

# TROPHIC TRANSFER OF THE MARINE ALGAL BIOTOXIN DOMOIC ACID TO THE NORTH ATLANTIC RIGHT WHALE, *EUBALAENA GLACIALIS*



Photo: New England Aquarium

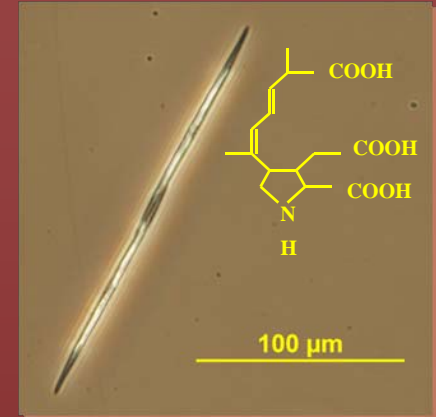
**L.F. Leandro**

Grice Marine Lab, College of Charleston  
NOAA/NOS, Marine Biotoxins Program

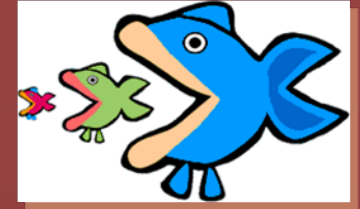


# Domoic acid

- Potent neurotoxin produced by algal species of the genus *Pseudo-nitzschia*
- Exposure to domoic acid (DA) in humans leads to Amnesic Shellfish Poisoning (ASP)
  - Gastrointestinal (e.g., vomiting, diarrhea, nausea) and neurological (e.g., dizziness, disorientation, lethargy, seizures and permanent short term memory loss) problems



# DA poisoning events

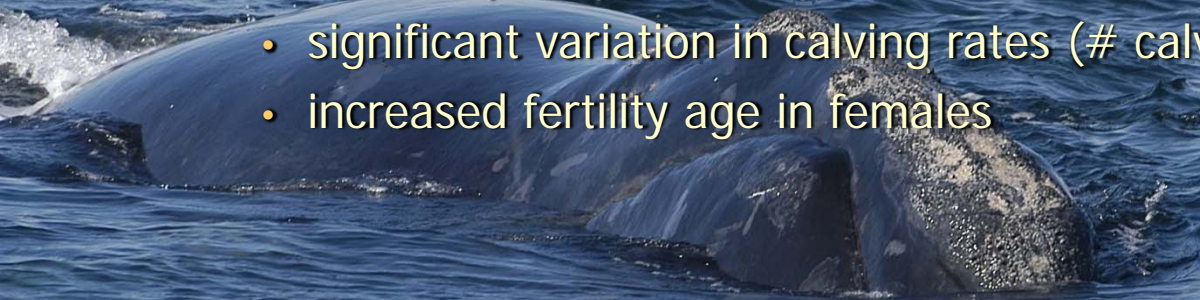


- Several marine bird and mammal mortality events
  - >145 pelicans and cormorants (Monterey Bay, California 1991)
  - Hundreds California sea lions and other marine mammal (Californian coast 1998, 2000, 2002...)
  - **Vector:** planktivorous fish species (anchovies and sardines)
- Blue and humpback whales exposed to DA (Monterey Bay, California 2000)
  - **Vector:** krill and planktivorous fish
- N. Atlantic right whales may also be exposed to DA...



# North Atlantic right whale (*Eubalaena glacialis*)

- N. Atlantic right whales are highly threatened (pop 350-400)
  - Human-caused mortality - ship collisions and entanglements
  - Reproductive dysfunction:
    - unusually longer calving intervals
    - significant variation in calving rates (# calves/year)
    - increased fertility age in females





# North Atlantic right whale (*Eubalaena glacialis*)

- Studies have shown that whales are exposed to Paralytic Shellfish Poisoning (PSP) toxins by ingesting contaminated copepods (*Calanus finmarchicus*)



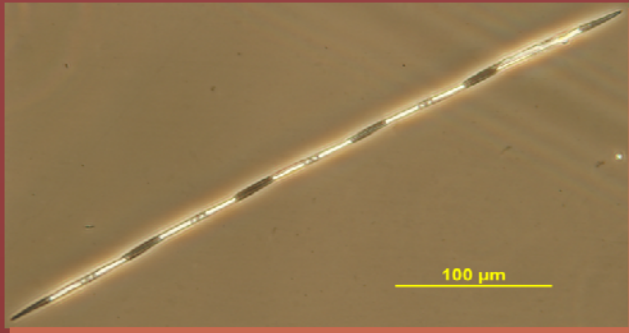
Copepod: *Calanus finmarchicus*



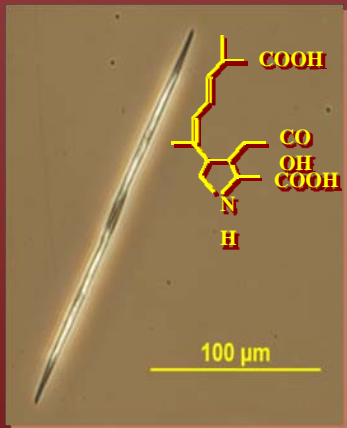
Photo: T. Verslycke



# The big picture

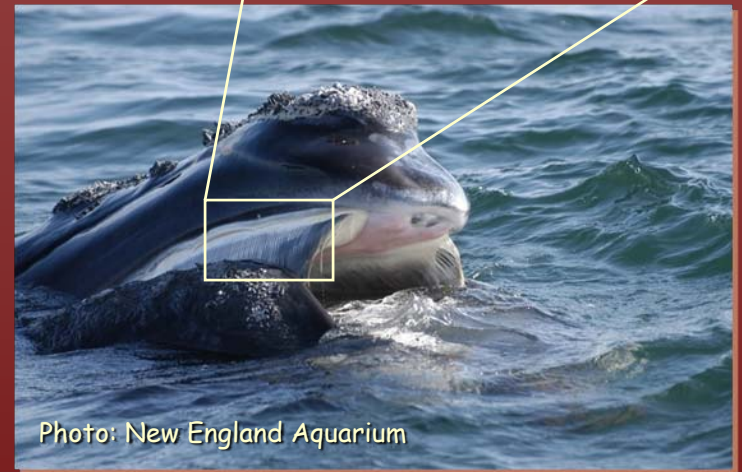


Toxic *Pseudo-nitzschia*



Toxic *Pseudo-nitzschia*

mesh size  
~ 335 µm



N. Atlantic right whale

**Vector**



copepod



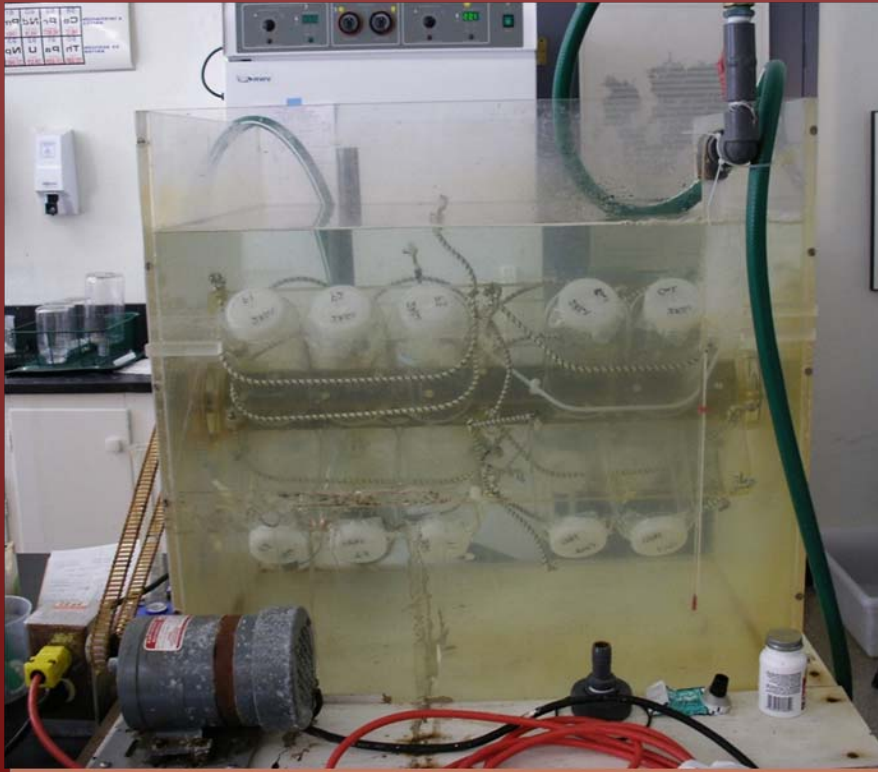


# Study objectives

1. Can copepods (*C. finmarchicus*) ingest DA-producing *Pseudo-nitzschia* and accumulate DA in their tissues?
2. Is DA present in N. Atlantic right whale feces and copepods collected in the field?
3. Are fragments of DA-producing algae and/or copepods present in right whale feces?

# Objective 1: Copepods and Domoic Acid

Feeding experiments: Copepods exposed to toxic and non-toxic algae



copepods exposed to toxic algae

DA accumulation experiments

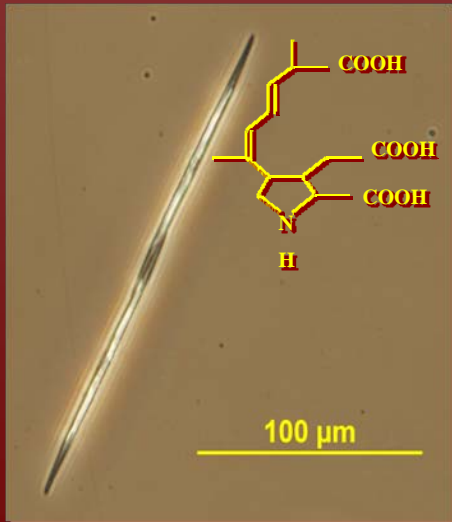


copepods placed in filtered seawater without algae



# Objective 1: Results and conclusion

- Grazing experiments
  - Copepods consumed DA-producing *Pseudo-nitzschia*
  - Copepods consumed equal amounts of both toxic and non-toxic algae
- DA accumulation experiments
  - Copepods accumulated DA and retained toxin in their tissues at least 48 h post removal of toxic source



toxic *Pseudo-nitzschia*



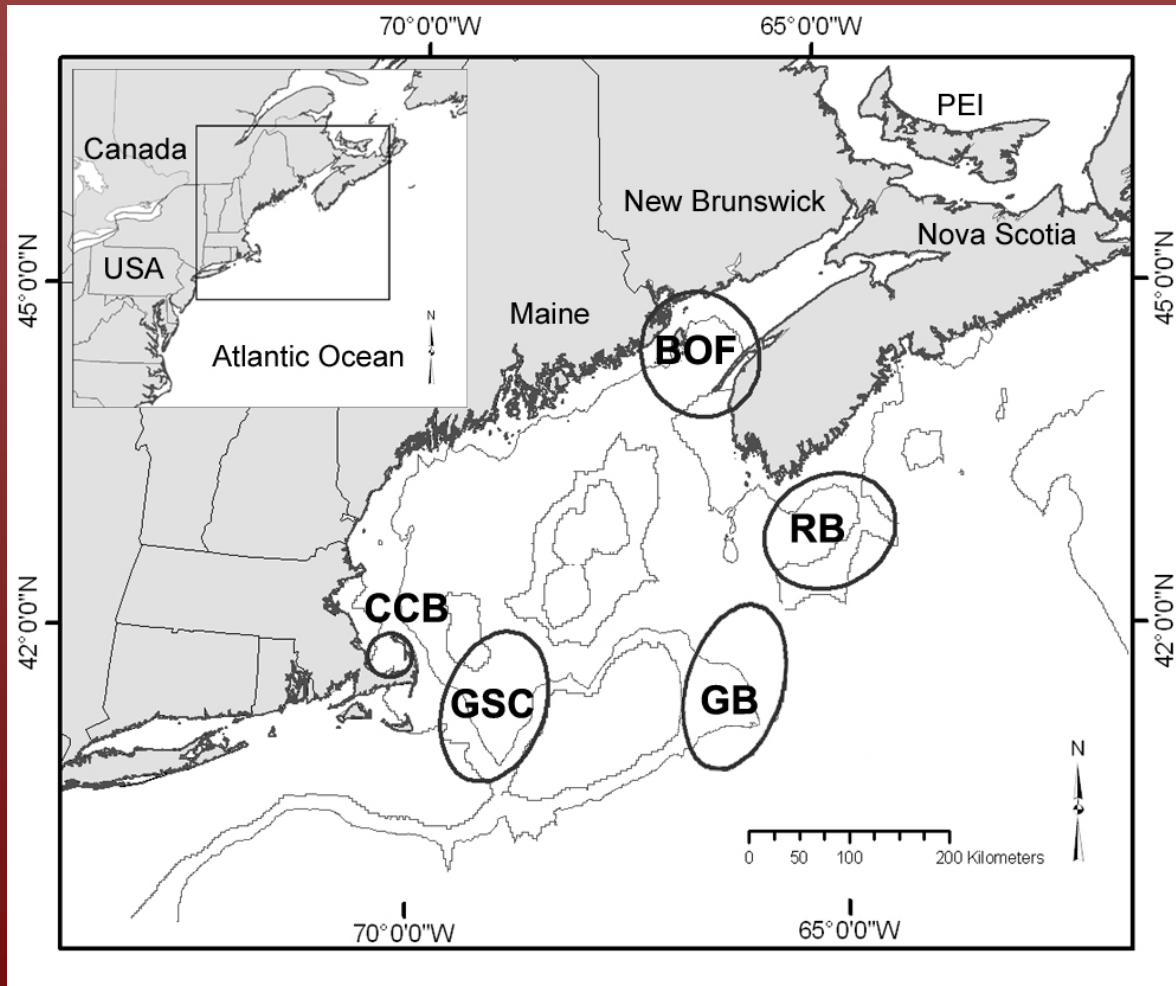
*C. finmarchicus*

# Study objectives

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# Objective 2: Sampling locations



## Sample type collections (April-Sept: 2005, 2006)

- Right whale feces
- Zooplankton
- Phytoplankton

## Legend

- BOF: Bay of Fundy
- RB: Roseway Basin
- GB: Georges Bank
- GSC: Great South Channel
- CCB: Cape Cod Bay

# Objective 2: Fecal sample collection in search of whale poop...

Fargo-the scat  
detecting dog!

- Fecal samples provided by Dr. R. Rolland's group (NEA, Boston, MA)



fecal samples  
scooped out with  
a net





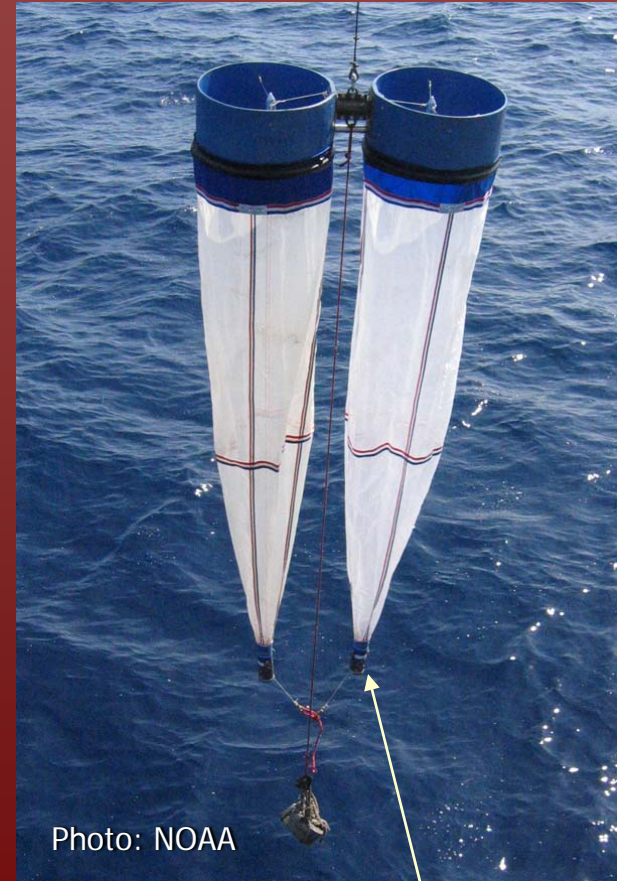
# Objective 2: plankton collection

Looking for DA-producing algae in proximity to whales



Phytoplankton net

Searching for copepods near feeding whales



Zooplankton (Bongo) net

# Objective 2: Results and conclusion

- Copepods: all samples contained DA; 0.02-0.18  $\mu\text{g}$  DA/g (n=32)
  - *C. finmarchicus* possible vector for DA transfer into right whales
- Whale feces: 69 of 70 samples contained DA; 0.02-0.61  $\mu\text{g}$  DA/g
  - Right whales exposed to DA for periods of up to several months

sea lion feces (1998): 1.31-182  $\mu\text{g}$  DA/g (Scholin et al. 2000)

# Study objectives

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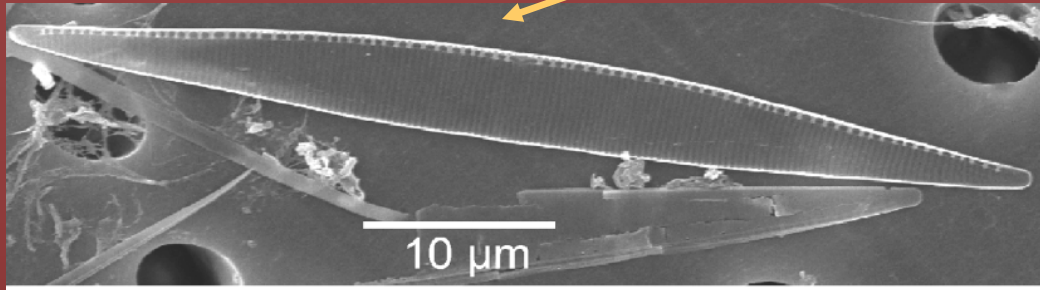


# Objective 3: Experimental outline

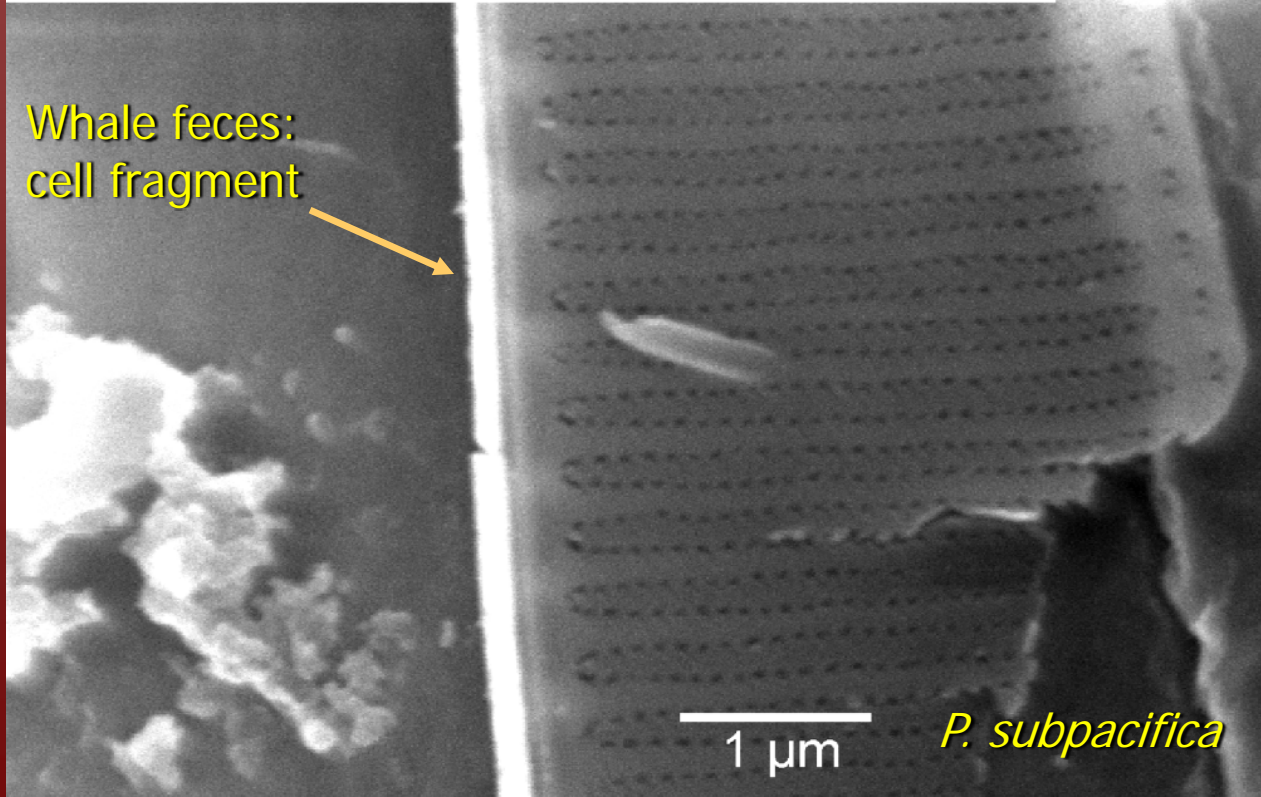
- Scanning and Transmission Electron Microscopy (SEM & TEM) to determine species of *Pseudo-nitzschia* present (whale feces and phytoplankton)
- SEM analyses in search of identifiable copepod fragments (whale feces only)

- SEM *Pseudo-nitzschia* images

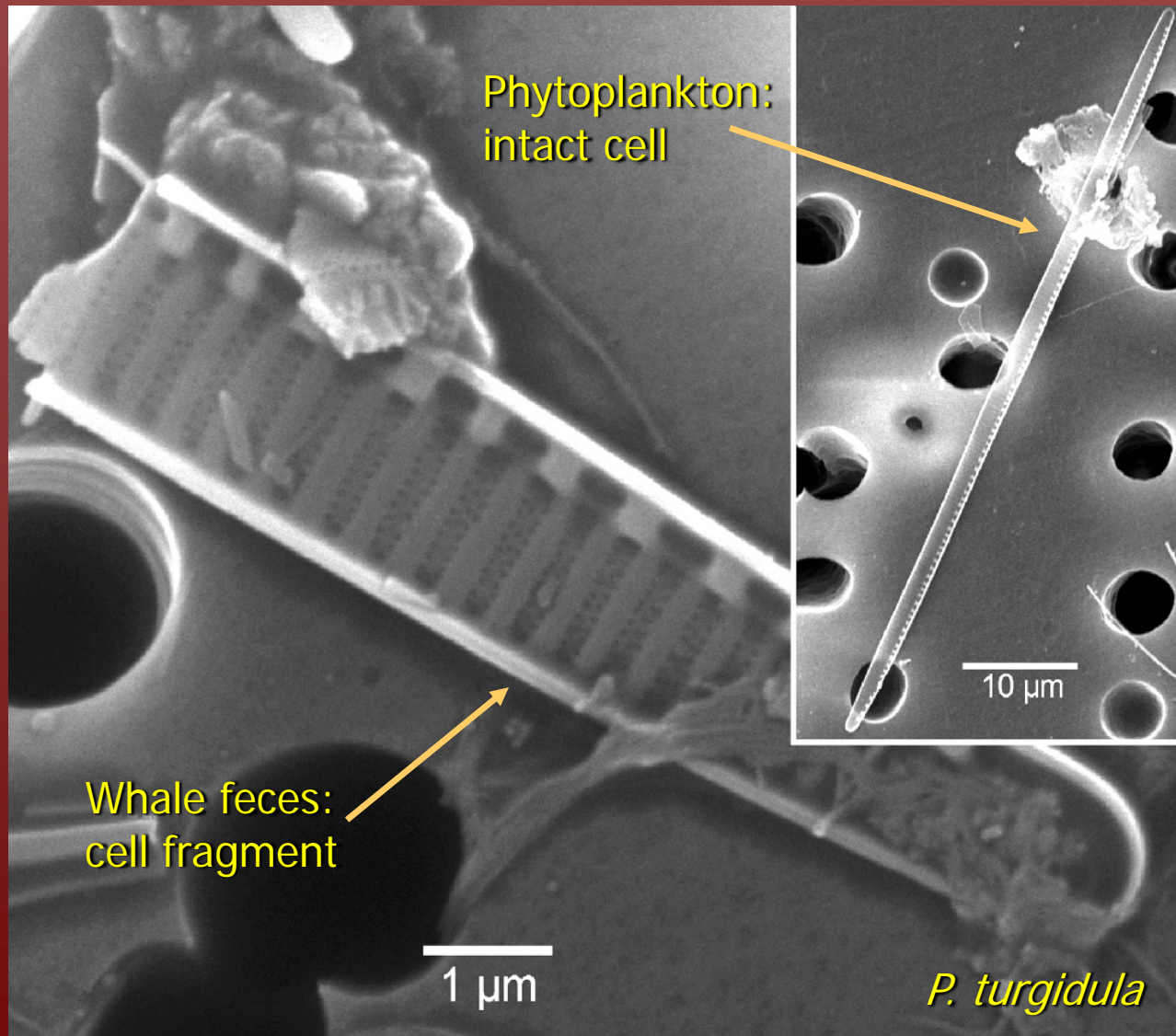
Phytoplankton:  
intact cell



Whale feces:  
cell fragment

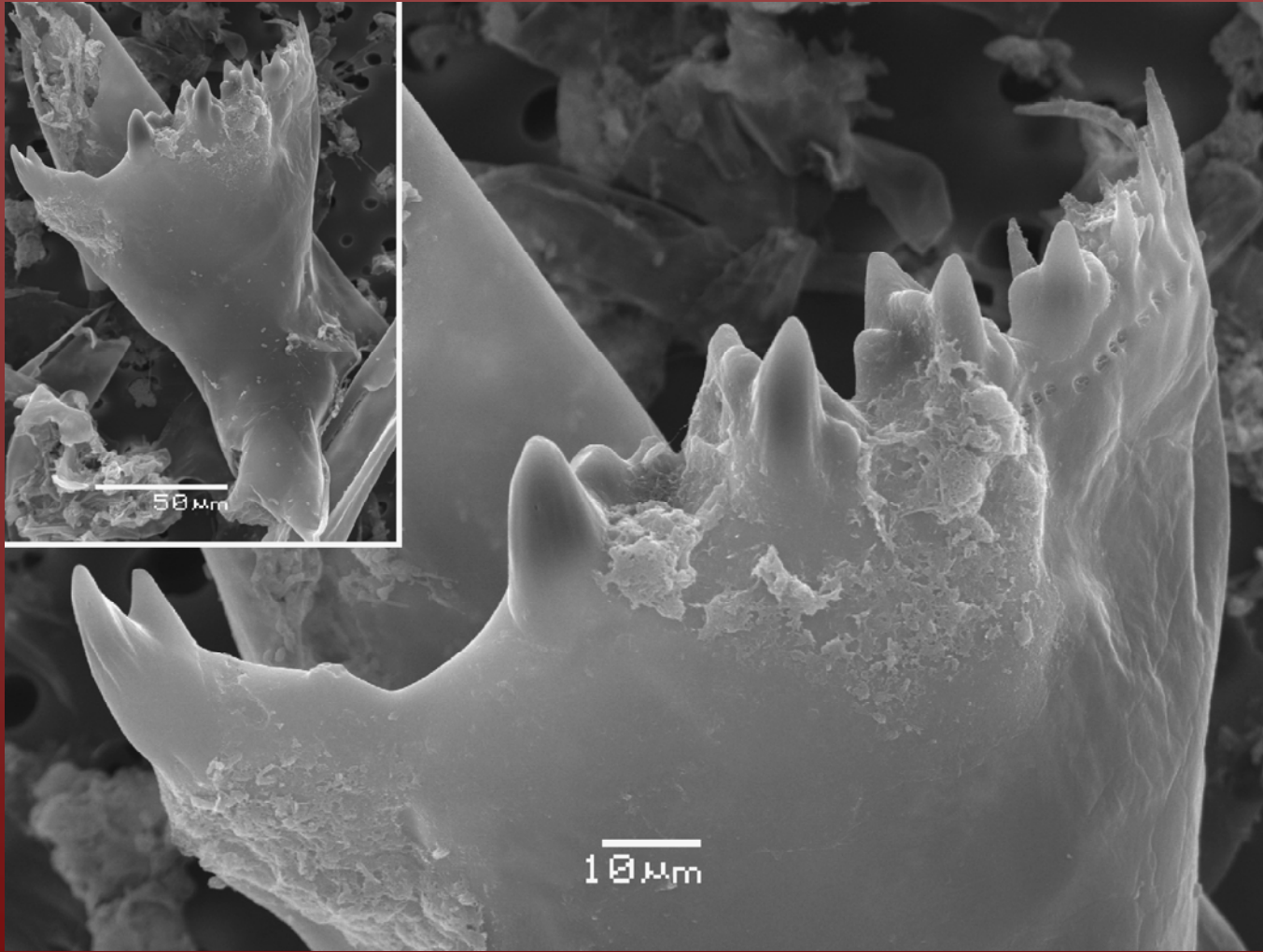


- SEM *Pseudo-nitzschia* images





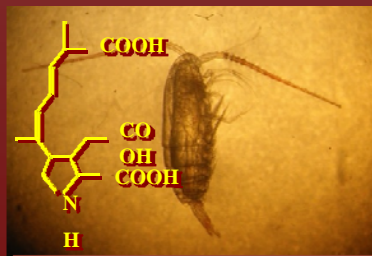
- Copepod fragments in whale feces in all 20 fecal samples analyzed



SEM image: *Calanus finmarchicus* mandible

# Objective 3: Conclusions

- Several potentially toxic (DA-producing) *Pseudo-nitzschia* spp. present in both phytoplankton and right whale fecal samples
  - Source(s) of DA in our samples
- Right whales ingested *C. finmarchicus* - likely vector for DA transfer into right whales



*C. finmarchicus*

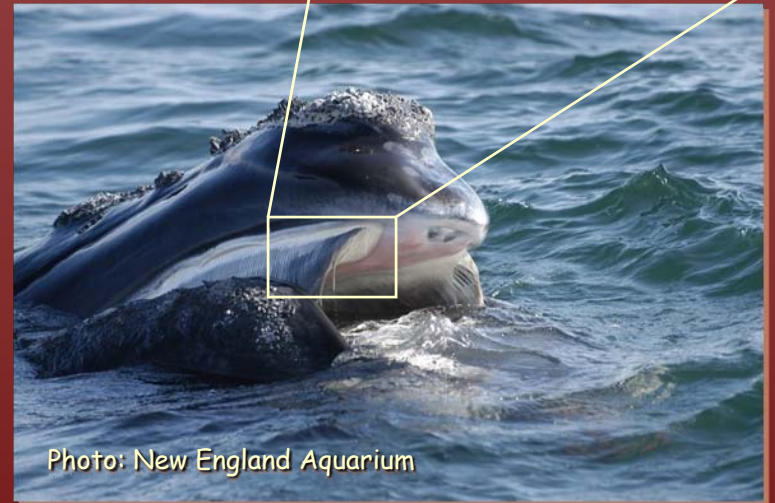


N. Atlantic right whale

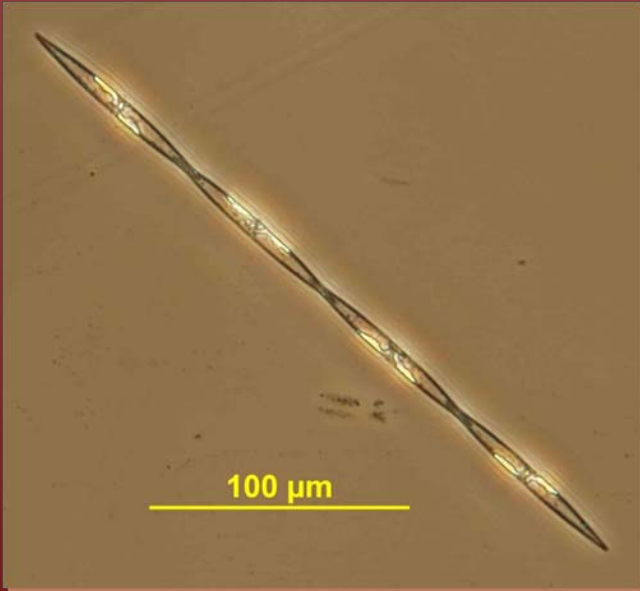
# Back to "big picture"

No intact *Pseudo-nitzschia* cells were present in whale feces

?



N. Atlantic right whale



toxic *Pseudo-nitzschia*



# N. Atlantic right whale Health & Reproduction-potential implications

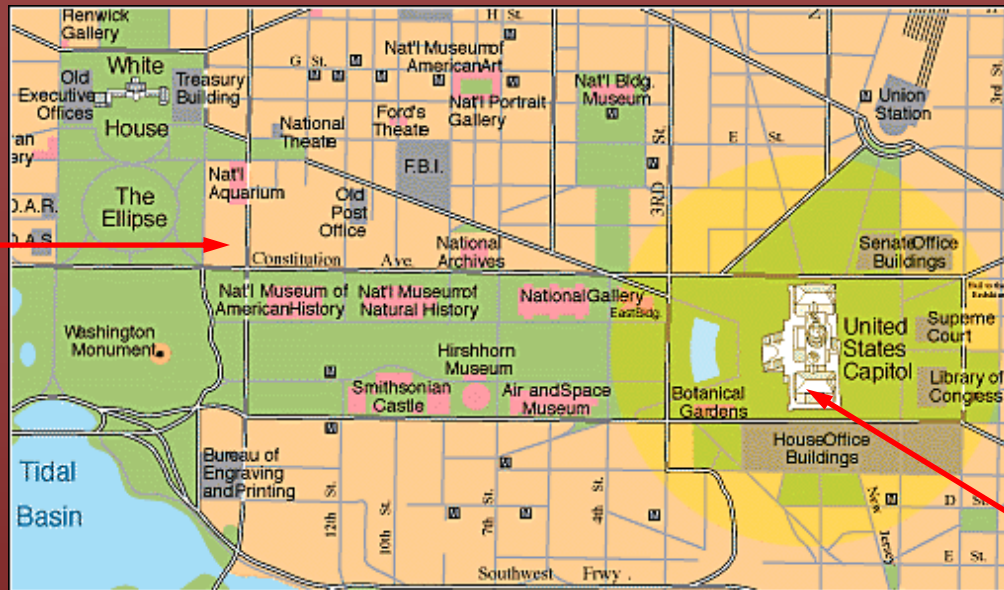
- What are the effects of continuous (several months) exposure of *E. glacialis* to sub-lethal DA levels?
- Sea lions exhibit reproductive failure (e.g., induced abortions, miscarriage & premature birth) as a result of DA exposure (Brodie et al. 2006)
- Studies with rodents have shown that pre-exposure to DA causes increased sensitivity to future exposures (Qiu et al. 2006)
- Many fecal samples tested positive for both DA and PSP toxins (Doucette et al. unpubl. data) – possible synergistic effects?

# From Science to Policy...

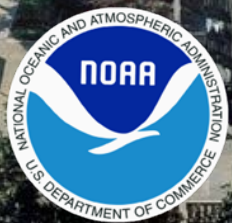




# NOAA Office of Legislative Affairs

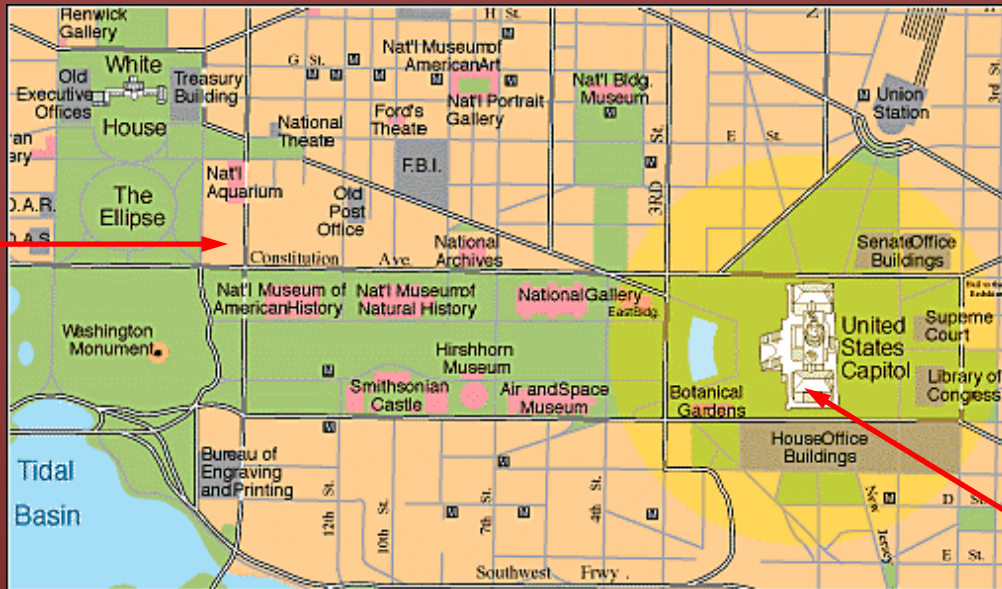


- Respond to NOAA-related inquiries from Congressional staff
- Prepare NOAA witnesses for testifying at Congressional hearings
- Coordinate and staff meetings between NOAA scientists and Members of Congress and/or staff
- Participate in developing legislative strategies for NOAA programs





# NOAA Office of Legislative Affairs



- Worked as a Congressional Specialist covering:
  - National Ocean Service (NOS): Harmful Algal Blooms, Hypoxia, Oceans and Human Health
  - Oceanic and Atmospheric Research (OAR): Great Lakes, Sea Grant, Aquatic Invasive Species and Ballast Water Management
  - NOAA Education

# Legislation

- Worked with Congressional staff to introduce legislation to reauthorize NOAA's HAB and Hypoxia programs



110TH CONGRESS  
2D SESSION

## S. 3191

To develop and promote a comprehensive plan for a national strategy to address harmful algal blooms and hypoxia through baseline research, forecasting and monitoring, and mitigation and control while helping communities detect, control, and mitigate coastal and Great Lakes harmful algal blooms and hypoxia events.

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IN THE SENATE OF THE UNITED STATES

JUNE 25, 2008

Ms. SNOWE (for herself, Mr. NELSON of Florida, Ms. CANTWELL, Mr. KERRY, Mr. VITTER, Mr. LEVIN, Mr. VOINOVICH, Mrs. BOXER, Mr. CARDIN, and Ms. MIKULSKI) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation.

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## A BILL

To develop and promote a comprehensive plan for a national strategy to address harmful algal blooms and hypoxia through baseline research, forecasting and monitoring, and mitigation and control while helping communities detect, control, and mitigate coastal and Great Lakes harmful algal blooms and hypoxia events.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*

Public Law 108-456  
108th Congress

### An Act

To reauthorize the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998, and for other purposes.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

### **TITLE I—HARMFUL ALGAL BLOOM AND HYPOXIA AMENDMENTS ACT OF 2004**

Harmful Algal  
Bloom and  
Hypoxia  
Amendments Act  
of 2004.  
16 USC 1451  
note.

#### SEC. 101. SHORT TITLE.

This title may be cited as the "Harmful Algal Bloom and Hypoxia Amendments Act of 2004".

16 USC 1451  
note.

#### SEC. 102. RETENTION OF TASK FORCE.

Section 603 of the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (16 U.S.C. 1451 nt) is amended by striking

# Legislation

- Worked with Congressional staff to introduce and pass legislation to reauthorize the National Sea Grant College Program Act



110TH CONGRESS  
2D SESSION

**S. 3160**

[Report No. 110-508]

To reauthorize and amend the National Sea Grant College Program Act,  
and for other purposes.

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IN THE SENATE OF THE UNITED STATES

JUNE 19, 2008

Mr. INOUE (for himself, Mr. STEVENS, Ms. CANTWELL, Ms. SNOWE, Mr. KERRY, and Mr. REED) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

SEPTEMBER 25 (legislative day, SEPTEMBER 17), 2008

Reported by Mr. INOUE, without amendment

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## **A BILL**

To reauthorize and amend the National Sea Grant College  
Program Act, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*  
2 *tives of the United States of America in Congress assembled,*

3 **SECTION 1. SHORT TITLE.**

4 This Act may be cited as the “National Sea Grant  
5 College Program Amendments Act of 2008”.



# Congressional Hearings

- Briefed and staffed NOAA witnesses for Congressional Hearings
  - Sea Grant - Dr. Craig McClean (Dep. AA for OAR)
  - HABs - Dr. Robert Magnien (Director CSCOR)
  - Great Lakes - Dr. Craig Stow (GLERL)



U.S. HOUSE OF REPRESENTATIVES  
COMMITTEE ON SCIENCE AND TECHNOLOGY

SUITE 2320 RAYBURN HOUSE OFFICE BUILDING  
WASHINGTON, DC 20515-6301  
(202) 225-6376  
TTY: (202) 226-4410  
<http://science.house.gov>

May 14, 2008

Dr. Craig McLean  
Deputy Assistant Administrator for Programs  
& Administration  
Oceanic & Atmospheric Research  
National Oceanic & Atmospheric Administration  
1315 East West Hwy, Room: 11555  
Silver Spring, MD 20910-3282

Dear Dr. McLean,

The Subcommittee on Energy and Environment will hold a hearing entitled, "National Sea Grant College Program Act: H.R. 5618" on Wednesday, May 21, 2008, at 10:00 am in room 2325 of the Rayburn House Office Building. I am writing to invite you to testify at this hearing.

The purpose of the hearing is to receive testimony on H.R. 5618, the National Sea Grant College Program Act of 2008.

The hearing will focus on the proposed legislation to reauthorize the National Sea Grant Program through fiscal year 2014. The hearing will also examine the program's major accomplishments, program activities, and the effectiveness of the extension and outreach aspects of the program.

Please provide your views on H.R. 5618 highlighting features of the legislation you believe will improve the research, education, and training components of the National Sea Grant program. In addition, please provide your recommendations for strengthening the outreach and extension aspects of the Sea Grant program. In your testimony, please provide the Committee with highlights of the program's accomplishments over the past five years.

In order to allow sufficient time for questions at the hearing, you should highlight the most significant points of your testimony in an oral presentation of no more than five minutes. Your written statement may be as extensive as you wish and will be included in the hearing record in its entirety. Oral statements and answers to questions will be printed as part of the record of the hearing; only technical, grammatical, and typographical errors will be corrected.

Thank you!

