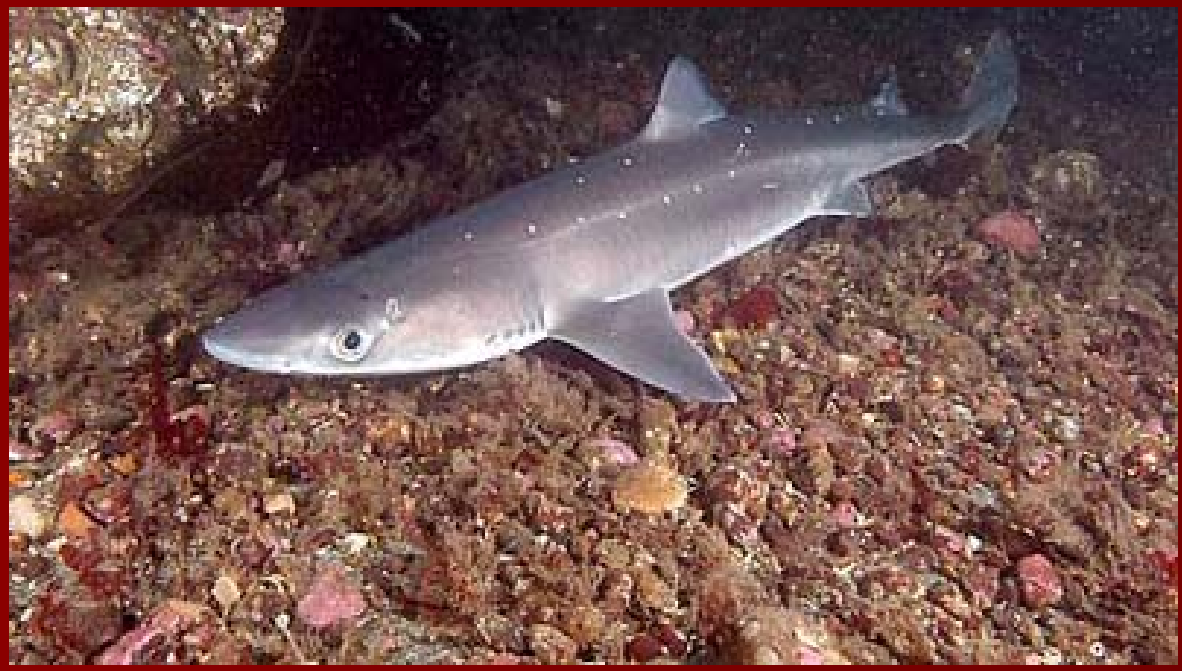
The NEUS Ctenophore-Dogfish Story



Jason Link, Mike Ford, Beth Fulton

NEUS Ctenophores & Dogfish

1. Can it be? That many more?
2. A unique sampling device
3. Implications for the sampler- dogfish energetics
4. Implications for the sampled- Ctenophora bounds on abundance estimates
5. Implications for overall ecosystem dynamics

Gelatinous ZP Explosions

- Many other systems have exhibited gelatinous zooplankton blooms, outbreaks, explosions, etc.
  - Some specifically and singularly Ctenophora
- Causality- usually attributed to eutrophication, water mass change, or overfishing induced predator release
- Most often noted in more enclosed or semi-enclosed marine systems (seas vs. open ocean)

Gelatinous ZP Sampling

- Difficult to sample
- Synoptically
  - Spatial extent- entire continental shelves
  - Temporal extent- decades
- One unique sampling device- fish stomachs
  - Spiny dogfish, *Squalus acanthias*

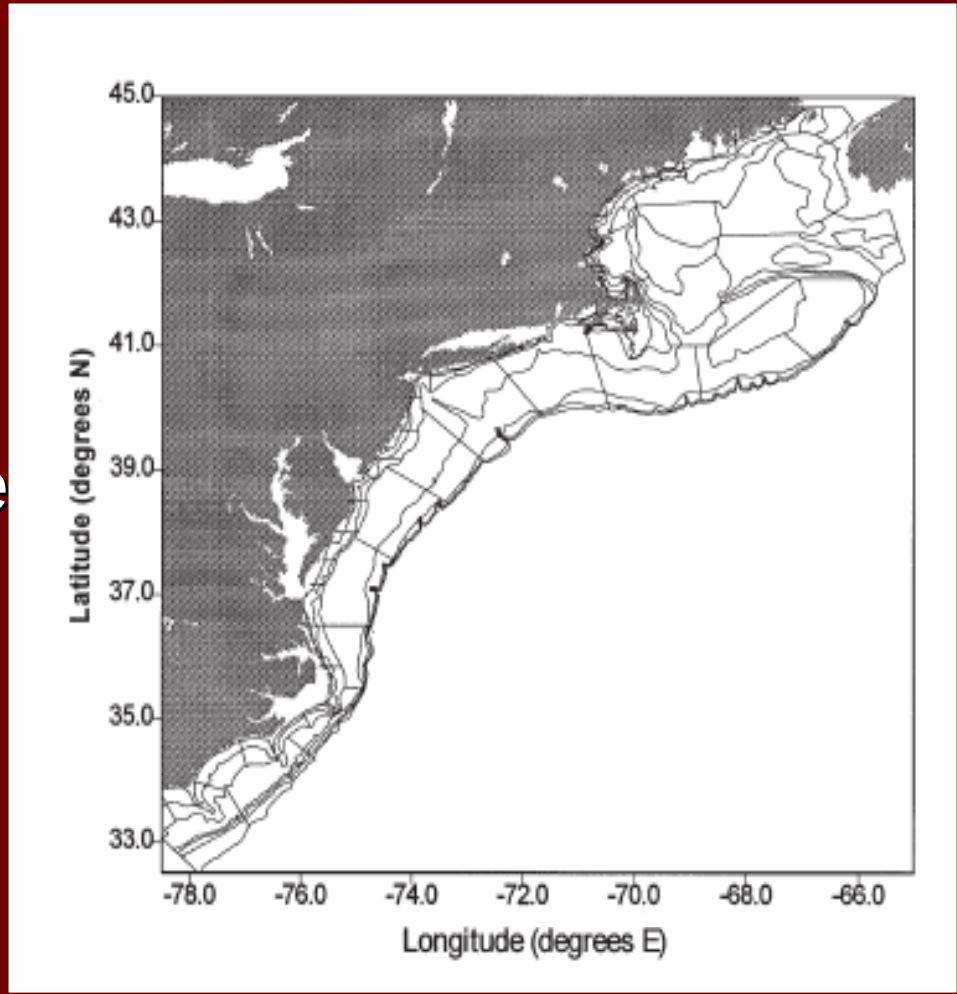
Spiny Dogfish as Samplers

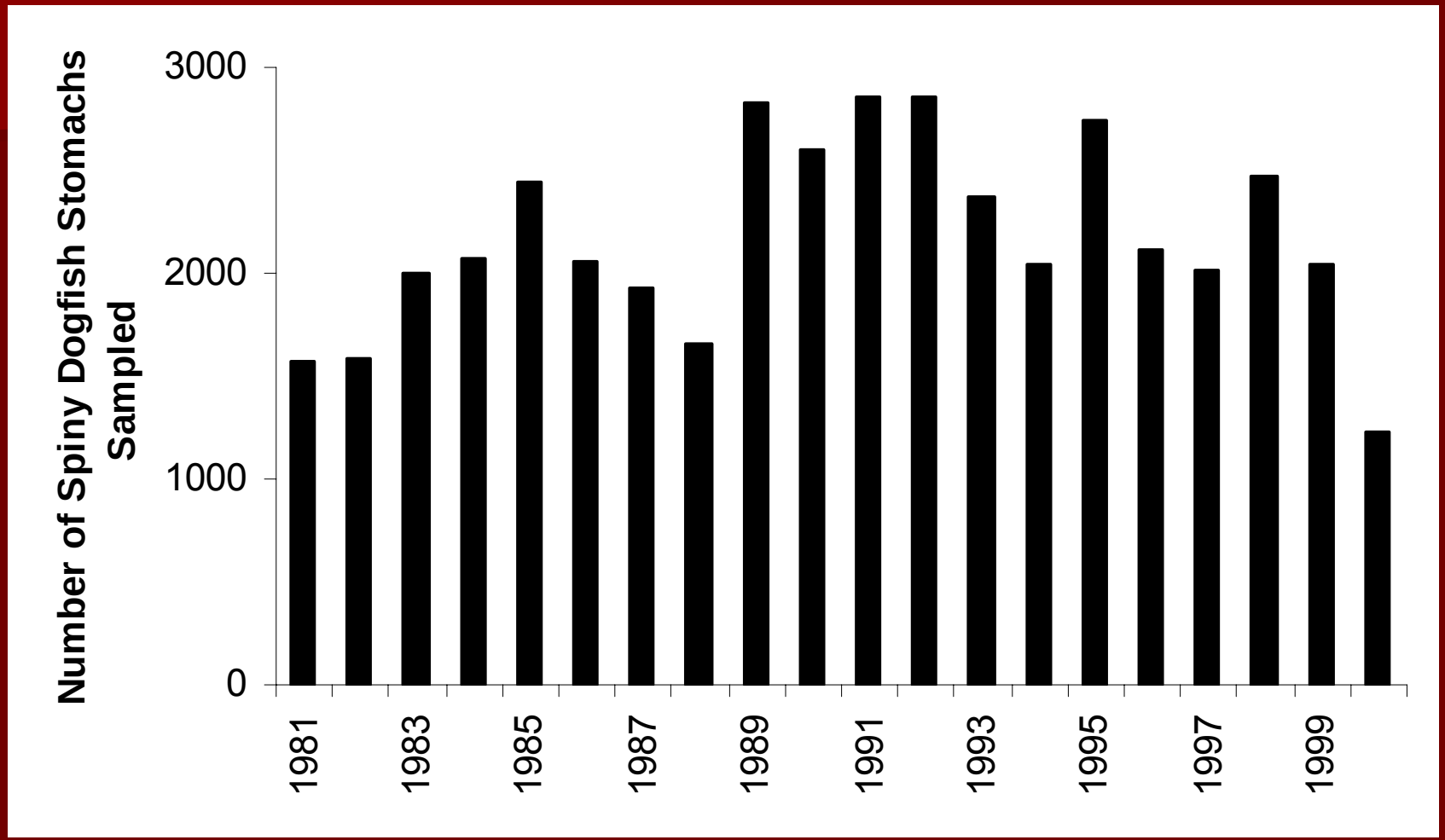
- > 43,000 dogfish stomachs
- > 1,000 stomachs per year, usually > 2,000
- Examined at-sea
  - volume (0.1cc)
  - composition (%)
  - numbers

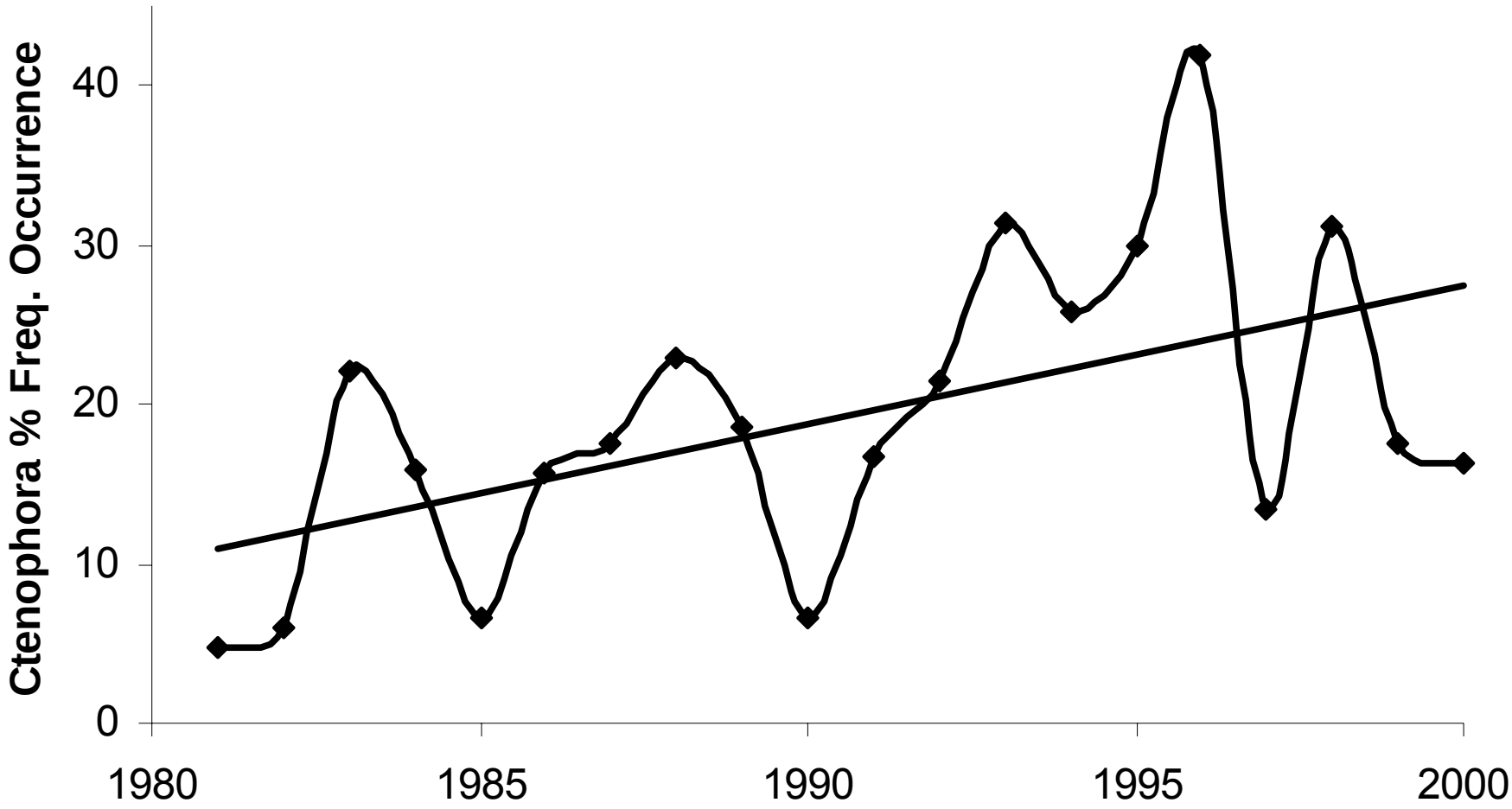
- Ctenophores observed likely *Mnemiopsis leidyi, Pleurobrachia pileus, Bolinopsis infundibulum* or some combination thereof
  - method precludes species identification

Spiny Dogfish Sampling Domain

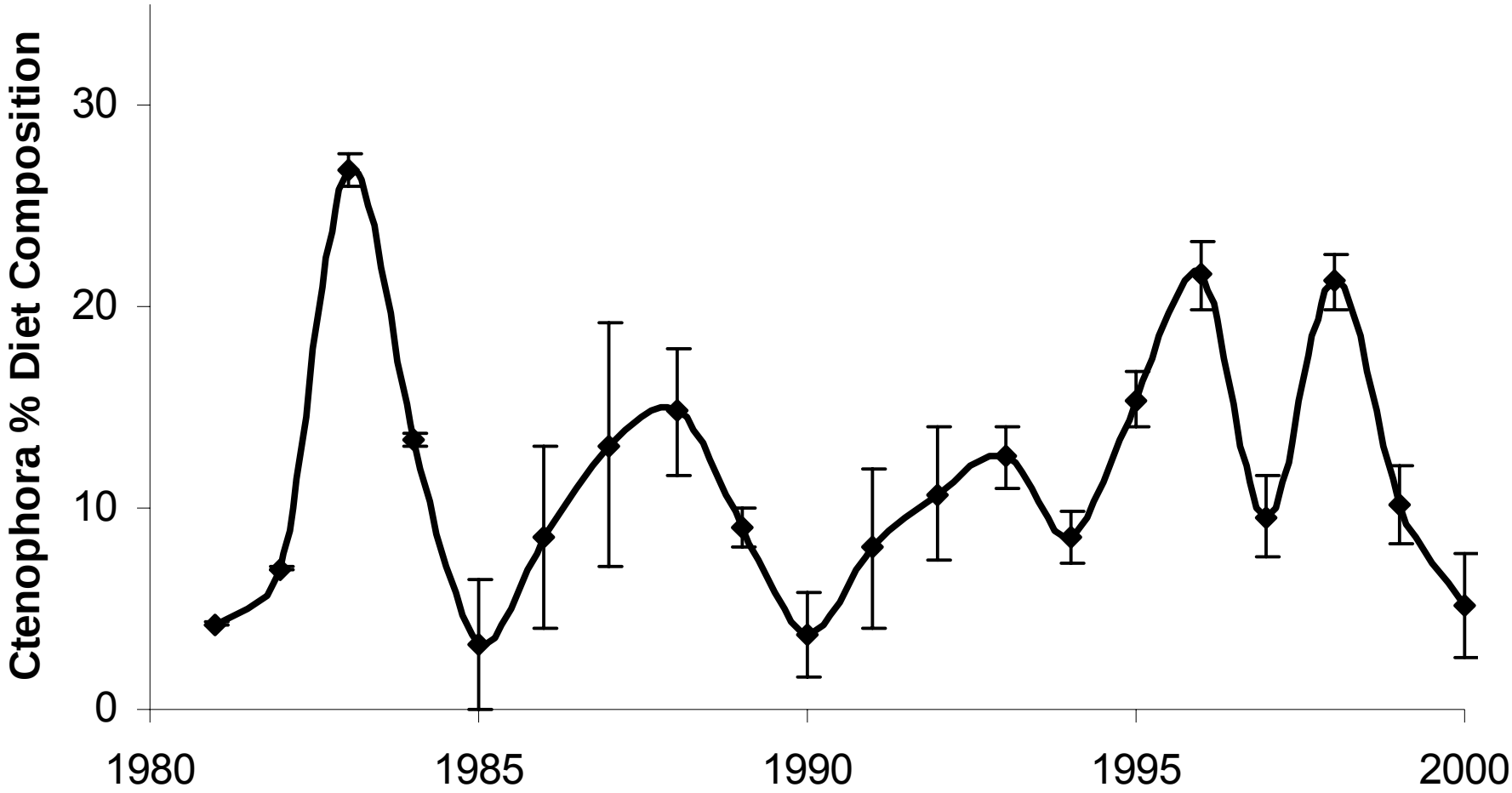
- 290,000 km^2
- Stratified random design
  ~ 1 station per 690 km^2
  ~ 27 m – 366 m
  ≥ 2 cruises yr^{-1}
  ~300-350 stations per cruise
- #36 Yankee bottom trawl
- 6.5 km h^{-1}, 30 min
- Stomachs from 1973–now
- Focus on 1981 – 2000



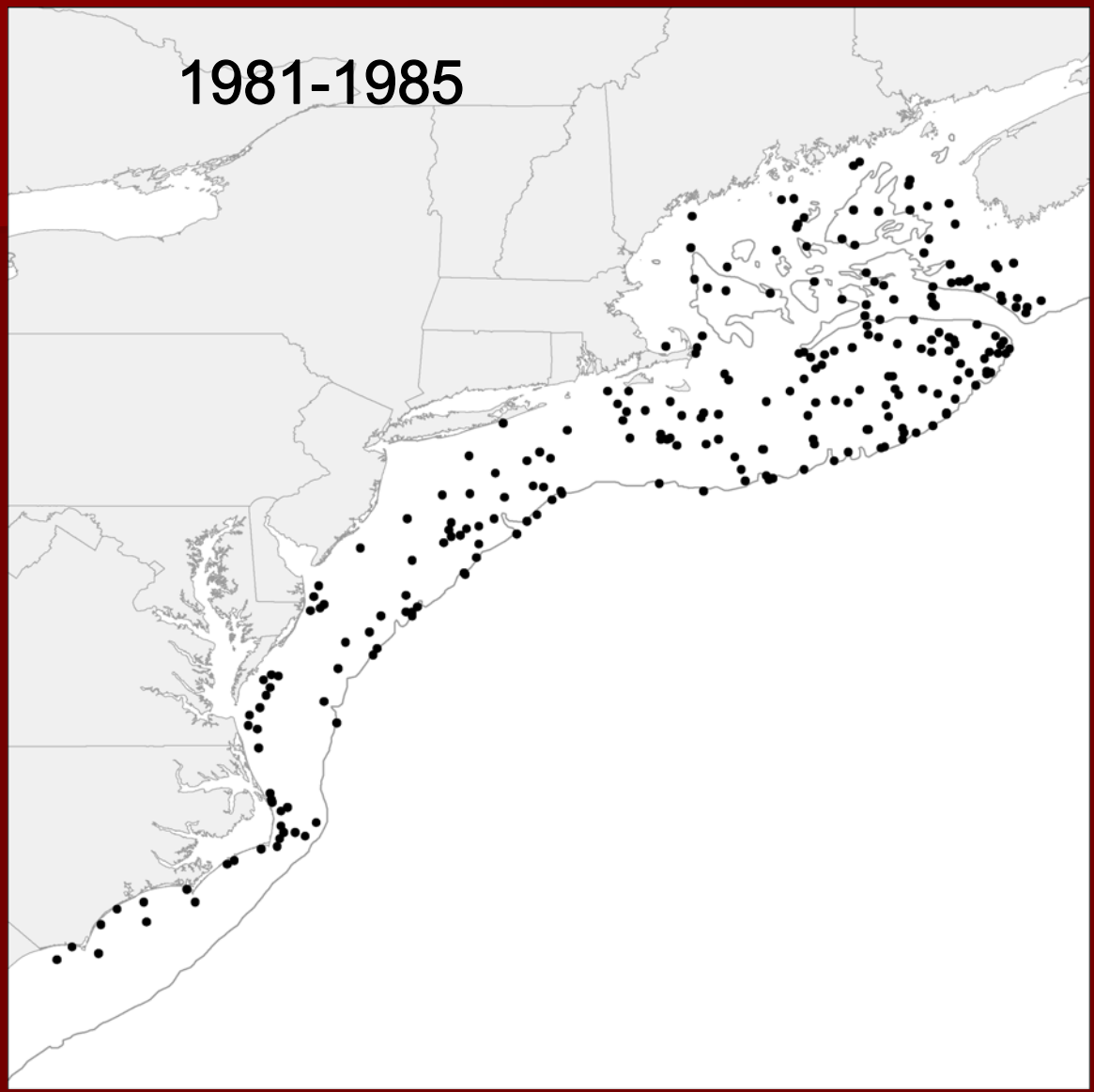

Number of Spiny Dogfish Stomachs Sampled
3000
2000
1000
0
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999

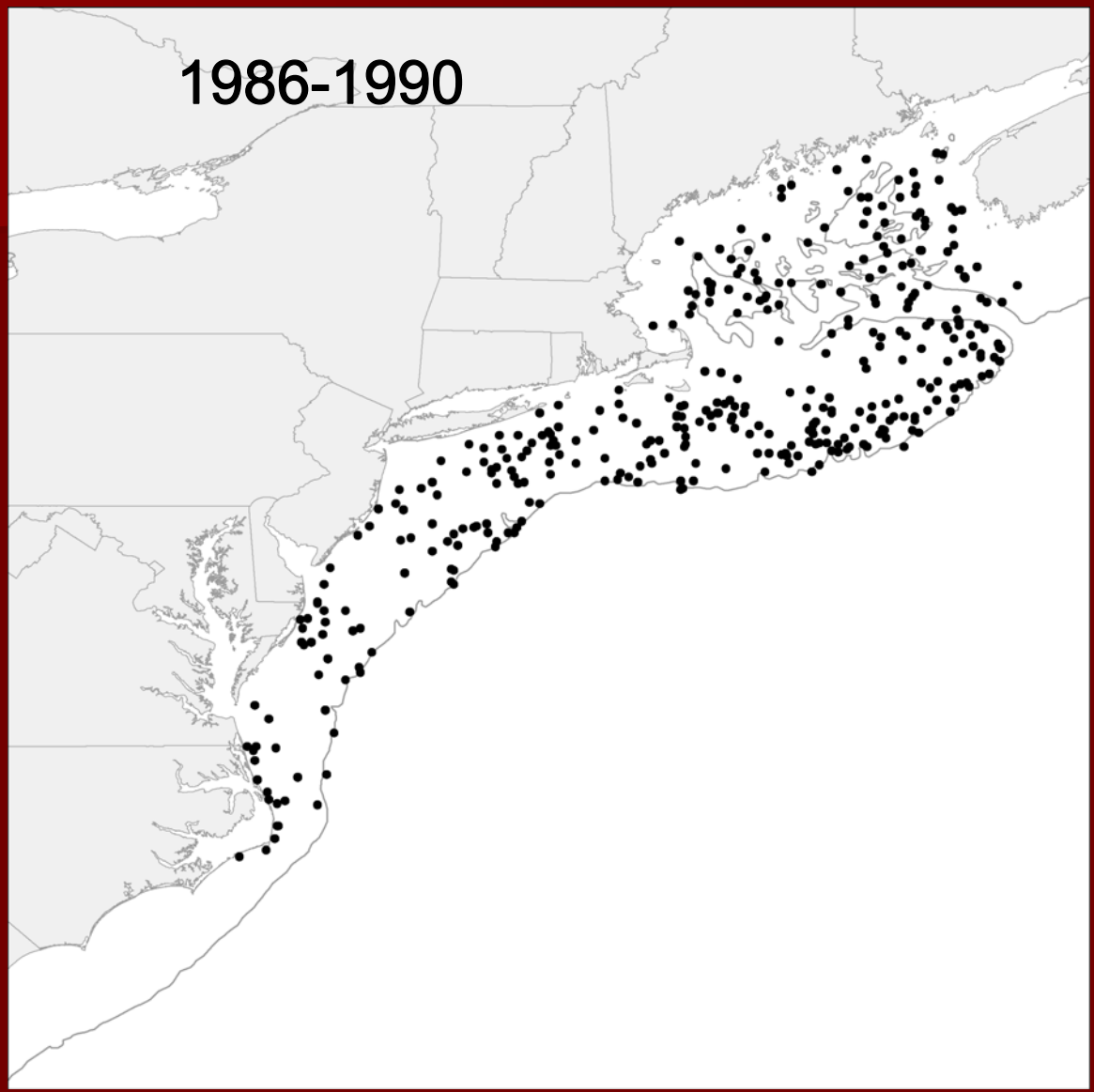


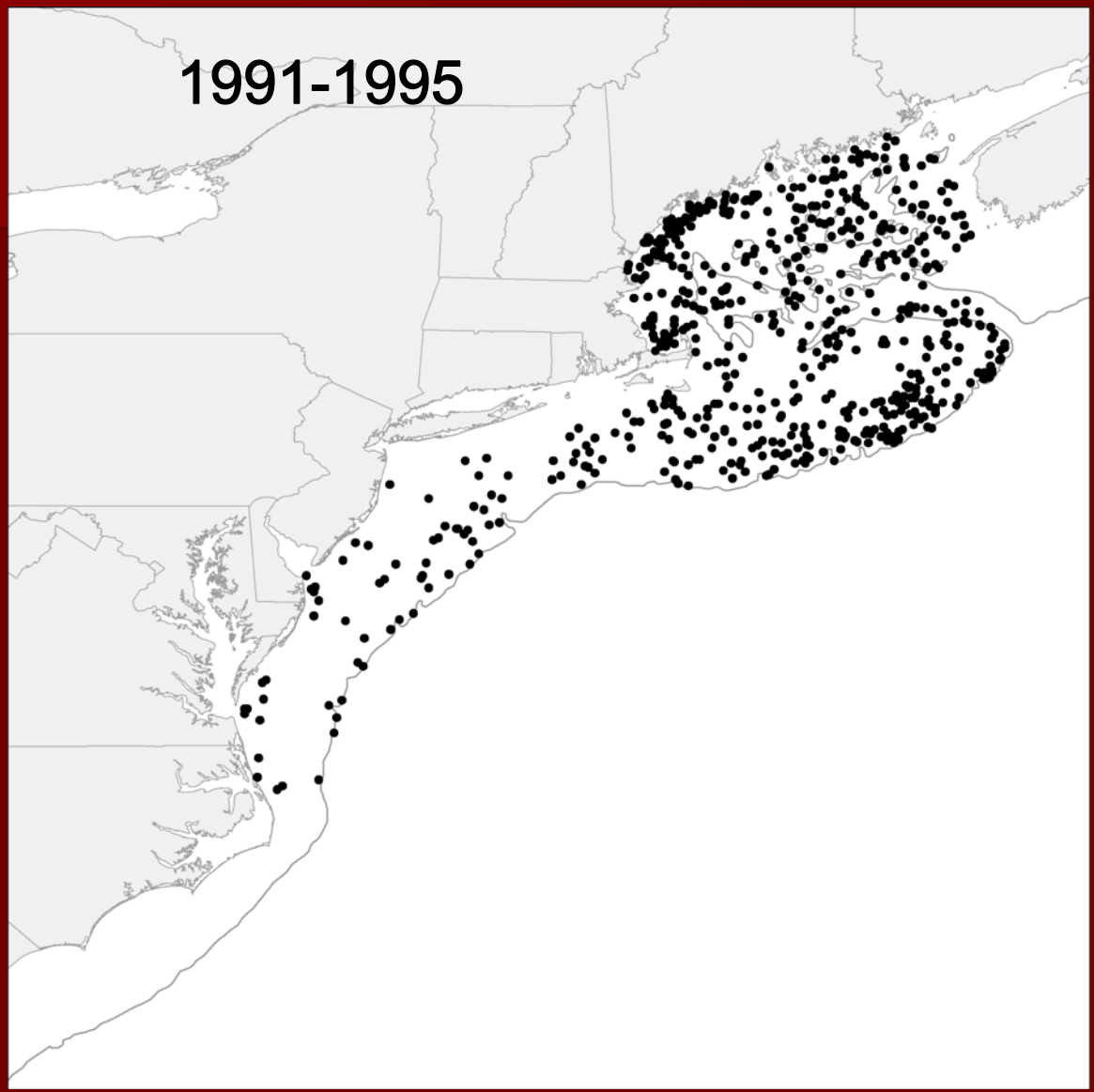
4-8 x more frequent now

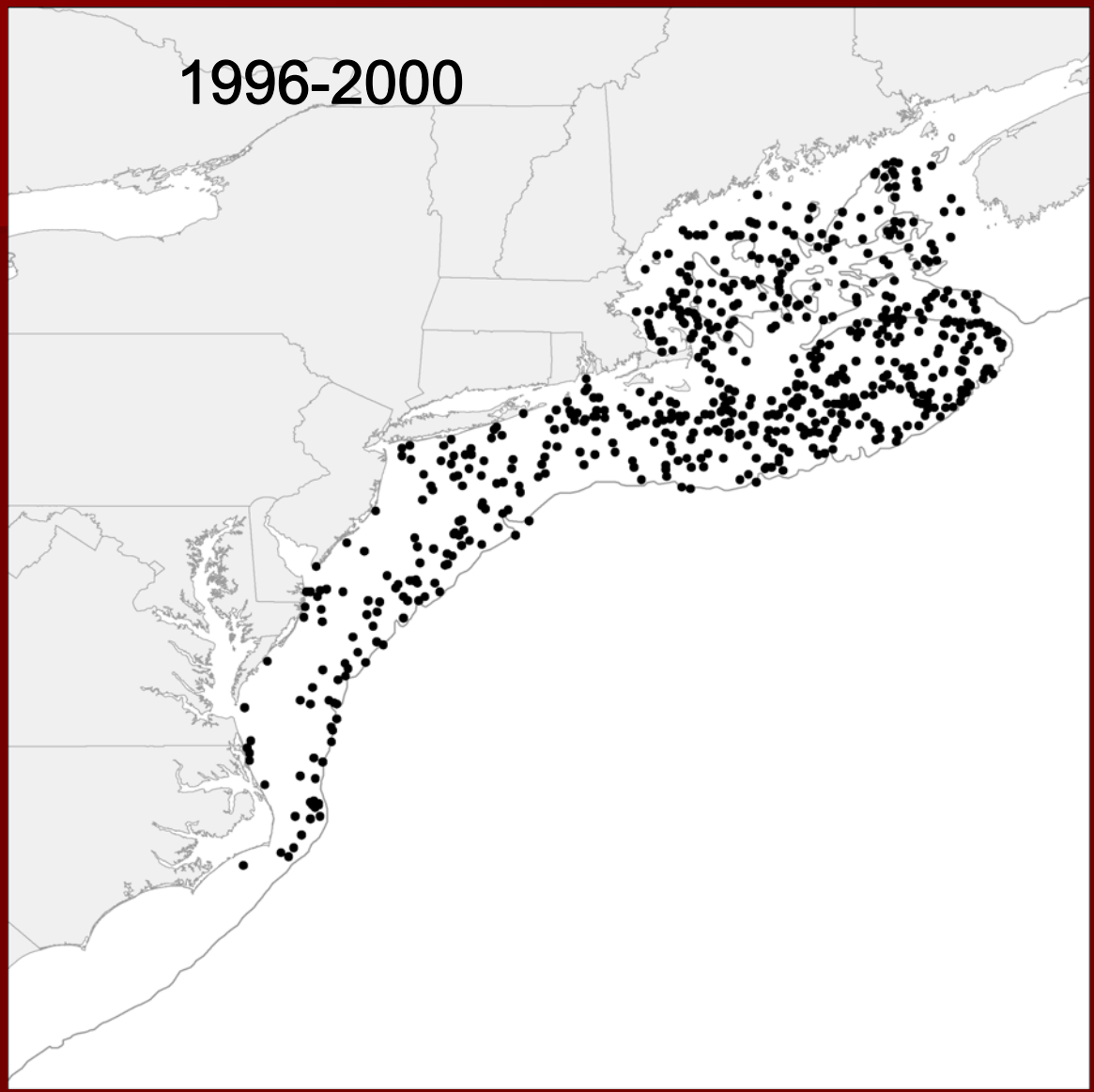

Ctenophora % Diet Composition
30
20
10
0
1980
1985
1990
1995
2000

Avg: 11.5 %


1981-1985


1986-1990


1991-1995

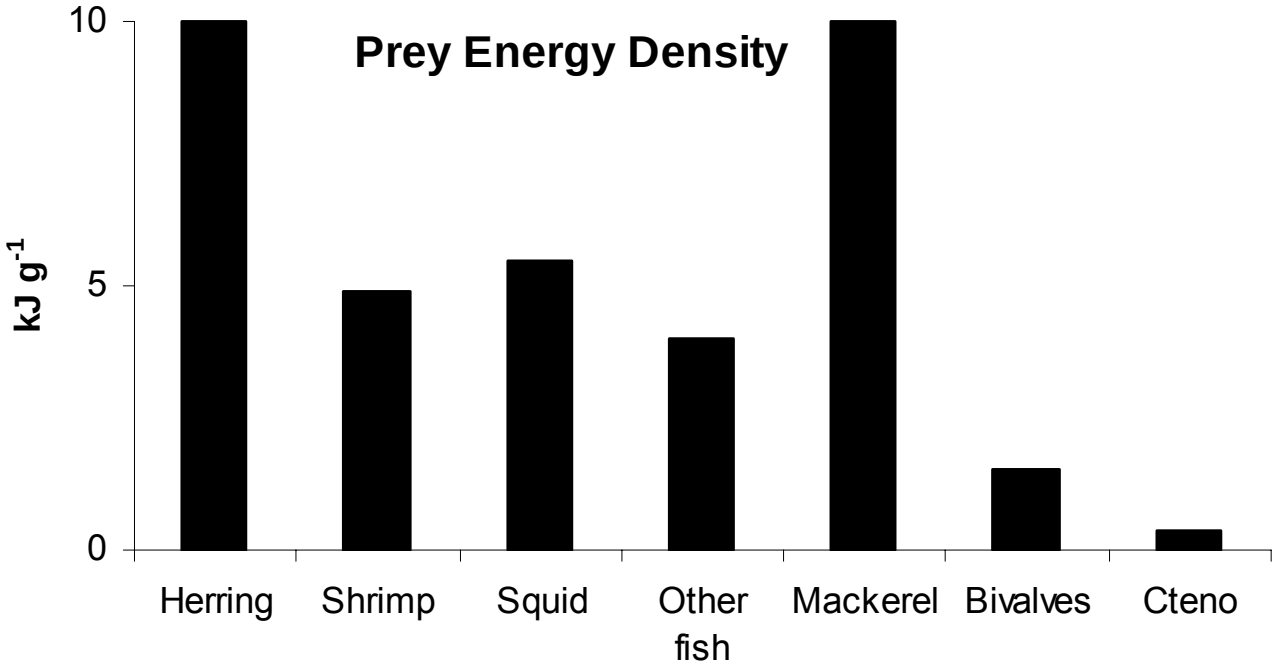

1996-2000

Sampling Observations

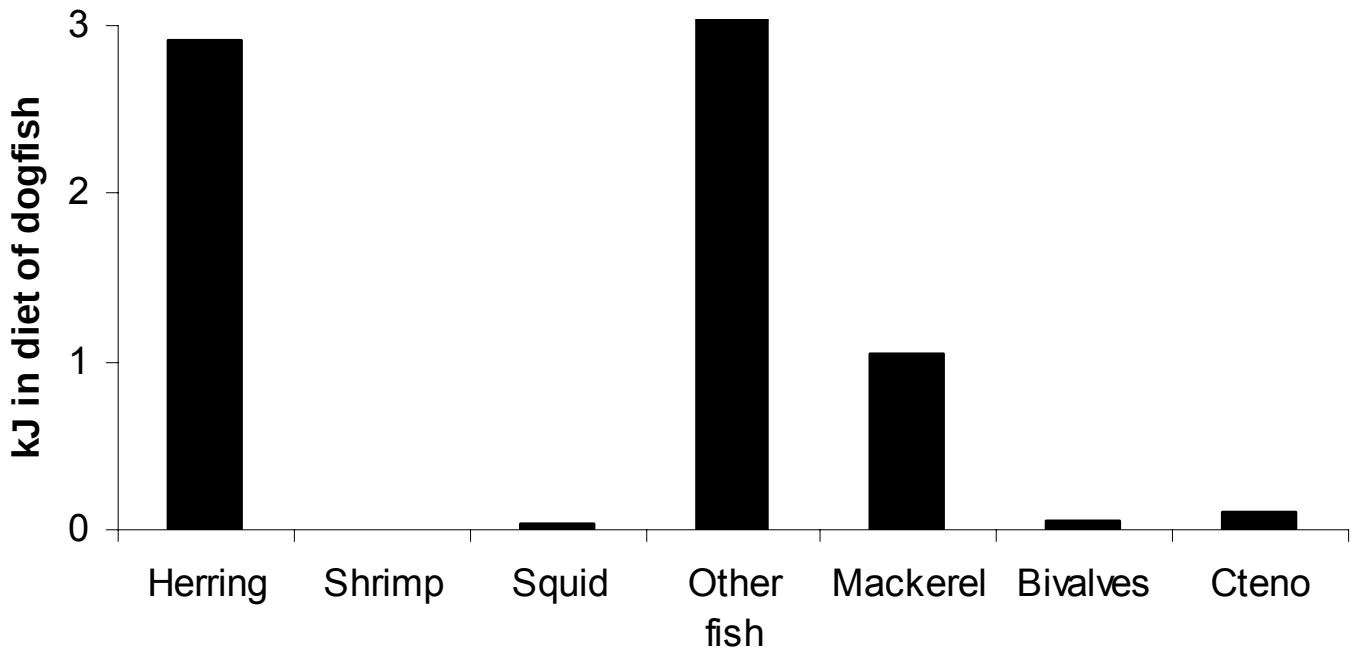
- Occurrence of Ctenophores has increased
- Distribution of Ctenophores has expanded
- Such an increase at the scale of an entire large marine ecosystem and for more than two decades has not been previously documented
- Of all possible alternatives, the explanation of increased ctenophore abundance is the one that is most logical given the available evidence

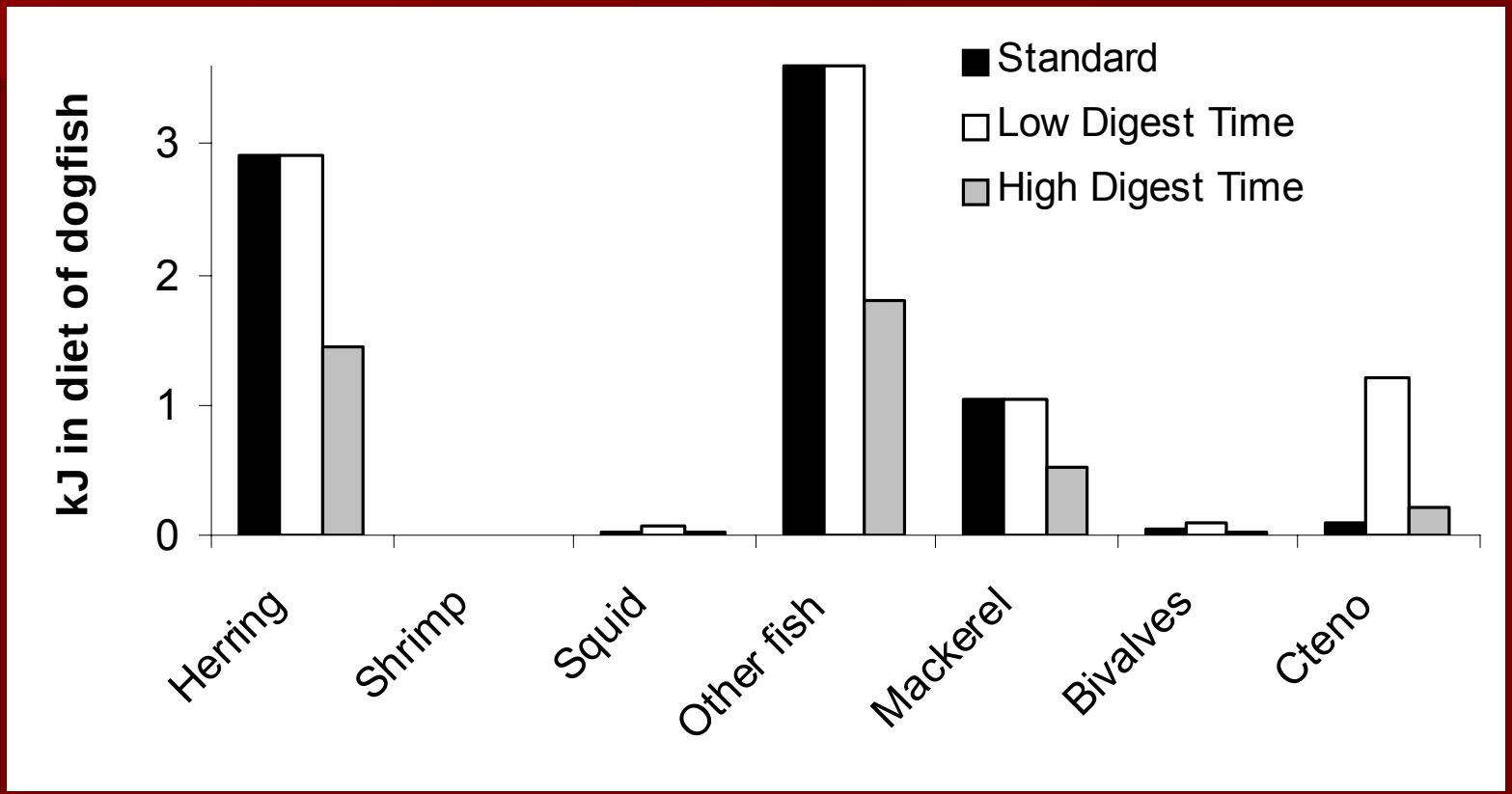
Energetic Implications for Dogfish

- Literature values of prey energy density
- Scaled by diet composition (here, avg value)
- Examined as a function of variable digestion times – consumption rates



Scaled by diet composition





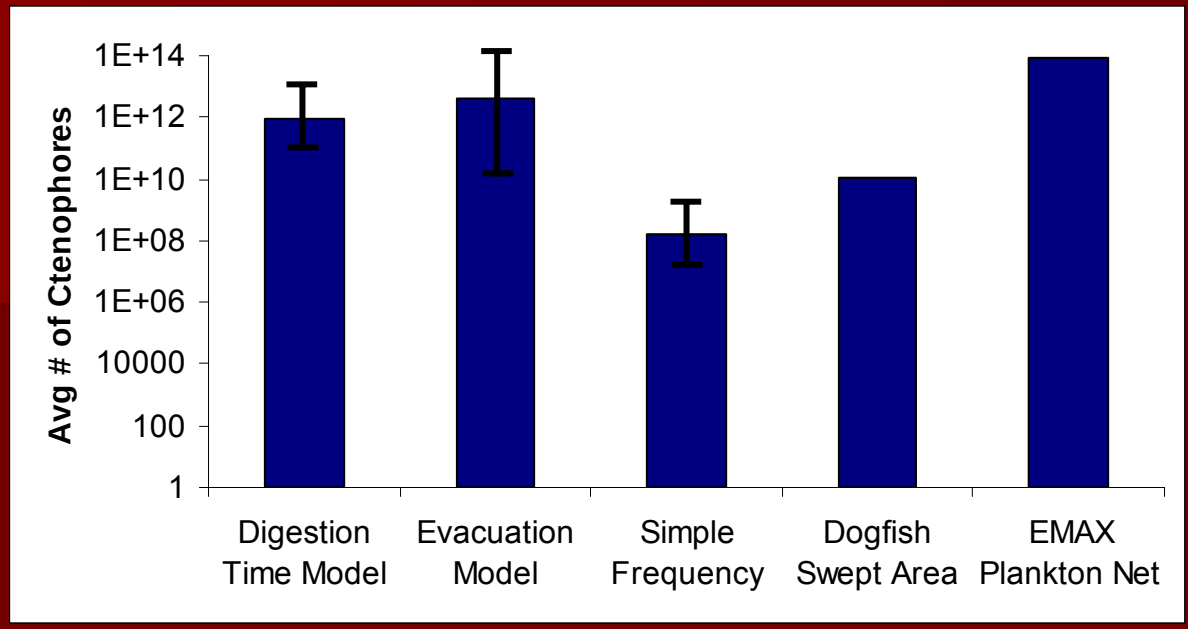
As a function of digestion time

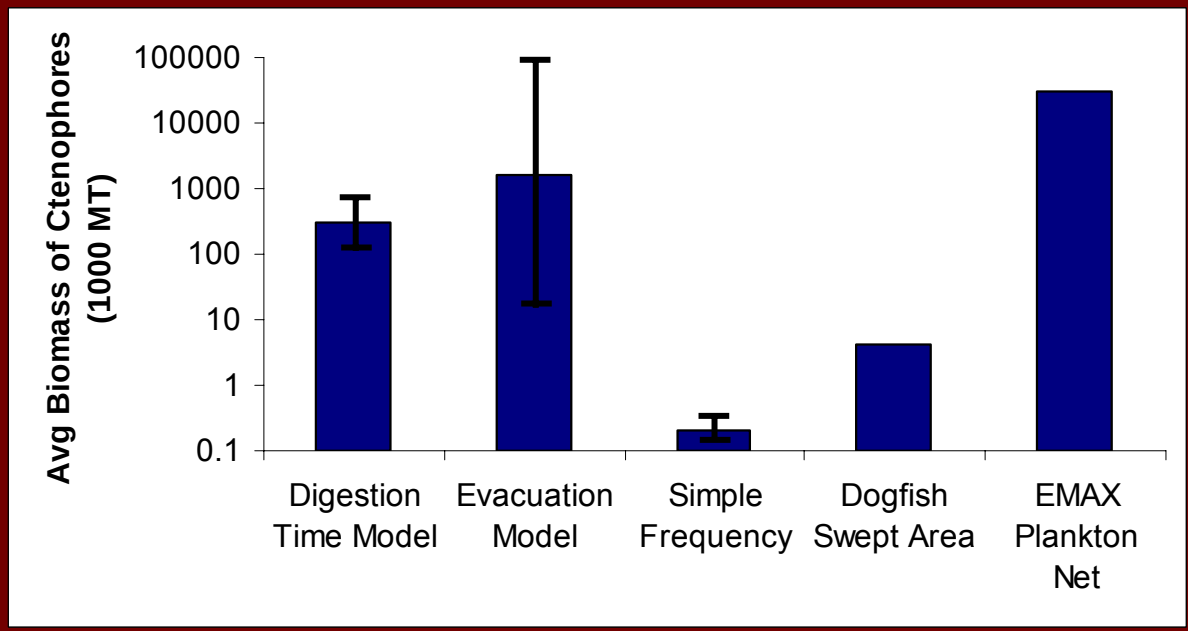
Energetic Implications for Dogfish

- Ctenophores have a low energy density relative to other spiny dogfish prey
- Scaling by % Diet Composition still emphasizes small pelagic fishes as most energetically important prey for spiny dogfish
- Faster digestion times can increase the energetic importance of Ctenophores in dogfish, but they are still a less energetically important prey than small pelagic fishes
- Based upon what we know of dogfish swimming and feeding behavior, it is likely that Ctenophores are an ambient prey item – a maintenance food for dogfish

So how many Ctenos are there?

- We explored 5 approaches to estimate Ctenophore abundance in the NEUS
  - Digestion Method
  - Consumption Model
  - Frequency per Dogfish Numbers Method
  - Swept Area of Dogfish Method
  - EMAX Plankton Net Method
- (Most) provided mean, min & max estimates
- Simple estimates and sensitivities of Ctenophore N & B


Avg # of Ctenophores
1E+14
1E+12
1E+10
1E+08
1E+06
10000
100
1
Digestion Time Model
Evacuation Model
Simple Frequency
Dogfish Swept Area
EMAX Plankton Net

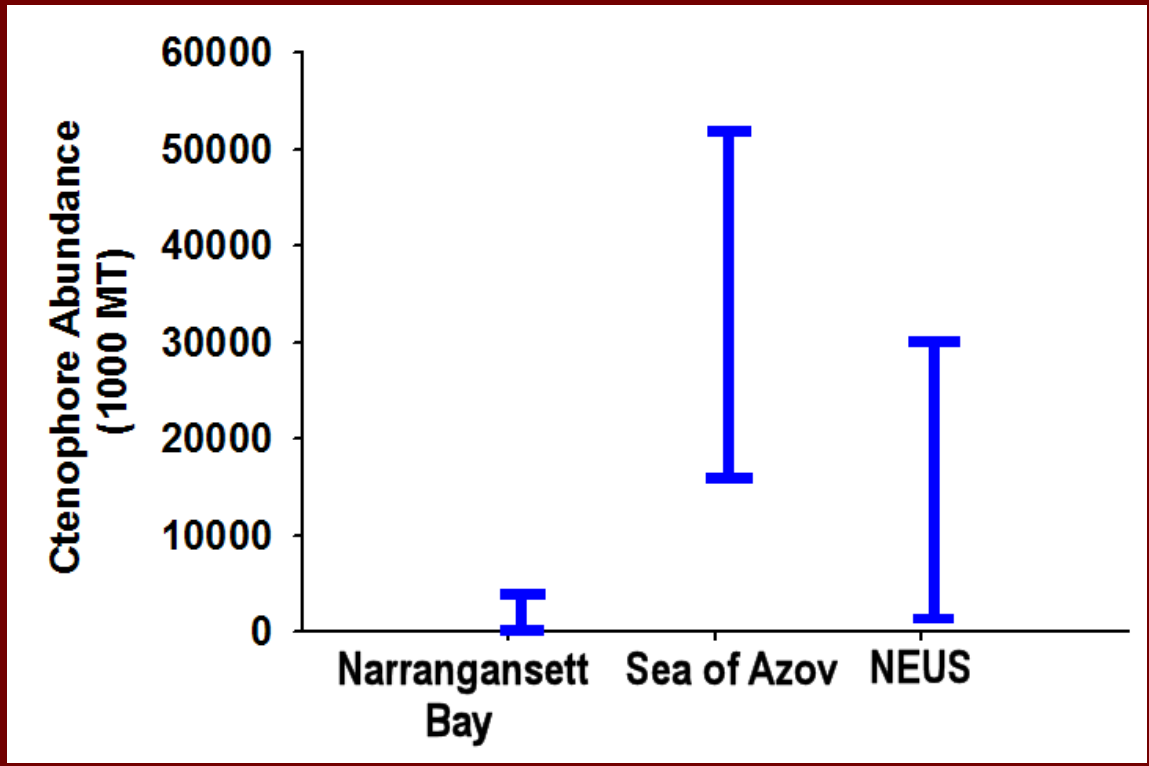

Avg Biomass of Ctenophores (1000 MT)
100000
10000
1000
100
10
1
0.1
Digestion Time Model
Evacuation Model
Simple Frequency
Dogfish Swept Area
EMAX Plankton Net

Bounding Ctenophore N & B

- Range of estimates from various methods spans 6 orders of magnitude
- Abundance of Ctenophores ranges between 10^8 and 10^{13}
- Biomass of Ctenophores between 500 and 30,000,000 Metric Tons
  - For context, most targeted fisheries landings are on the order of 5-40 MT

Bounding Ctenophore B

- Really THAT much?
- Other systems have reported similar levels of abundance after Ctenophora outbreaks



Ecosystem Implications

- A major and sustained increase in Ctenophores can have large ecosystem effects
  - Competition with commercial fish
  - Predation on commercial fish (larvae)
  - Negative feedback loop with major perturbations
- Bounding exercises like this can help
- Yet we need more directed information on gelatinous ZP abundance