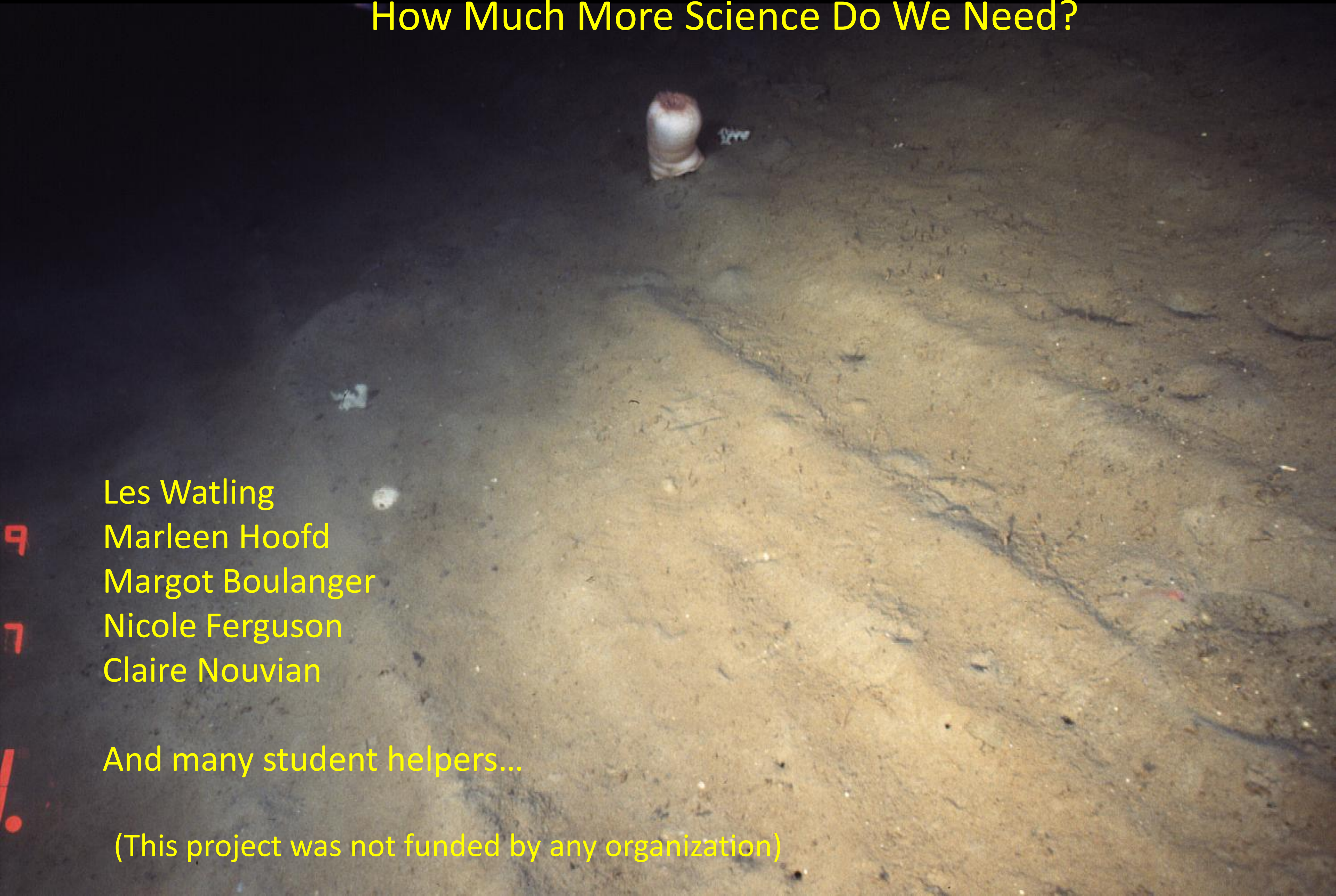
The Bottom Line on Bottom Trawling: How Much More Science Do We Need?



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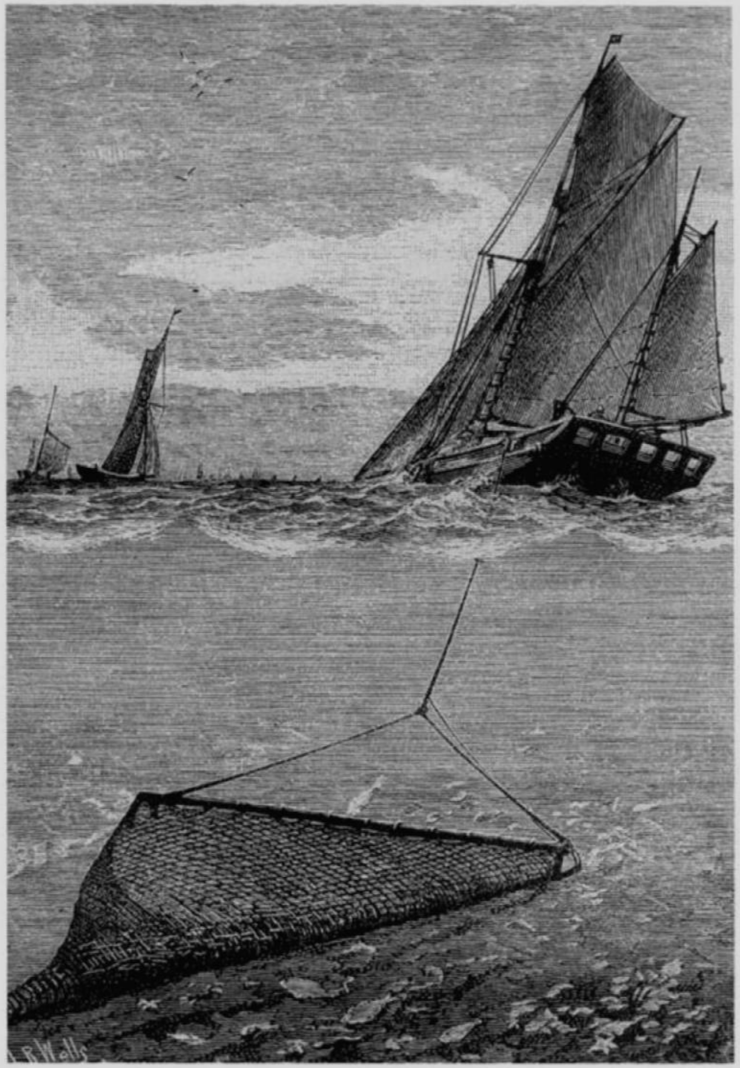
And many student helpers…

(This project was not funded by any organization)



Beam trawls consist of a bag net held open by a wooden or steel beam. They were invented in fourteenth-century England and were towed by sailing boats until the late nineteenth century when steam power was introduced. Source: Collins, J.W. (1889) The Beam Trawl Fishery of Great Britain with Notes on Beam Trawling in Other European Countries. *Government Printing Office, Washington, DC.*

The Trawling Revolution

Began in 14th Century; first complaint in 1376.

16th Century trawling bans; capital offence in France, etc.

Advent of steam power allowed larger trawls.

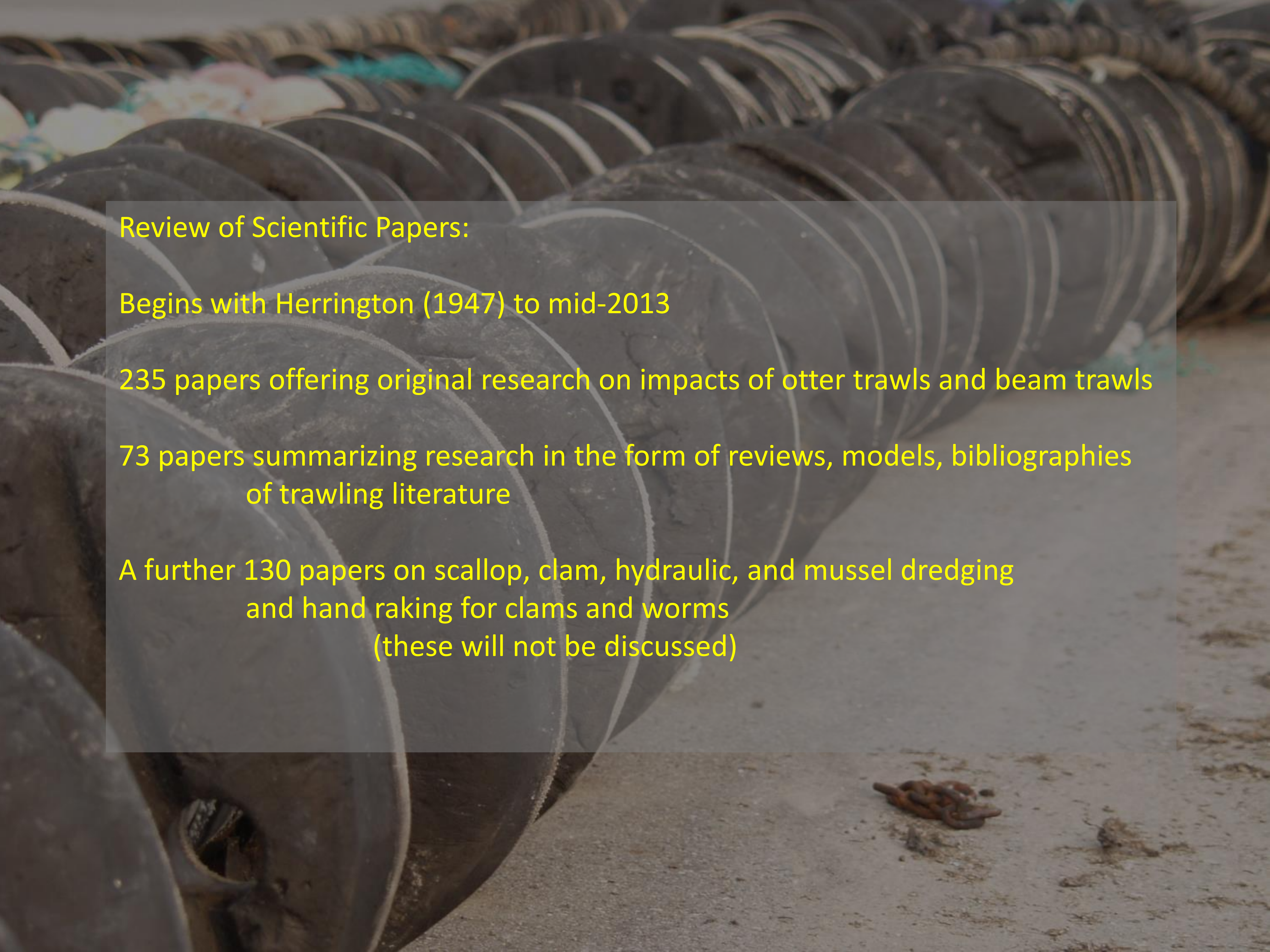
English trawling fleet over 800 boats by 1860.

Big protests against trawls in Ireland and Britain.

Royal Commission of 1863

Sea Fisheries Act eliminated all laws against trawling.

From Roberts C.M. 2007. Chapter 10.



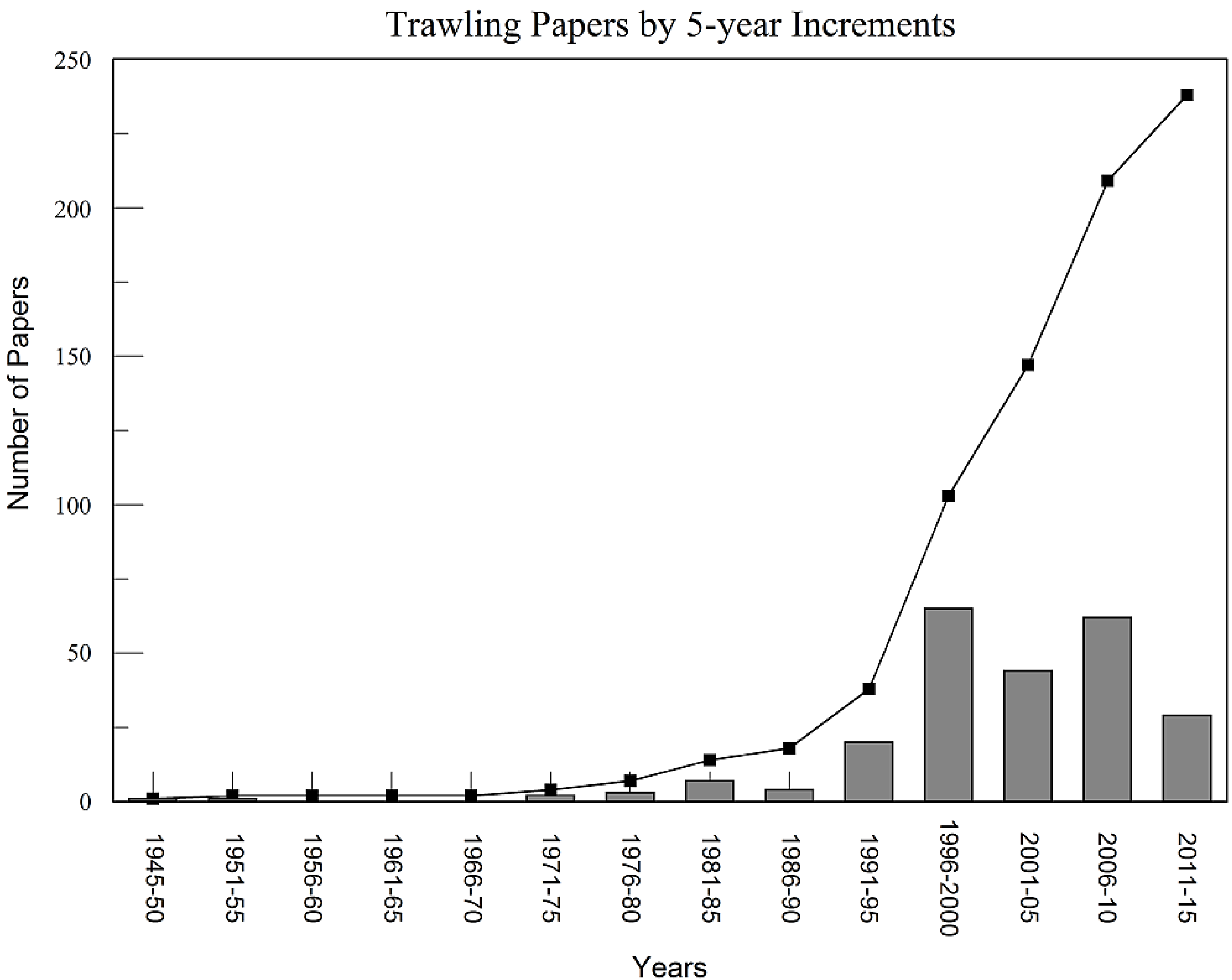
Review of Scientific Papers:

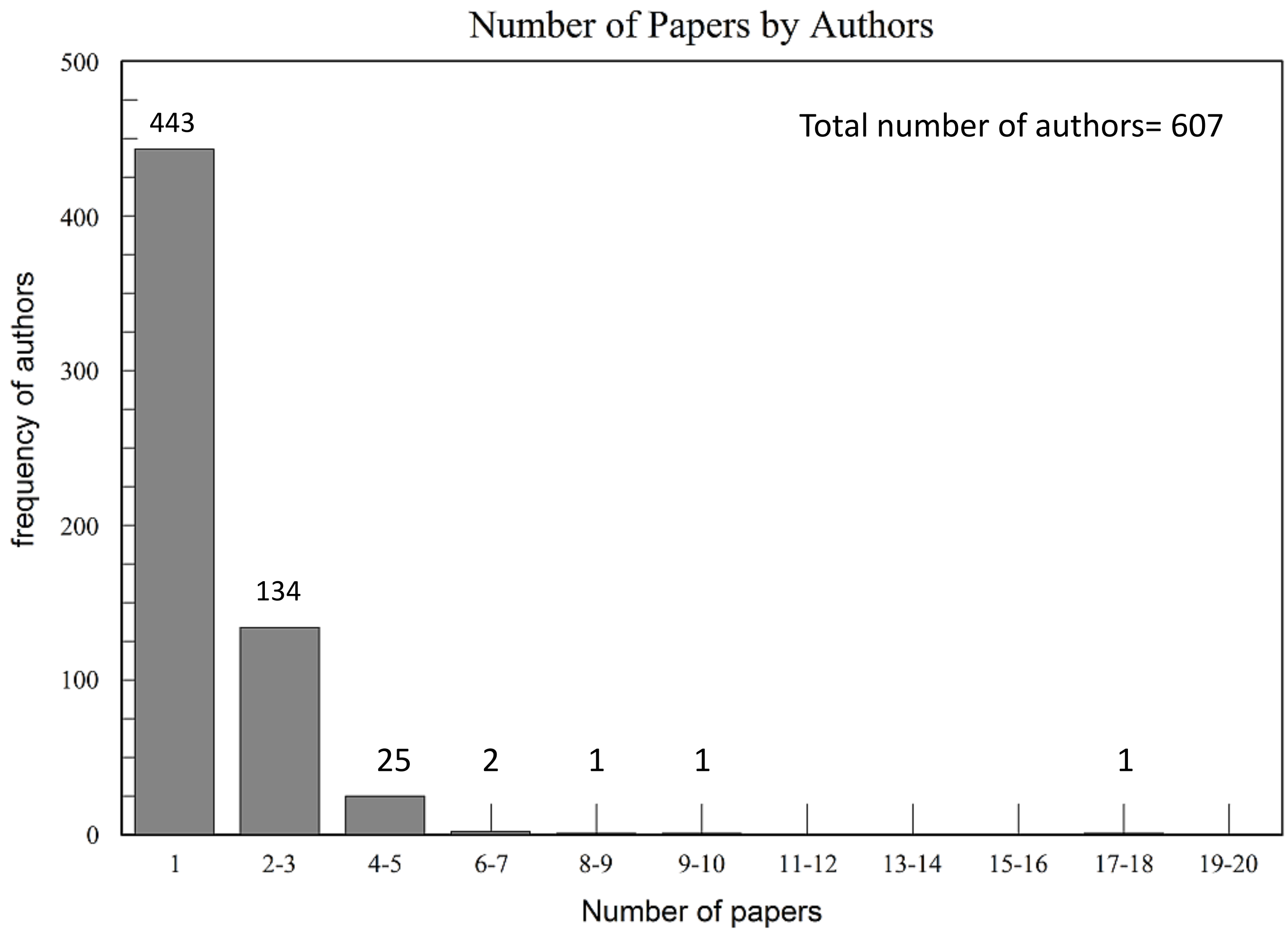
Begins with Herrington (1947) to mid-2013

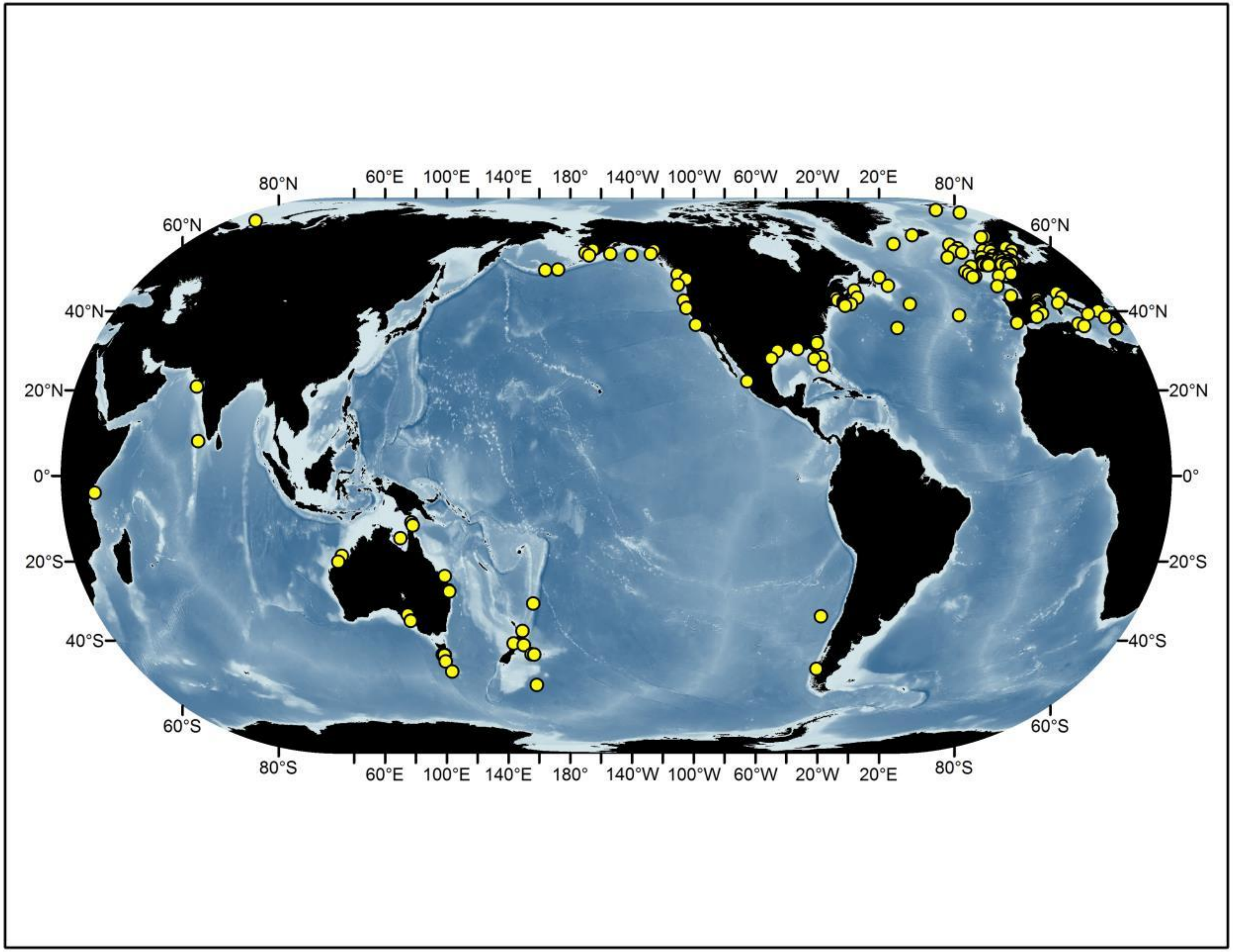
235 papers offering original research on impacts of otter trawls and beam trawls

73 papers summarizing research in the form of reviews, models, bibliographies of trawling literature

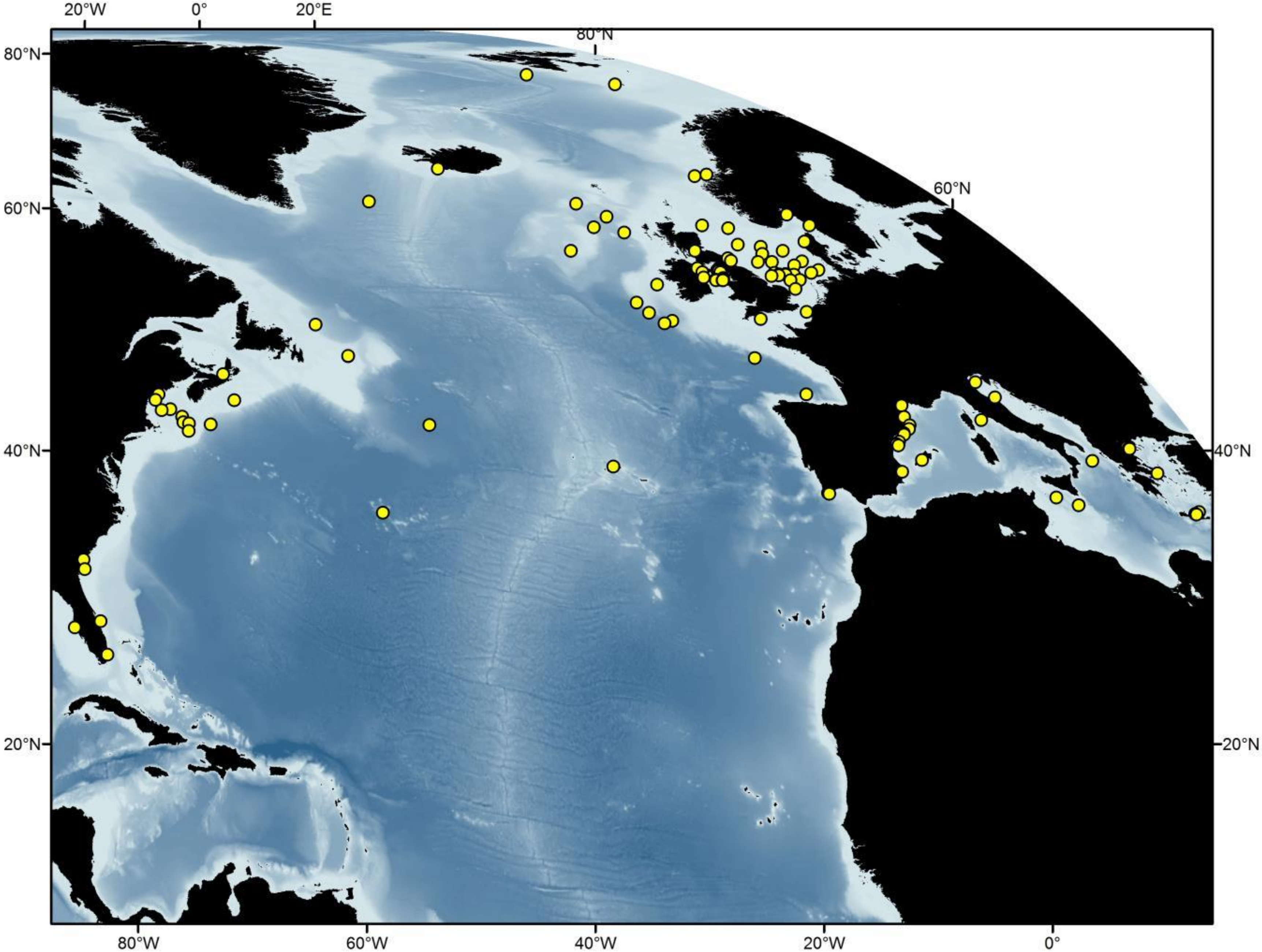
A further 130 papers on scallop, clam, hydraulic, and mussel dredging and hand raking for clams and worms (these will not be discussed)


Trawling Papers by 5-year Increments
Number of Papers
0
50
100
150
200
250
1945-50
1951-55
1956-60
1961-65
1966-70
1971-75
1976-80
1981-85
1986-90
1991-95
1996-2000
2001-05
2006-10
2011-15
Years


Number of Papers by Authors
Total number of authors= 607
frequency of authors
500
400
300
200
100
0
443
134
25
2
1
1
1
1
2-3
4-5
6-7
8-9
9-10
11-12
13-14
15-16
17-18
19-20
Number of papers



MPA and RFMO data courtesy O. Bos



20°W
0°
20°E
80°N
80°N
60°N
60°N
40°N
40°N
20°N
20°N
80°W
60°W
40°W
20°W
0°

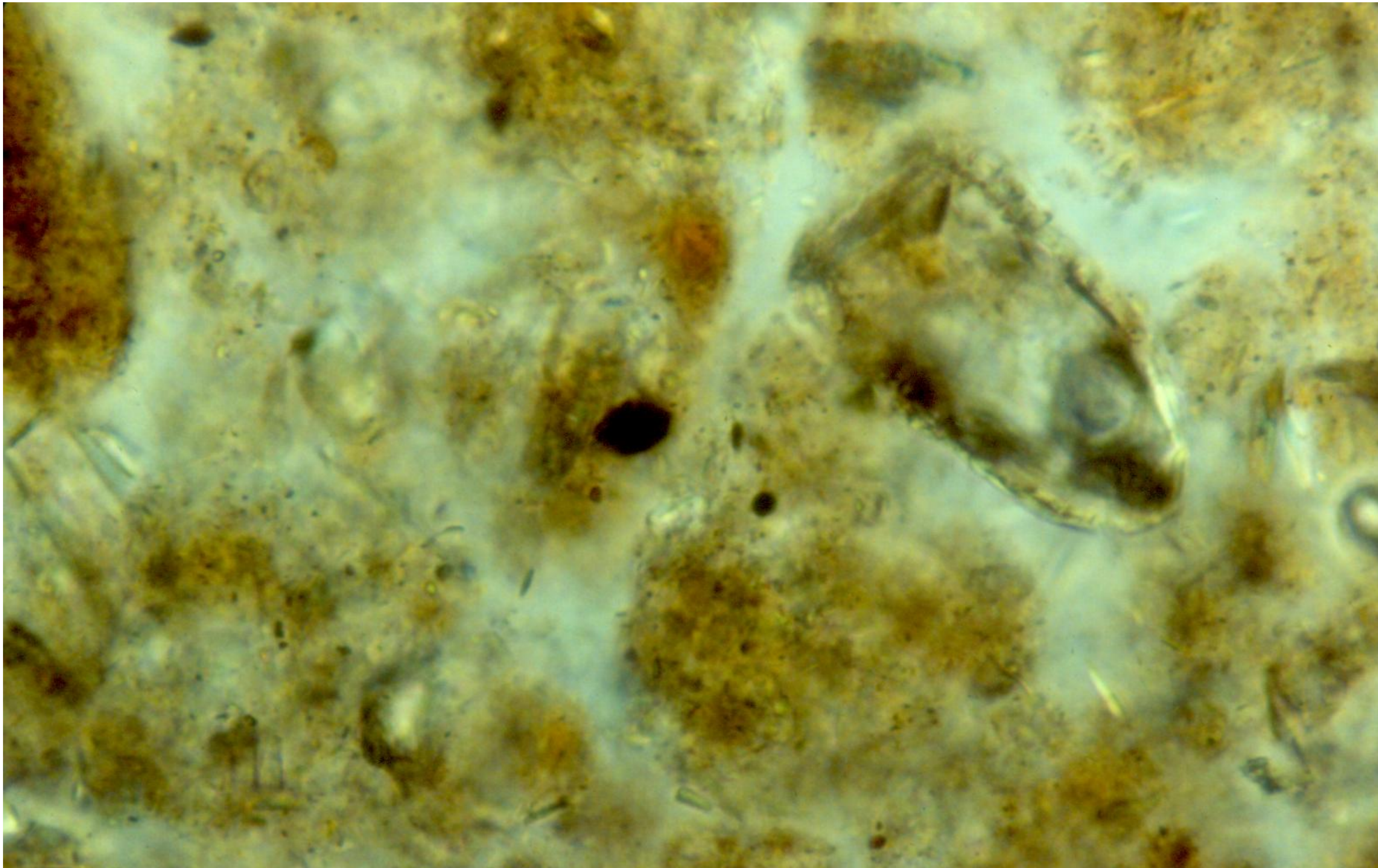
Partial Results of Trawling Impacts Studies

Focus	No. papers	Change	No change
Sediment changes	24	22 (depth of impact, resuspension, etc.)	2 (grain size)
Biogeochemistry	13	12 (nutrient release, bioturbators)	1 (long term)
Biodiversity	25	23 (no. species, evenness)	2 (species composition)
Faunal abundance	46	35 (decrease)* 11 (increase)*	4
Faunal biomass	31	22 (higher undisturbed) 4 (higher disturbed)	7

Are these results that we might have expected?

Principles About Bottom Communities of Importance to Making Trawling Impact Predictions

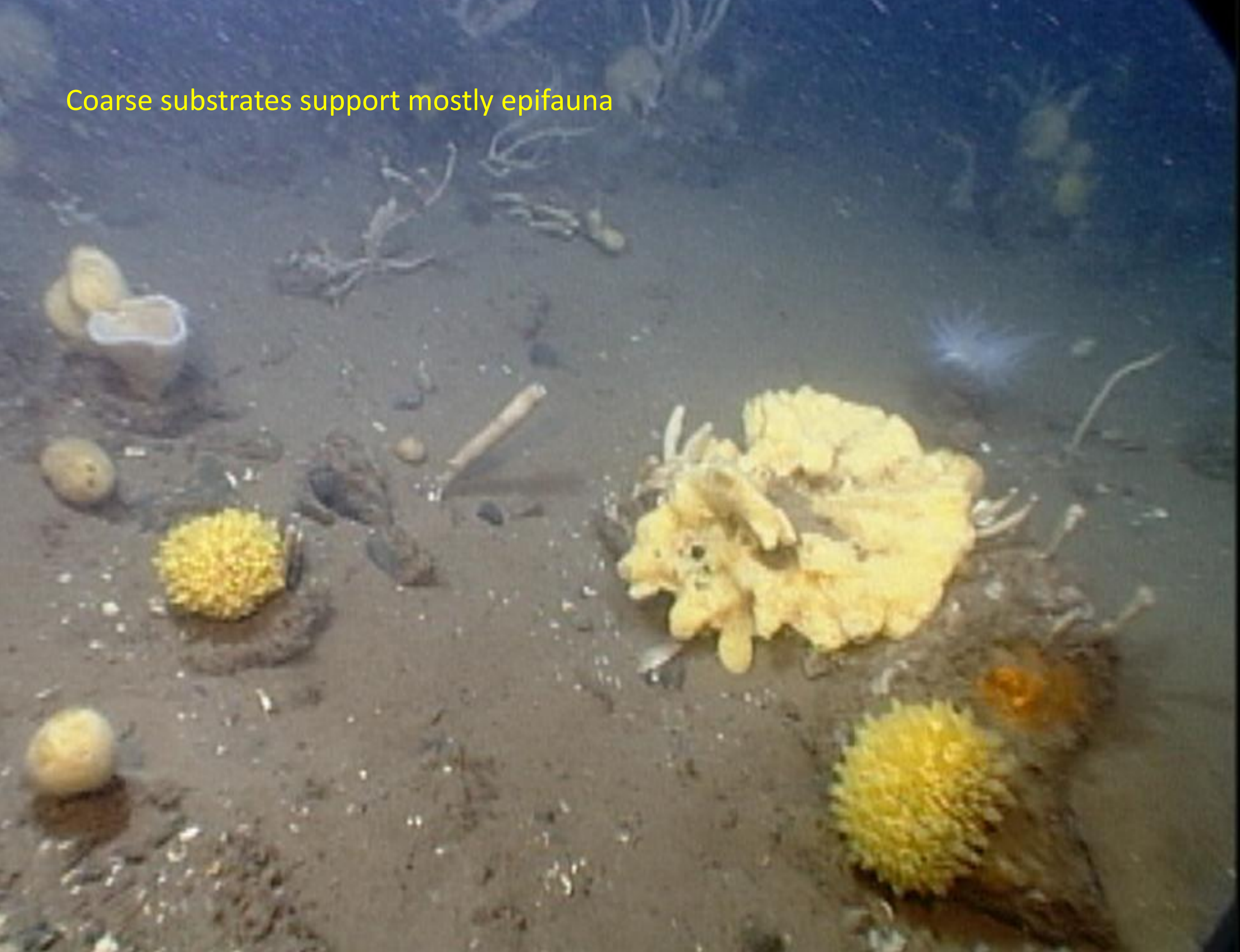
Muddy sediments have very low bulk density and high water content so are easily "resuspendable" even though "cohesive".



Principles About Bottom Communities of Importance to Making Trawling Impact Predictions

Sandy sediments, grains larger but structure important

Figure 7.12 Dye washout pattern under a rippled sediment surface in the laboratory flume experiment.


Coarse substrates support mostly epifauna

Principles About Bottom Communities of Importance to Making Trawling Impact Predictions

Bottom oscillatory velocities above 10 cm/s extend only to about 70 m under the highest storm waves.

Threshold for sandy sediments is about 12-25 cm/s

Epifaunal and soft sediment communities are adapted to the water velocities likely to be experienced at that site. These velocities will decrease with depth.

Trawling speed mostly exceeds storm wave velocities except at shallowest depth.

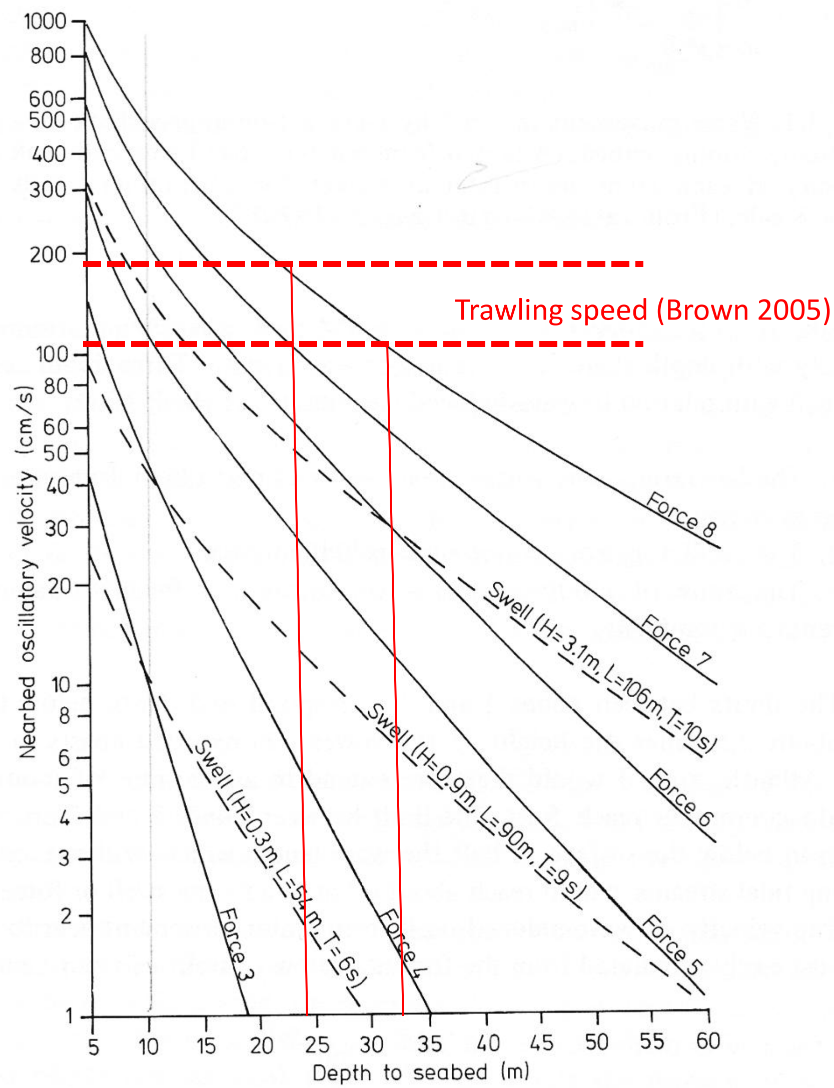


Fig. 3.2. The nearbed oscillatory velocity of fully developed wind-driven waves and swell waves on unbroken seabed from 5 to 60 m. The dimensions of swell waves are given: *H* = height, *L* = length, *T* = period. (From Hiscock (1976).)

Principles About Bottom Communities of Importance to Making Trawling Impact Predictions

Most animals live within 4-5 cm of the sediment-water interface: Food.

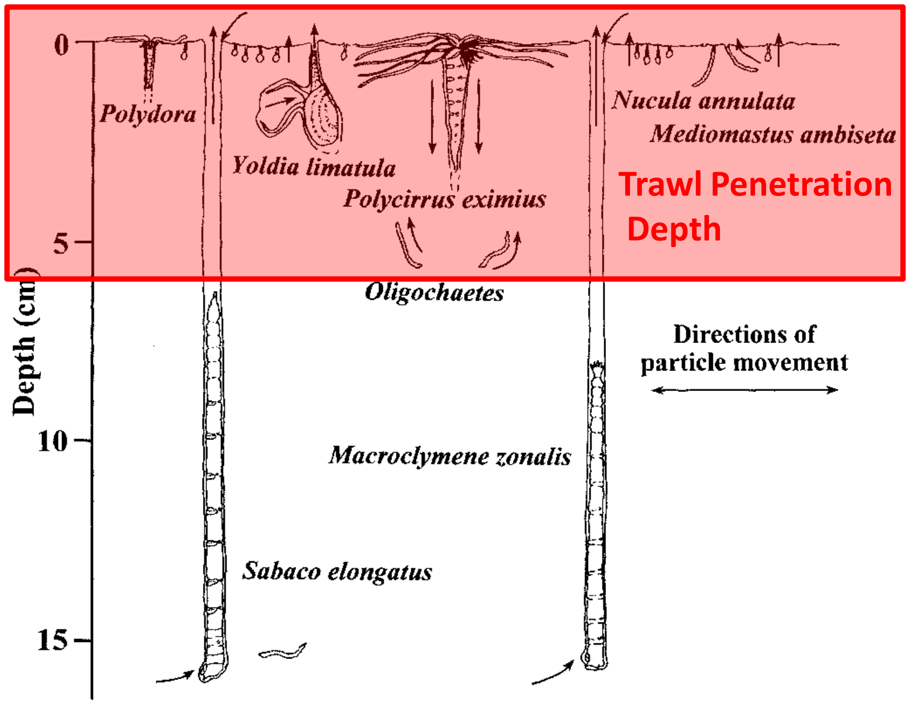


Fig. 3. The most abundant deposit feeders sampled at the Narragansett Bay study site. Arrows indicate particle trajectories. Feeding mechanisms and rates are summarized in Table 2.

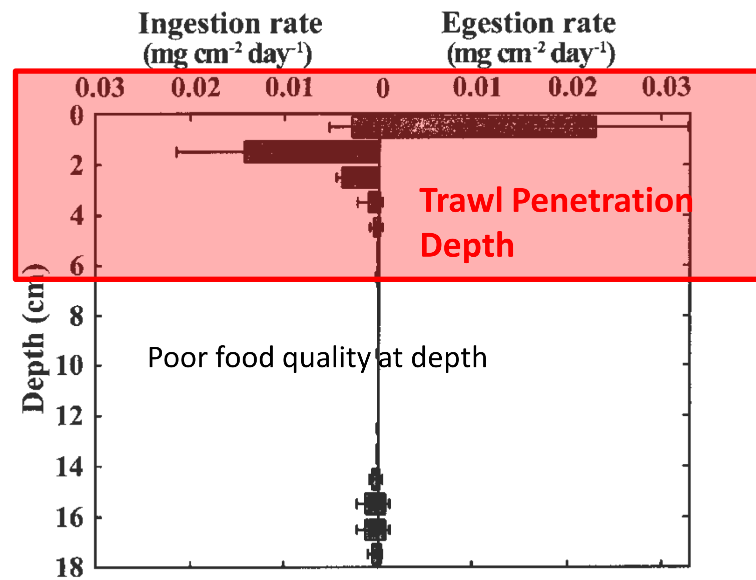


Fig. 5. Rates and depths of particle movement at the study site. Ingestion rates at each depth represent the sum of all deposit feeding rates in each row of the transition matrix ($f_{i,+}$), whereas egestion rates represent the sum of deposit-feeding rates in each column of the transition matrix ($f_{+,j}$). For this plot, the model box size (Δx) was set at 1 cm. Error bars represent the range in ingestion and egestion rates at each depth.

From Shull (2001)

Principles About Bottom Communities of Importance to Making Trawling Impact Predictions

Most animals live within 4-5 cm of the sediment-water interface: Oxygen.

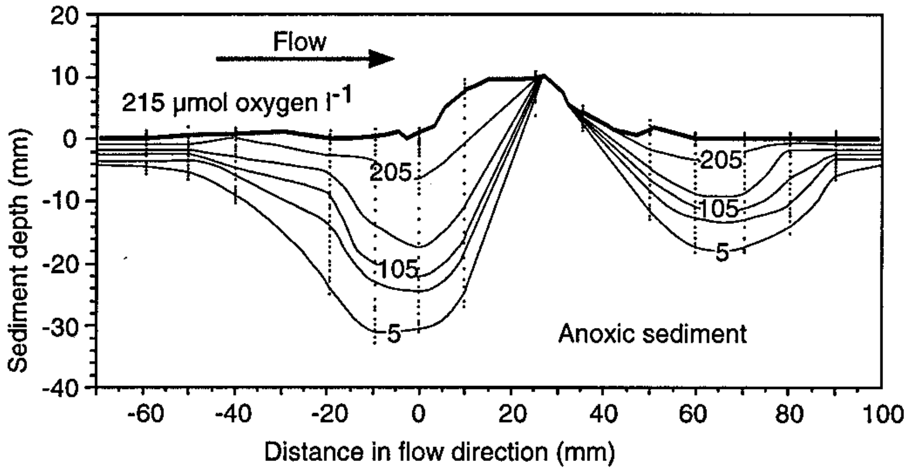


Figure 7.16 O_2 penetration around a small sediment mound, exposed to flow. (Reproduced from Ziebis et al. [1996b], with kind permission of Marine Ecology Progress Series)

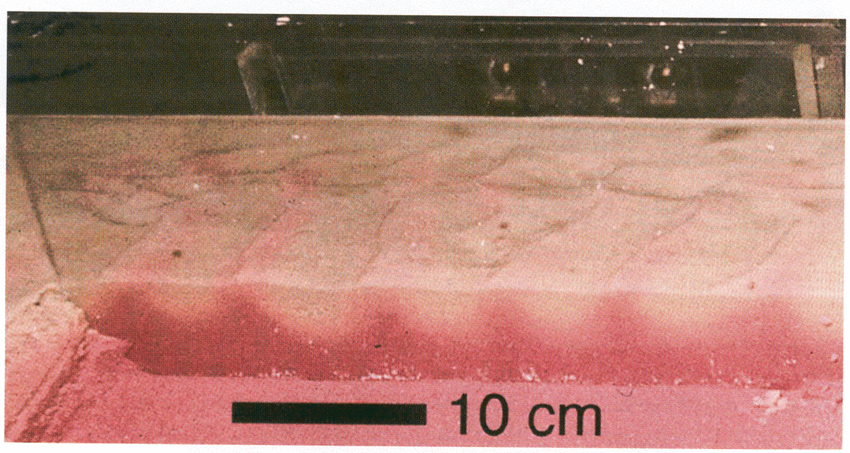


Figure 7.12 Dye washout pattern under a rippled sediment surface in the laboratory flume experiment.

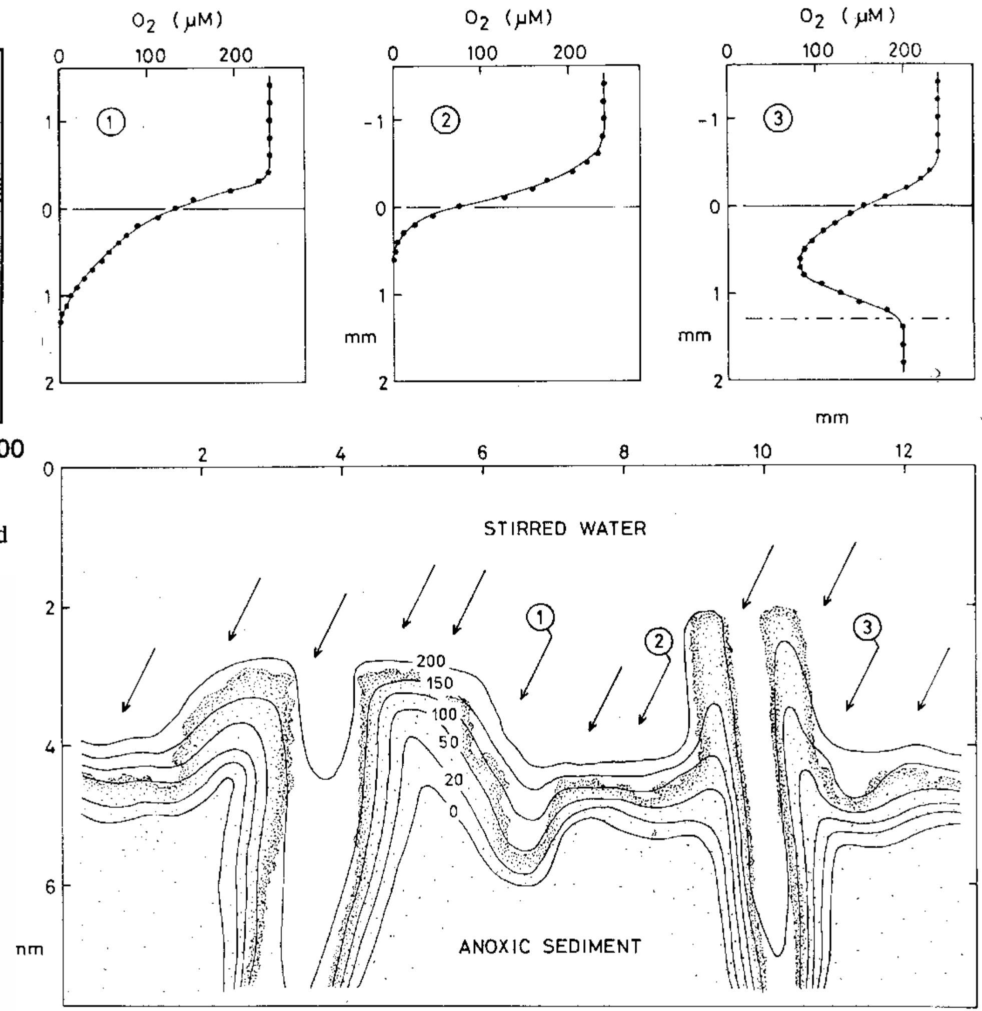


Fig. 7. Vertical section through a sediment surface including two polychaete tubes from Lendrup Lagoon, imfjorden. The isopleths of oxygen were constructed from twelve microprofiles of which three are shown. umbers on the isopleths indicate μmol O_2 liter^{-1}. Oxygen from the aerated seawater penetrated through the iffusive boundary layer into a thin, oxic sediment zone which followed the surface topography.

from Jorgensen and Revsbech (1985)

Trawling Impact: Water Depth

We can partition results into 3 depth groups:

1. Very shallow bays. Seasonal and storm effects very strong, probably overwhelms trawling impacts sometime during the year.

2. Deeper bays and continental shelf. Some seasonal effects noticeable but storm effects diminished, trawl impacts more easily discernable and longer lasting.

3. Continental slope, seamounts, and other deep-sea areas. Very slight seasonal signal, physical water motion effects rare, trawl impacts easy to determine and very long lasting.

Predicting Impacts of Bottom Trawling: First Principles of Benthic Ecology

Sediment composition determined by local near bottom water velocity over long time periods

Short term increase in hydrodynamic regime will change sediment grain size

Soft sediment areas dominated by infauna, hard bottoms dominated by epifauna

Bottom trawl gear is made out of rope and steel. No epifauna and larger infauna cannot resist the forces applied.

In soft sediments, most animals are “small” and live near the sediment-water interface because food is higher quality and oxygen is diminished rapidly within the sediments.

Trawling impacts upper 4-8 cm due to changes in hydrodynamic regime or direct impact – that is the habitat of most bottom-dwellers

Smaller species may be able to “tumble” and re-settle. Can they reconstruct their burrow or tube?

But trawling is not continuous over most places, so habitat is fragmented.

How much fragmentation is too much?

PLANET OF WEEDS

Tallying the losses of Earth's animals and plants

By David Quammen

THE SPECIES THAT SURVIVE WILL BE LIKE WEEDS, REPRODUCING QUICKLY AND SURVIVING ALMOST ANYWHERE

Harper's Magazine (1998)

The prairie of Iowa 150 years ago: 400 plant species, including grasses, legumes, wildflowers; prairie potholes, wetlands, and riparian woodlands. 250 species of animals not counting invertebrates. 30 million acres

The prairie of Iowa today: 30,000 acres of prairie remain, more than 100 plant species and 37 animal species are endangered. Plant diversity of whole state dominated by maize, soybean, oats, alfalfa, two species of clover.

Is there an ecosystem level parallel with respect to bottom habitats and trawling?


Mahalo!
From All of Us!