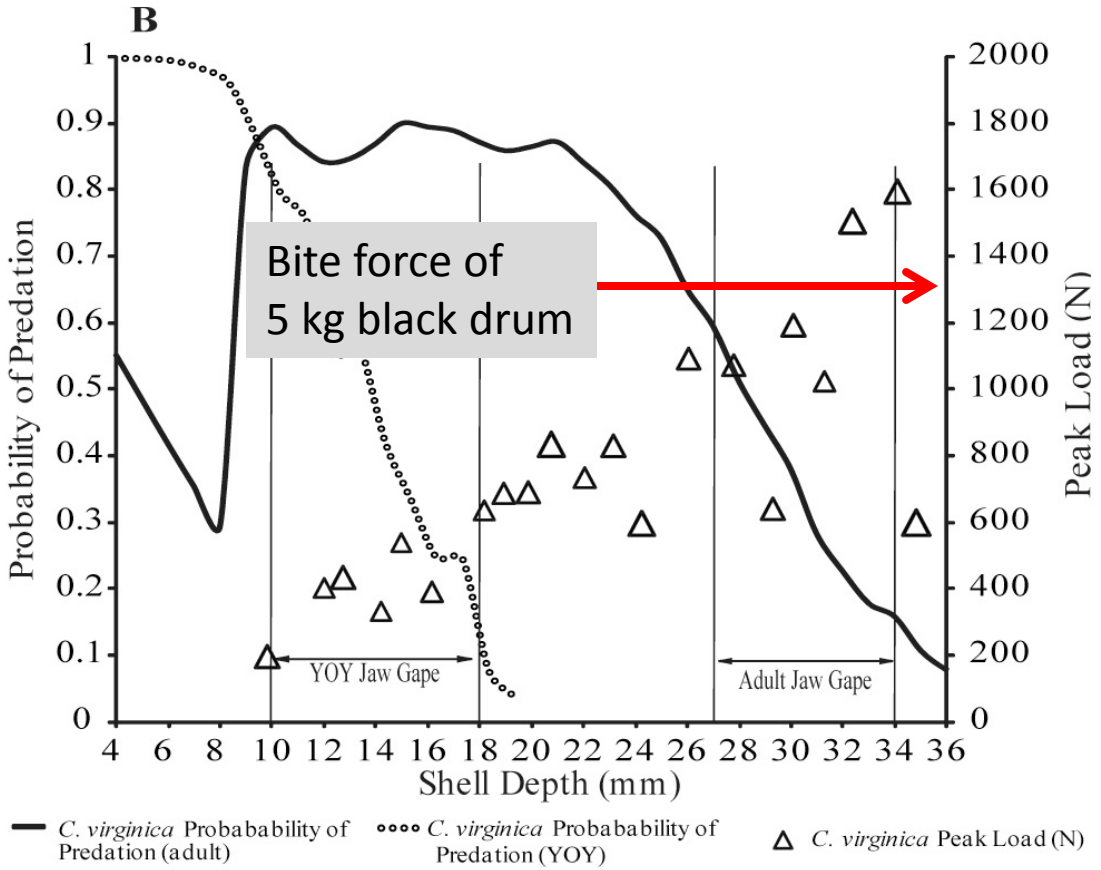


Table 3 Descriptive statistics for bite force scenarios in *Rhinoptera bonasus*.

Muscle division	Medial (N)	Lateral (N)
Class 3 without fibrocartilage	144.0 ± 0.09 25.3–336.1	146.9 ± 0.03 25.3–362.1
Class 3 with fibrocartilage	194.8 ± 0.64 25.3–480.2	199.8 ± 0.65 25.3–520.2
Measured bite force	201.7 ± 0.24 50.8–561.1	

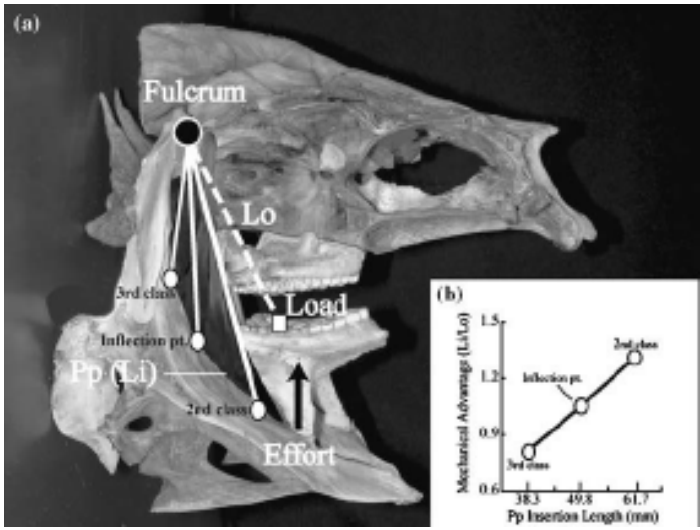
Values are the mean ± SEM. Range from smallest individual to largest.

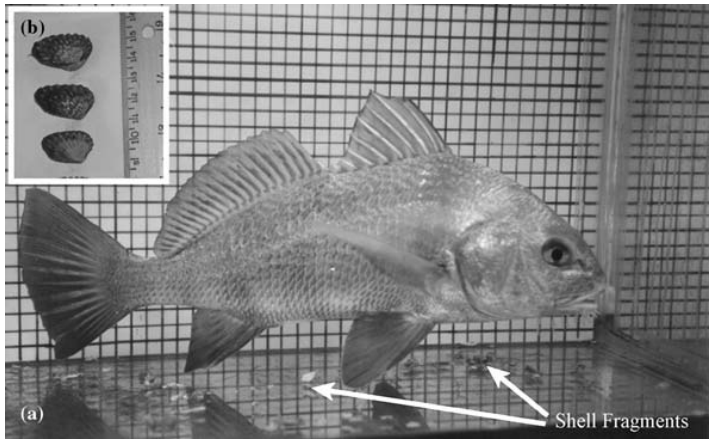
Kolmann et al. 2015 – Journal of Anatomy



Black drum maximum bite force:

~1,300 N at 5 kg
>11,000 N at largest size





Environmental Biology of Fishes (2005) 74:261–272
DOI 10.1007/s10641-005-3218-0

Disparity between feeding performance and predicted muscle strength in the pharyngeal musculature of black drum, *Pogonias cromis* (Sciaenidae)

Justin R. Grubich[a,b]
[a]*Department of Biological Science, Florida State University, Tallahassee, Florida 32306, USA*
[b]*Division of Fishes, Department of Zoology, The Field Museum of Natural History, 1400 S. Lakeshore Dr., Chicago, Illinois 60605, USA (e-mail: jgrubich@fmnh.org)*

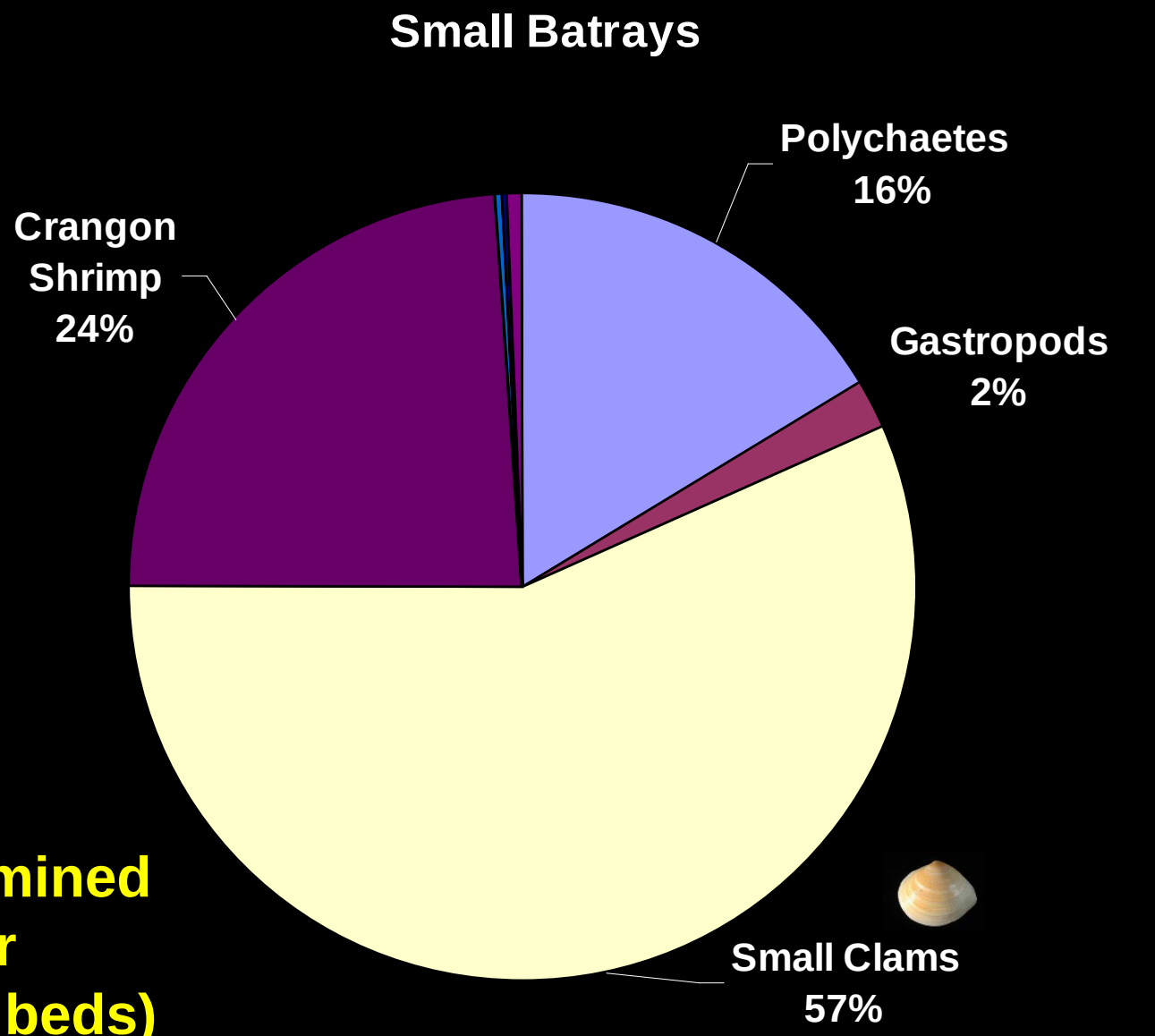
Grubich 2005 – Env. Biol. Of Fishes

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).”

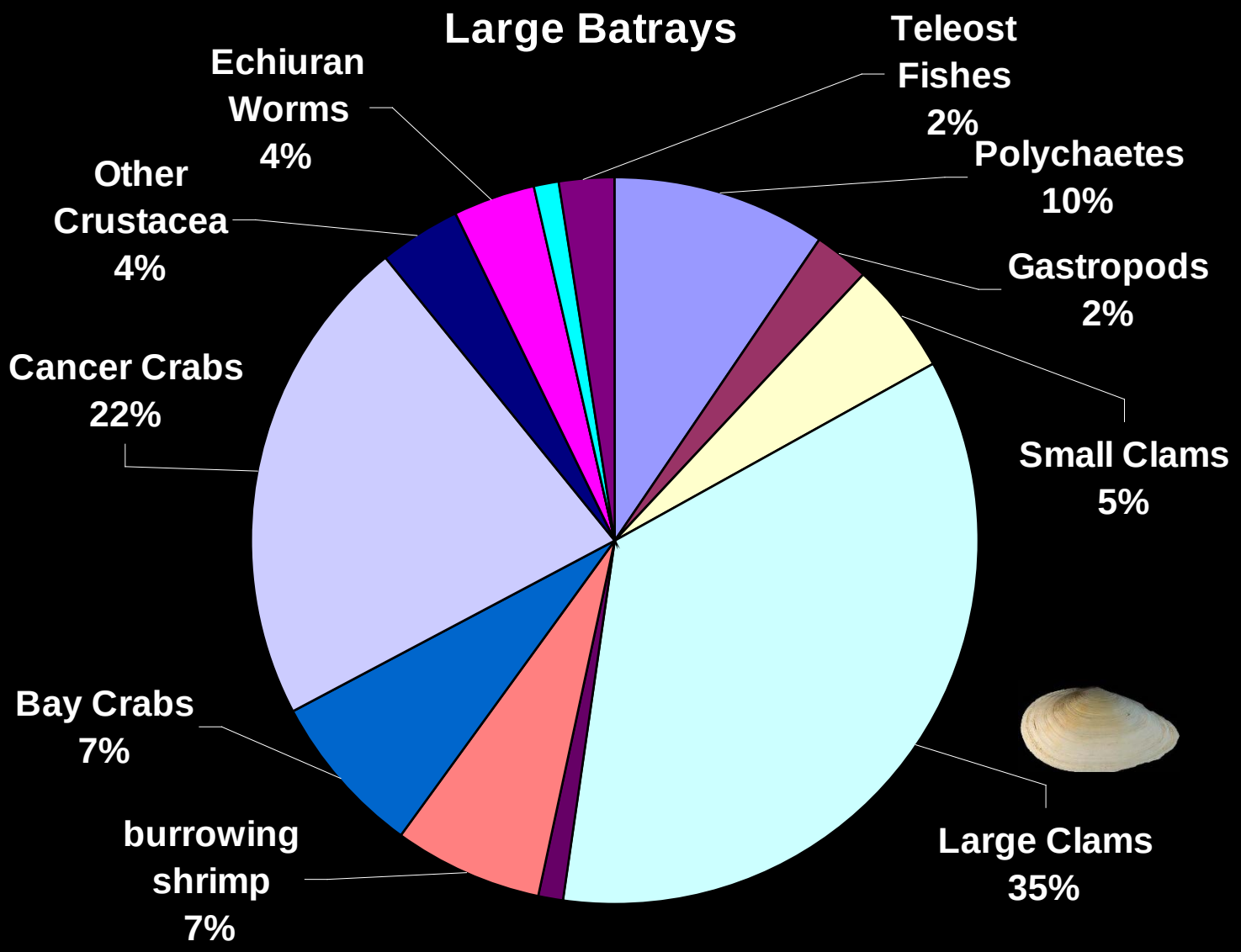
From Gray et al. 1997

Gray et al. 1997



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

93% contained prey



“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