
SUSTAINABLE
LOCAL
HEALTHY
VENTURA
SHELLFISH ENTERPRISE
Promoting healthy oceans with sustainable shellfish aquaculture
Aerial Photography Los Angeles

VSE Collaborative

Policy Partners

Core Team

Academic & Research Partners

BREN SCHOOL OF
ENVIRONMENTAL SCIENCE
& MANAGEMENT

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Broader Project Goals

- Increase the supply of healthy, sustainably produced, and locally grown shellfish
- Sustain Ventura Harbor as a major west coast fishing port and enhance the local economy & working waterfront
- Establish an entitlement and permitting **blueprint** for aquaculture projects across California
- Provide economies of scale and technical support to small producers who would otherwise be unable to participate in shellfish aquaculture
- Enhance public knowledge and understanding of sustainable shellfish farming practices

Expected Outcomes

- Twenty 100-acre growing sites located within the 3-mile limit of California *state* waters
- New seafood product to be landed in Ventura Harbor
- Ventura Port District will obtain all permits, sublease to producers, and provide infrastructure

Workshop 2

Biology of Bivalve Shellfish | Mussel Growing Technology and Equipment

The Biology of Mussel Hatchery Culture

Doug Bush, General Manager & Partner
The Cultured Abalone Farm, Goleta, CA

Offshore Mussel Farming Technologies and Considerations

Scott Lindell, Principal Investigator
Woods Hole Oceanographic Institution, MA

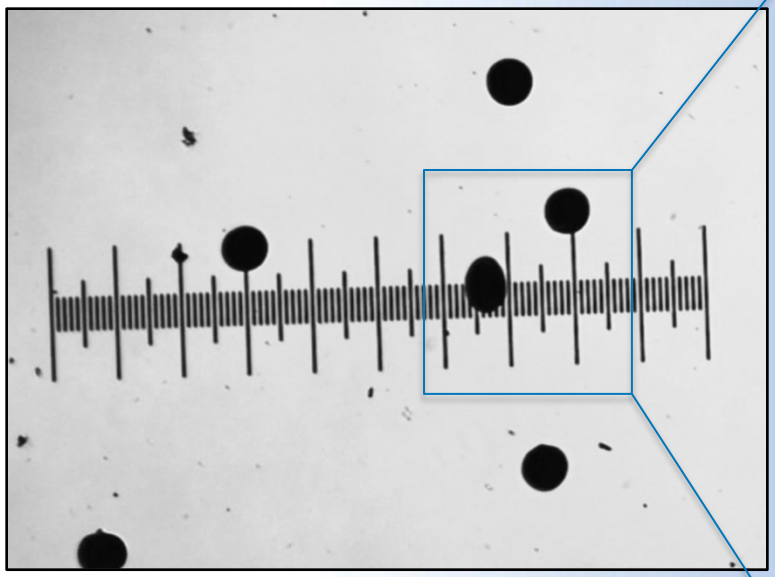
Biology of Mussel Hatchery Culture

- unfertilized eggs of *M. galloprovincialis* ~60 μm
- each female releases 5-12 million eggs
- eggs are pink/orange in coloration
- sperm is white
- gamete release is induced by thermal cycling
  - alternating water temperature between 14 – 24°C for 45 min. at a time until gametes are observed

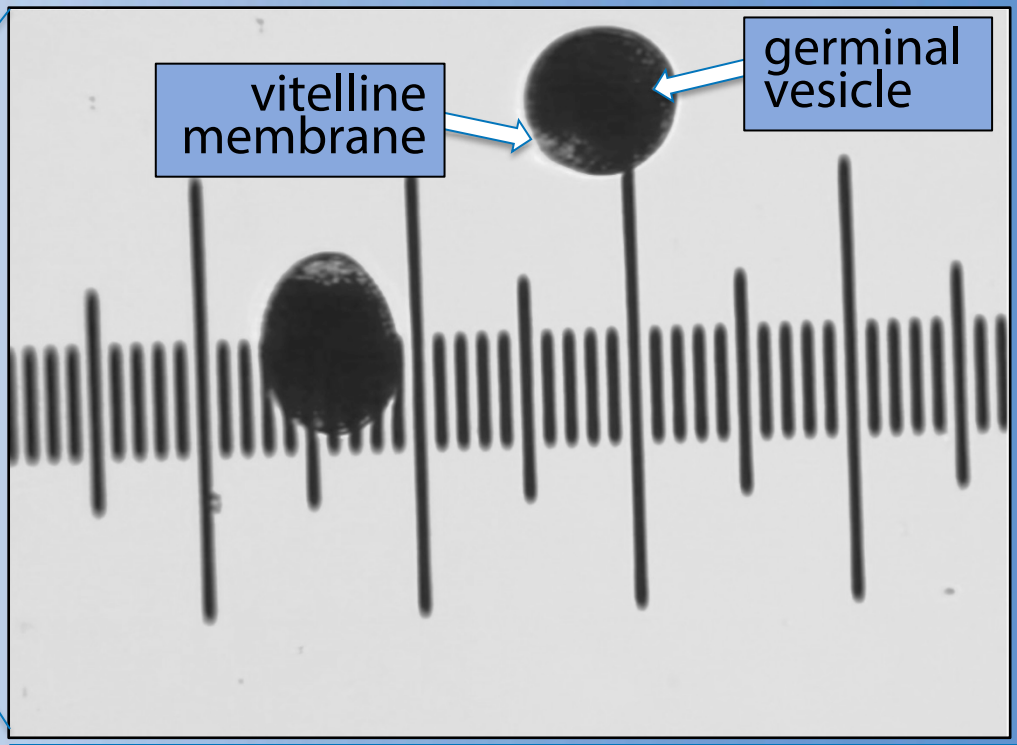
Female mussels with eggs

Biology of Mussel Hatchery Culture

Low magnification



High magnification

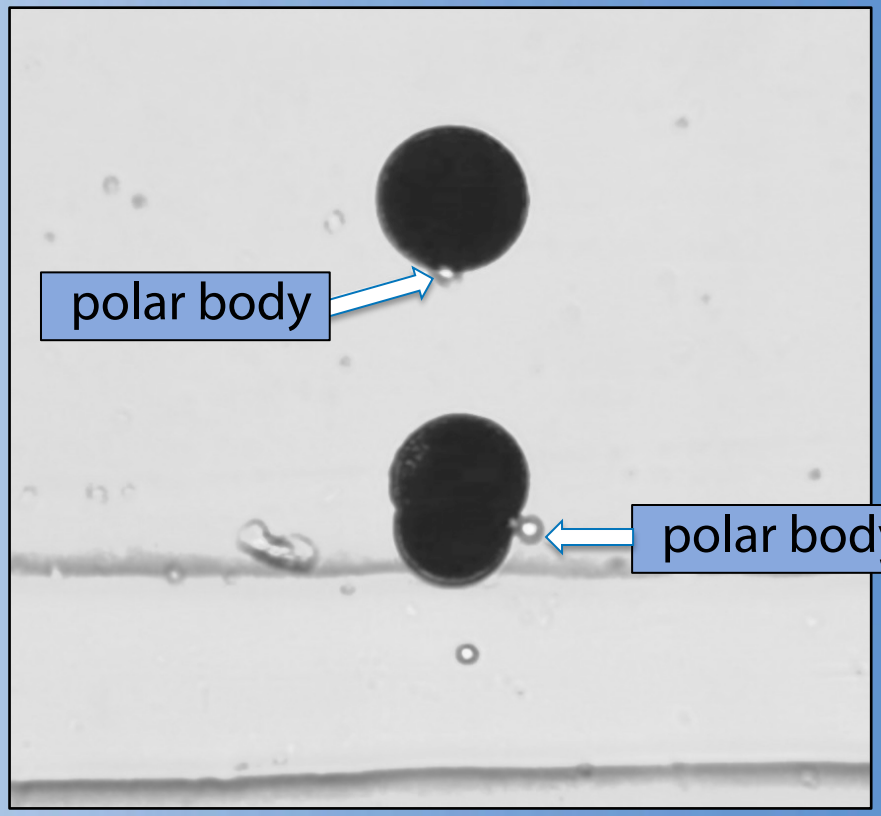


1 cell division (10 µm)

Biology of Mussel Hatchery Culture

- Polar bodies visible
  15 min. post-fertilization
- First cell division occurs
  ~30 min. post-fertilization

30 minutes post-fertilization

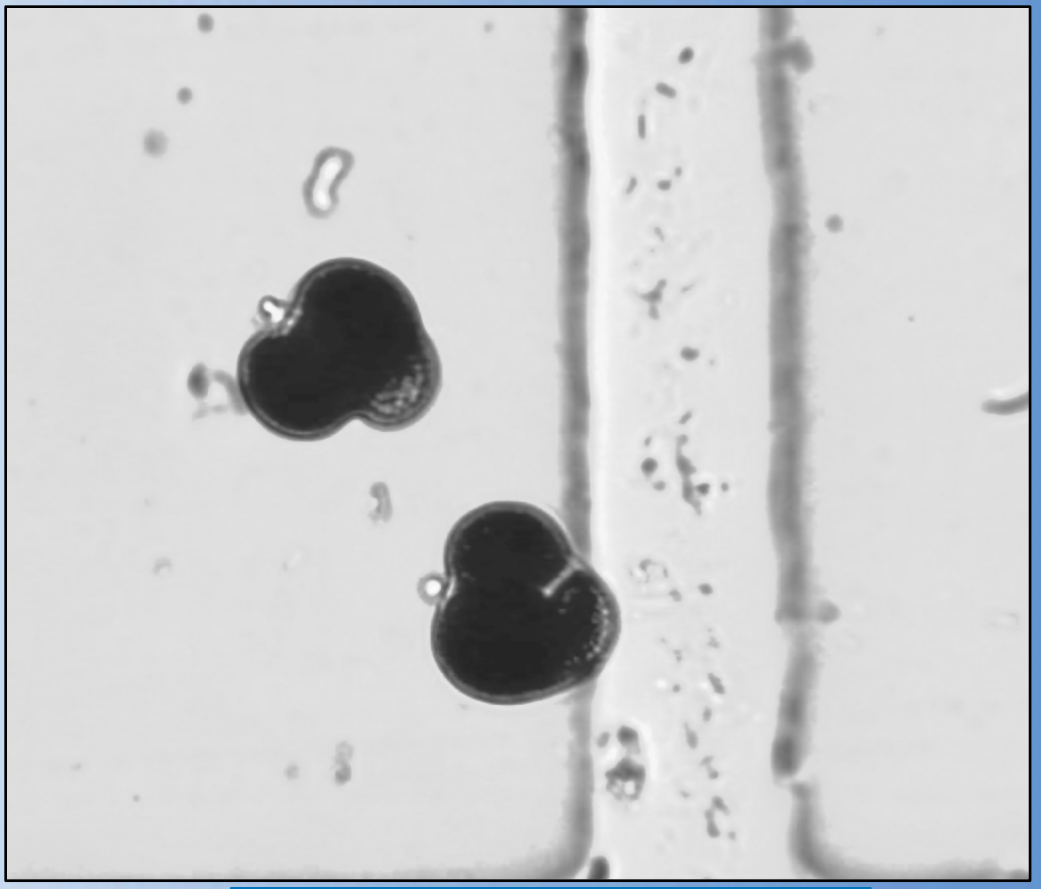


single-cell and two-cell embryo

Biology of Mussel Hatchery Culture

- second cell division
- ~ 60 μm diameter

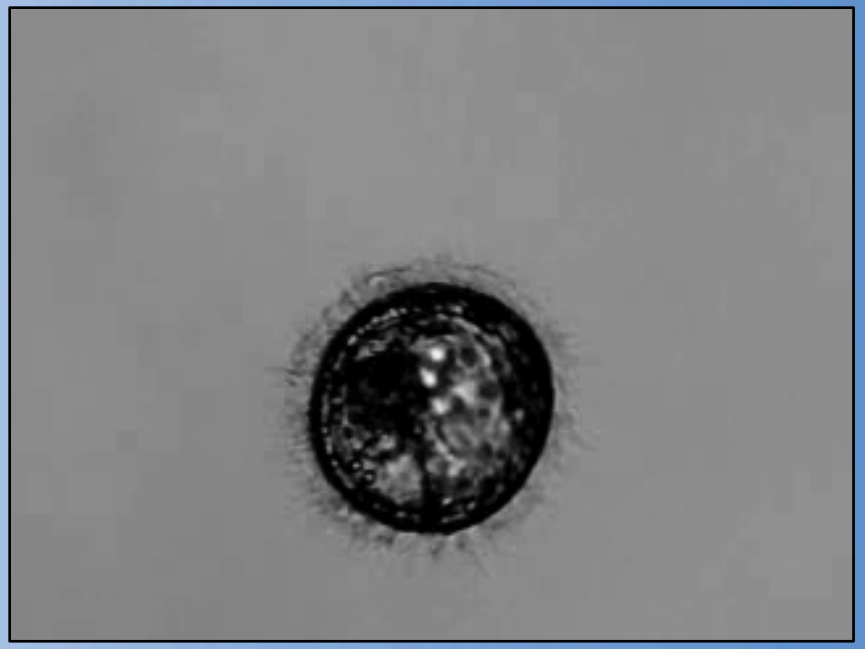
60 minutes post-fertilization



Four-cell embryo

Biology of Mussel Hatchery Culture

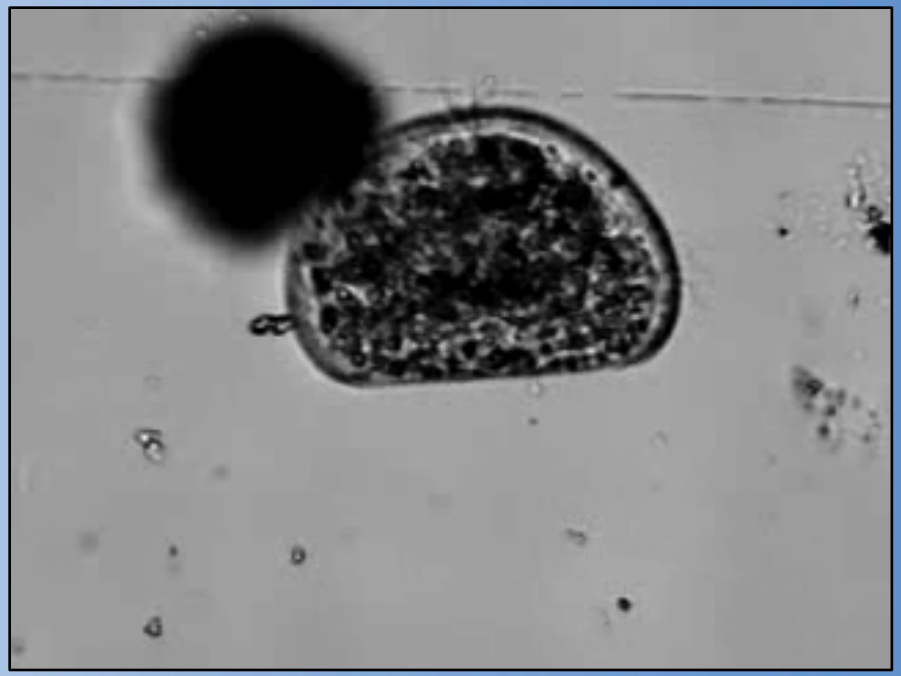
- Hatched blastula
- Ciliated band for propulsion
- Still reliant on yolk nutrients
- 60 – 70 μm in diameter



Video of blastula movement

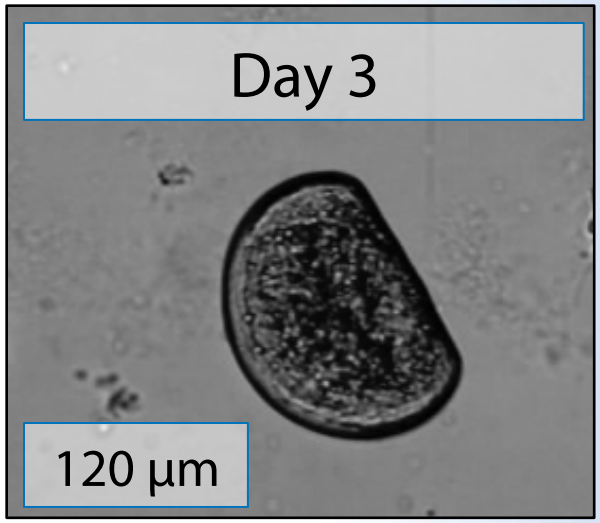
Biology of Mussel Hatchery Culture

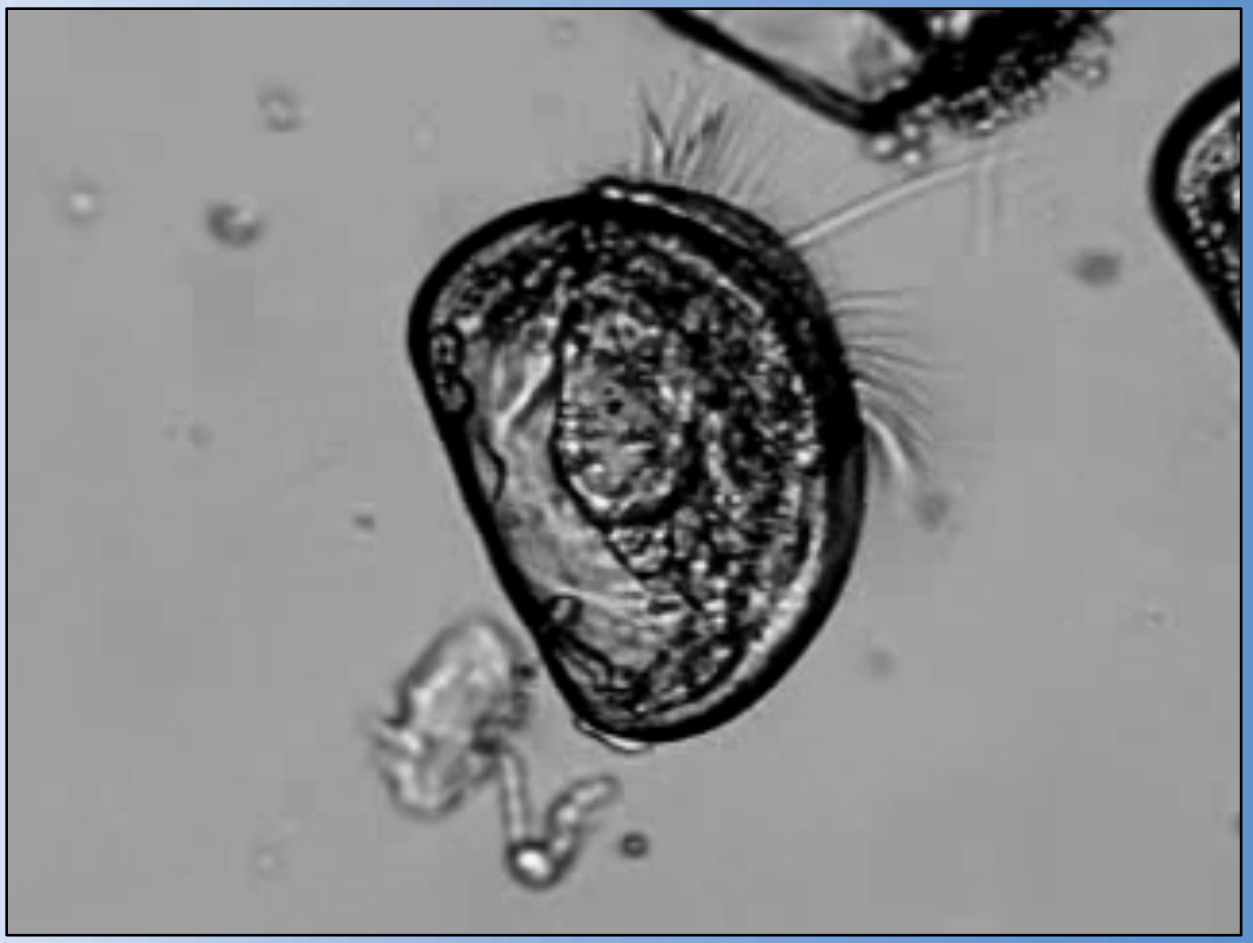
- D-Hinge veliger stage
- Veliger larva is velum-bearing
- Ciliated velum can extend past the shell for filtering particulate food as well as propulsion
- Veliger has formed a thin, translucent shell secreted by shell gland at the hinge



Video of cilia propulsion

Biology of Mussel Hatchery Culture

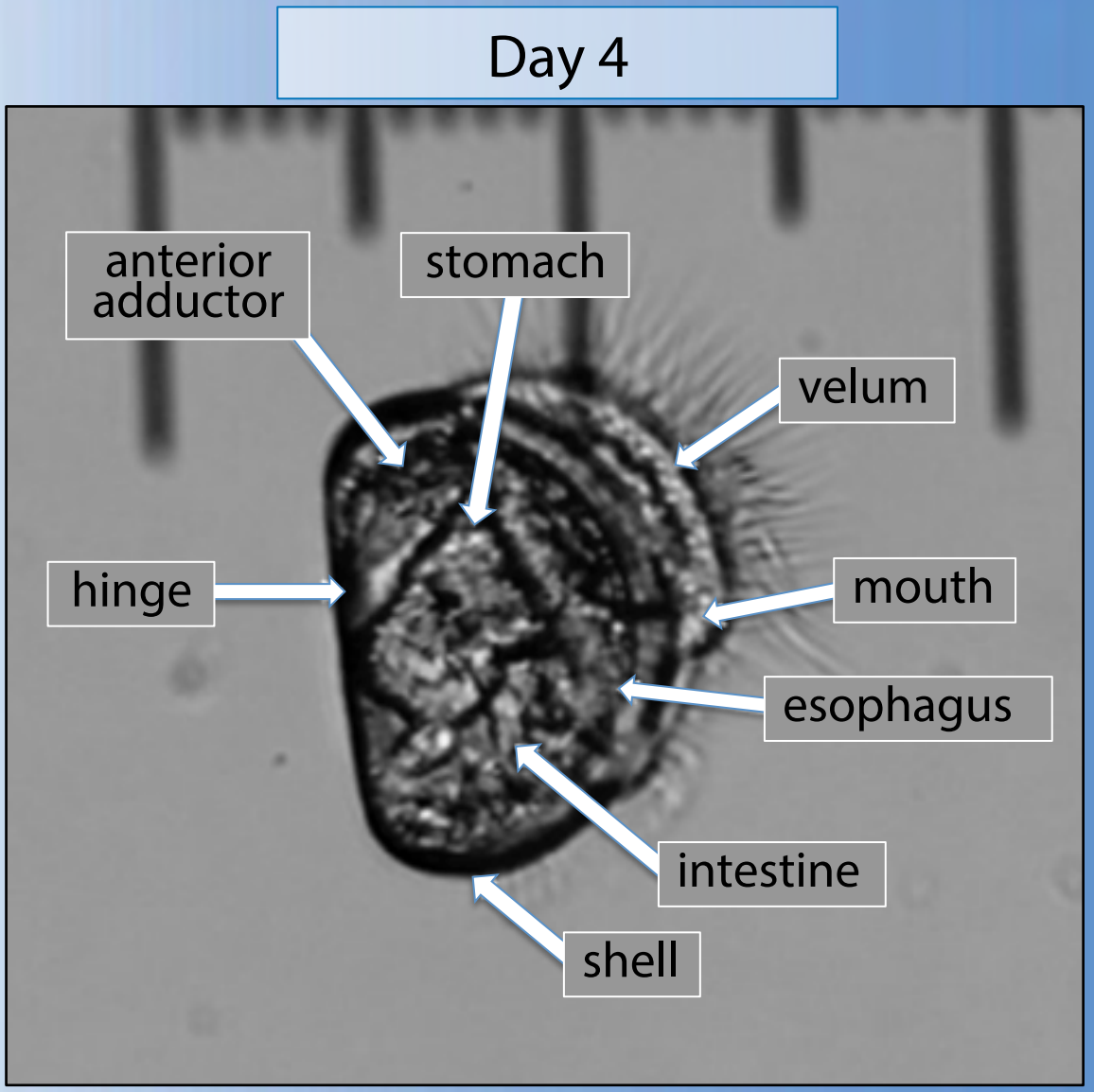




Video of veliger larva extending velum

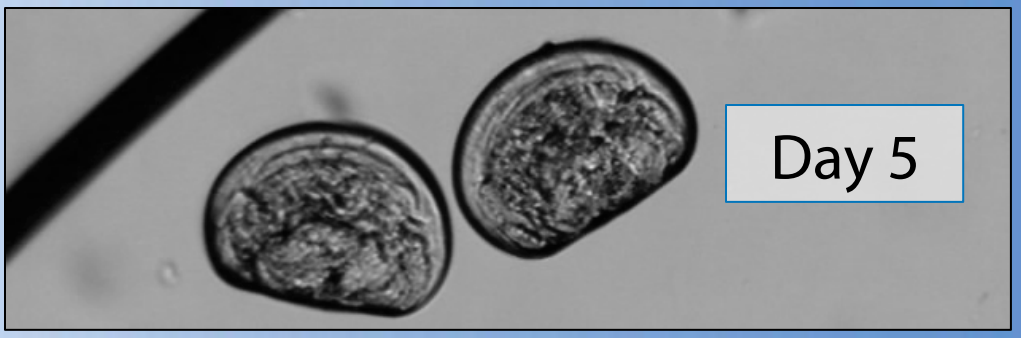
Biology of Mussel Hatchery Culture

- 120 µm
- well-defined velum
- visible digestive system



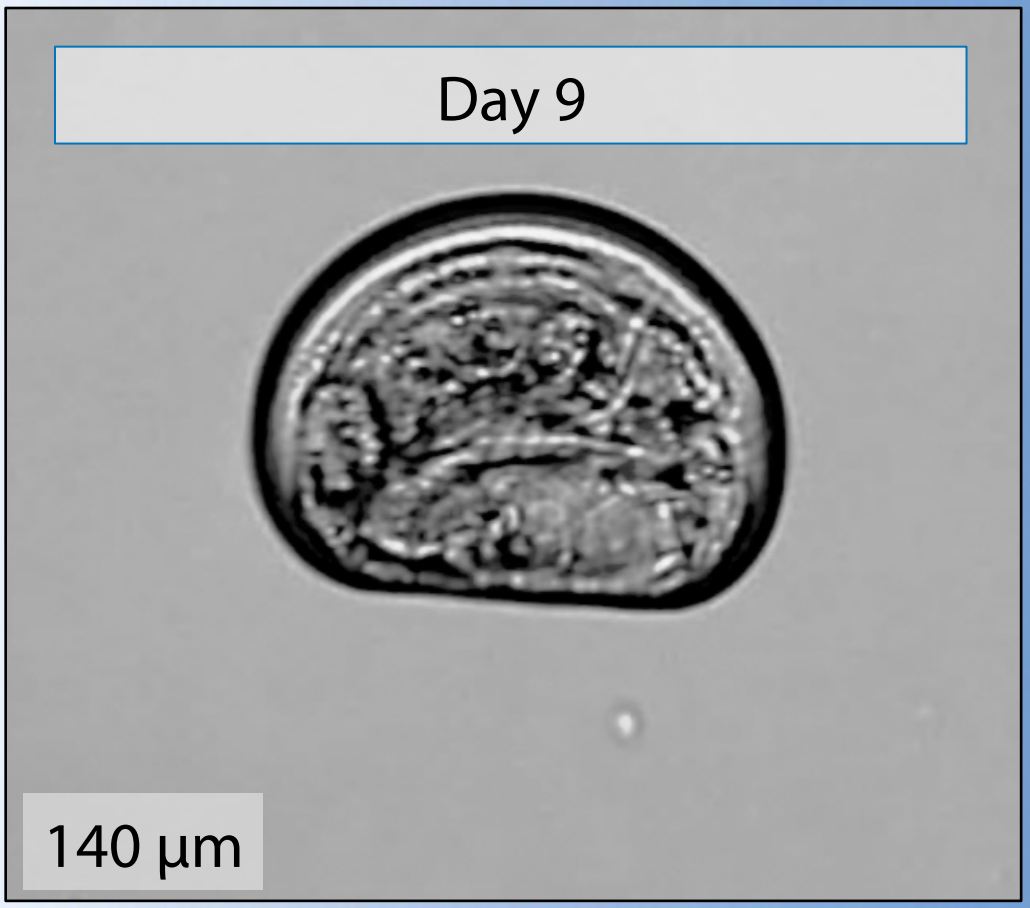
Biology of Mussel Hatchery Culture

- 130 µm
- visible mantle



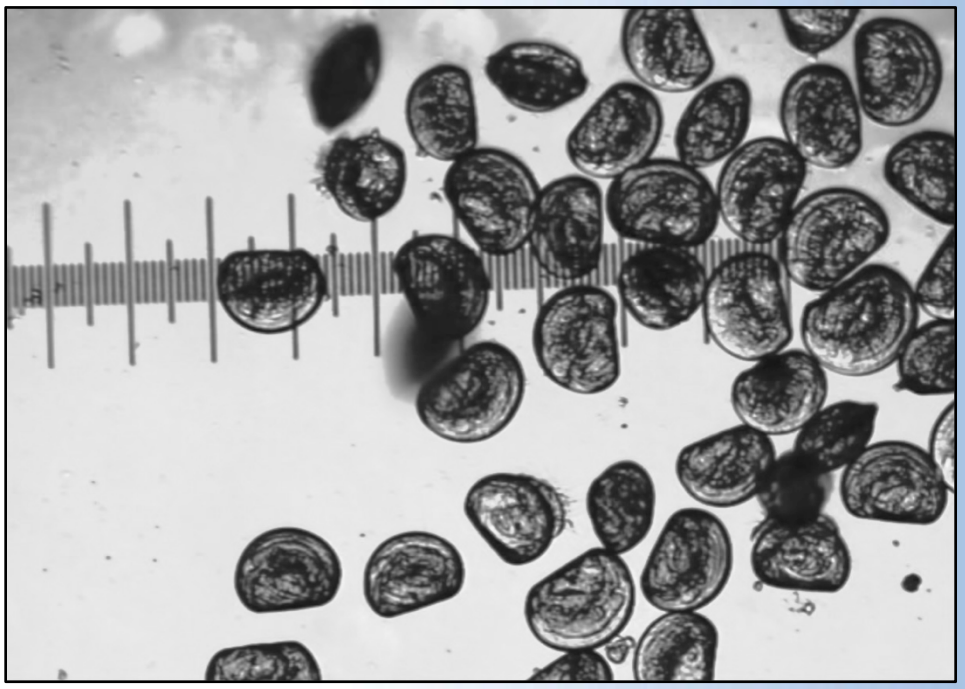
Video of internal movement

Biology of Mussel Hatchery Culture



Biology of Mussel Hatchery Culture

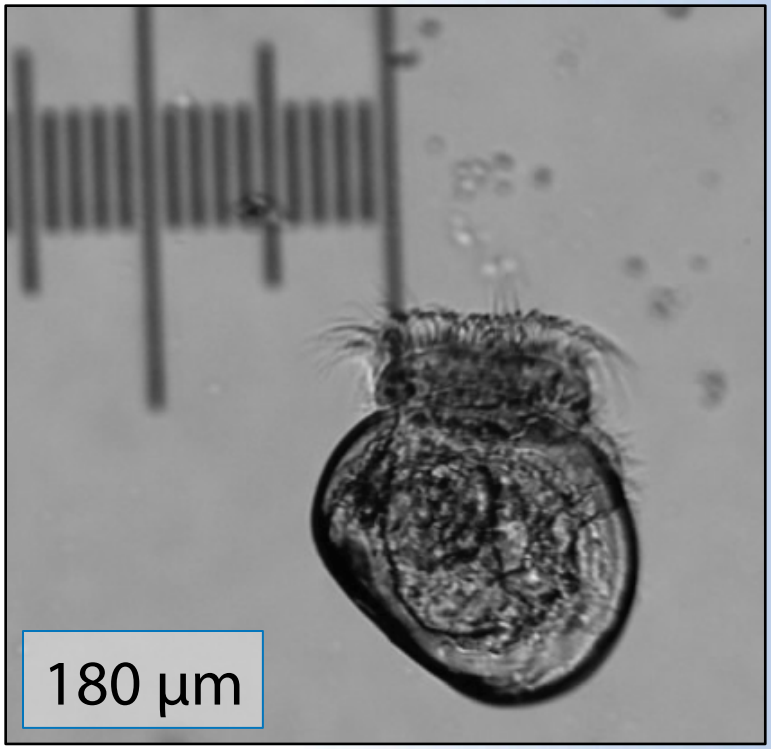
Day 12

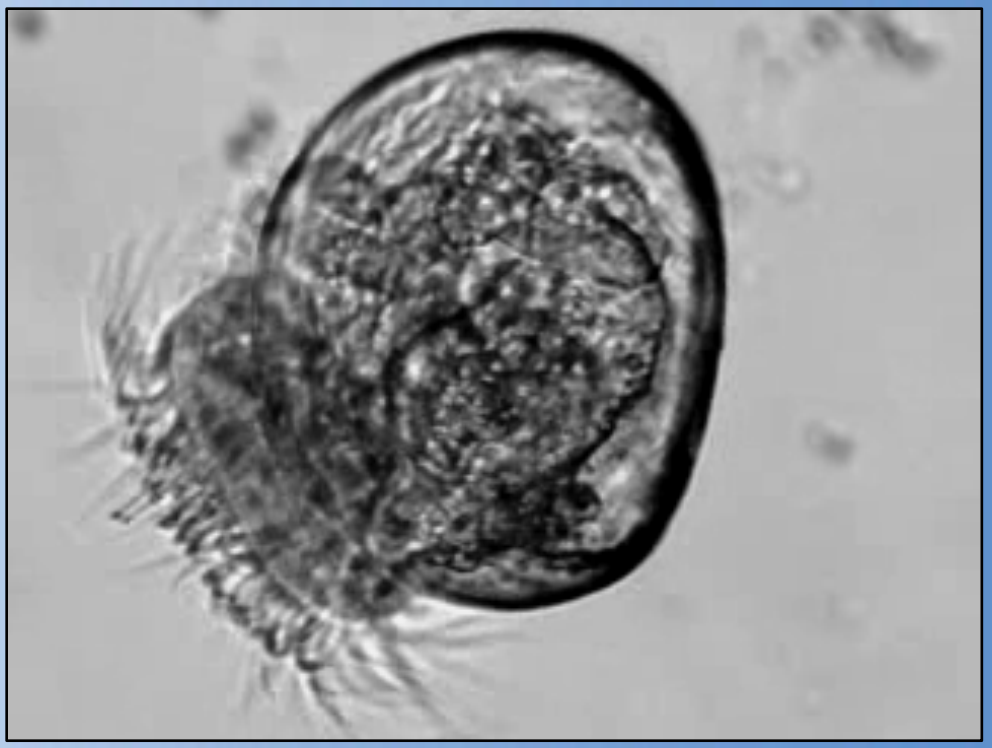


- 170 µm
- Umbo formation visible
  - an umbo is a knob-like growth containing the beak, which is the oldest point of each valve's shell

Biology of Mussel Hatchery Culture

Day 14 | Part 1

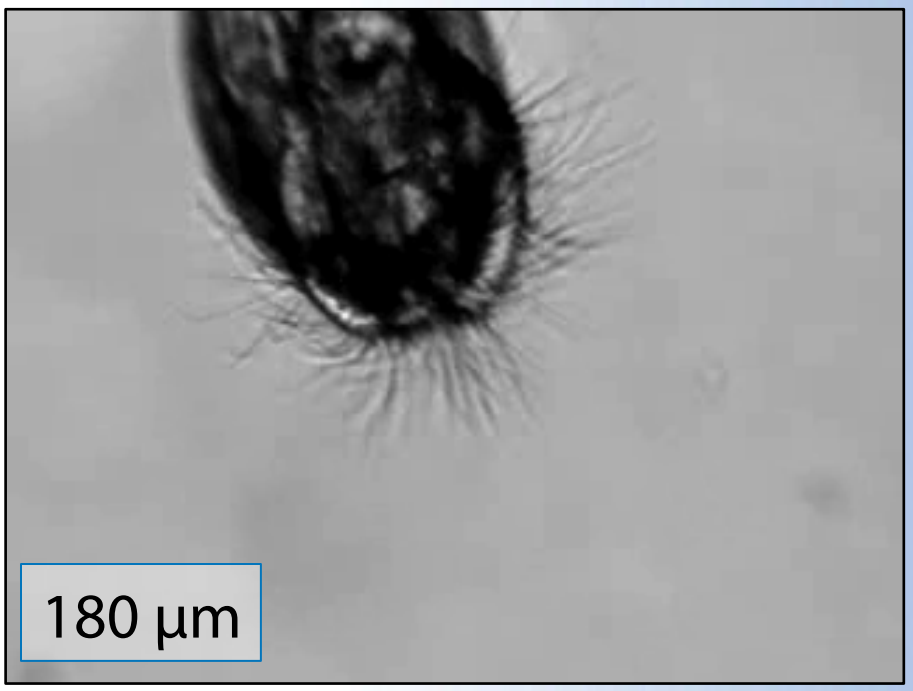




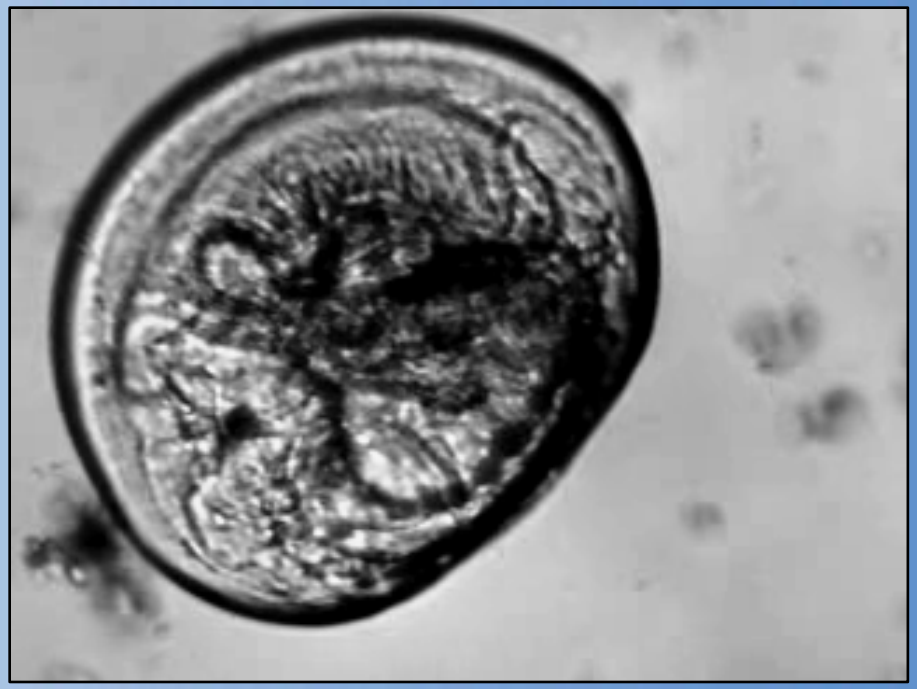
Video of veliger movement from *side*

Biology of Mussel Hatchery Culture

Day 14 | Part 2



Video of veliger movement from *above* (also *spooked* at end)

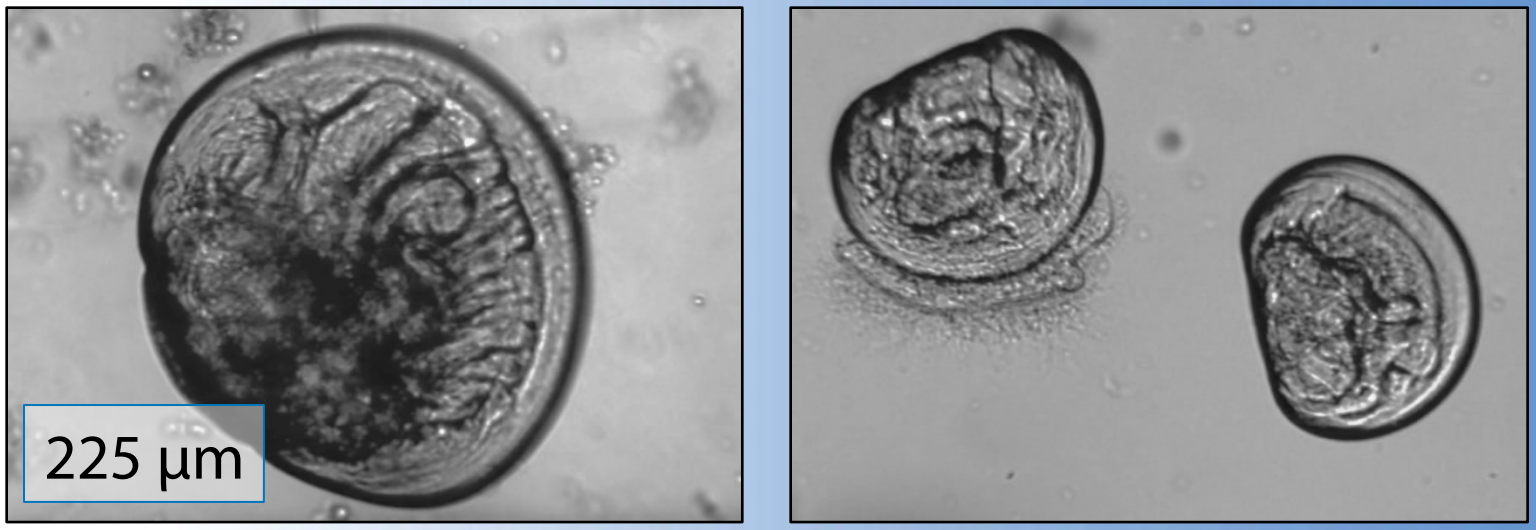


Video of food in larval gut

Biology of Mussel Hatchery Culture

Day 17 | Part 1

- Shell is growing width-wise



Two veligers at same development stage (one with velum *extended* and the other with velum *retracted*)

Biology of Mussel Hatchery Culture

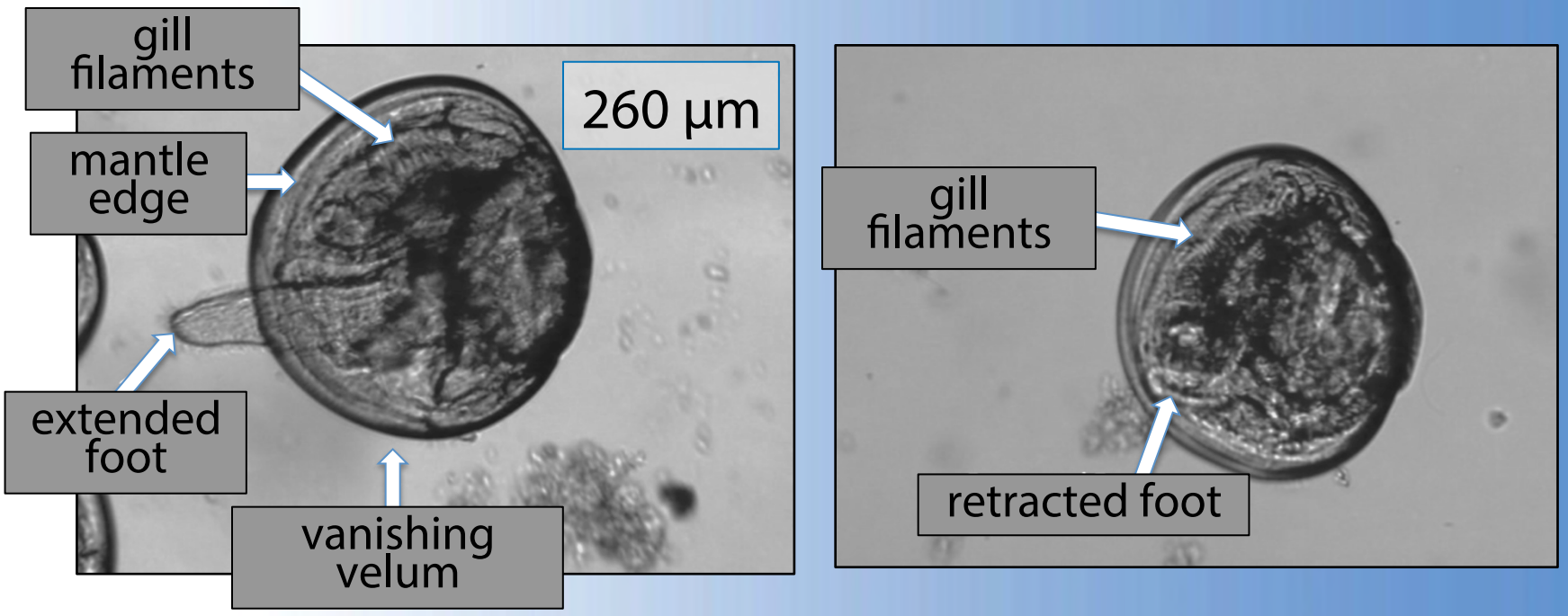
Day 17 | Part 2

Video of internal organ movement

Biology of Mussel Hatchery Culture

Biology of Mussel Hatchery Culture

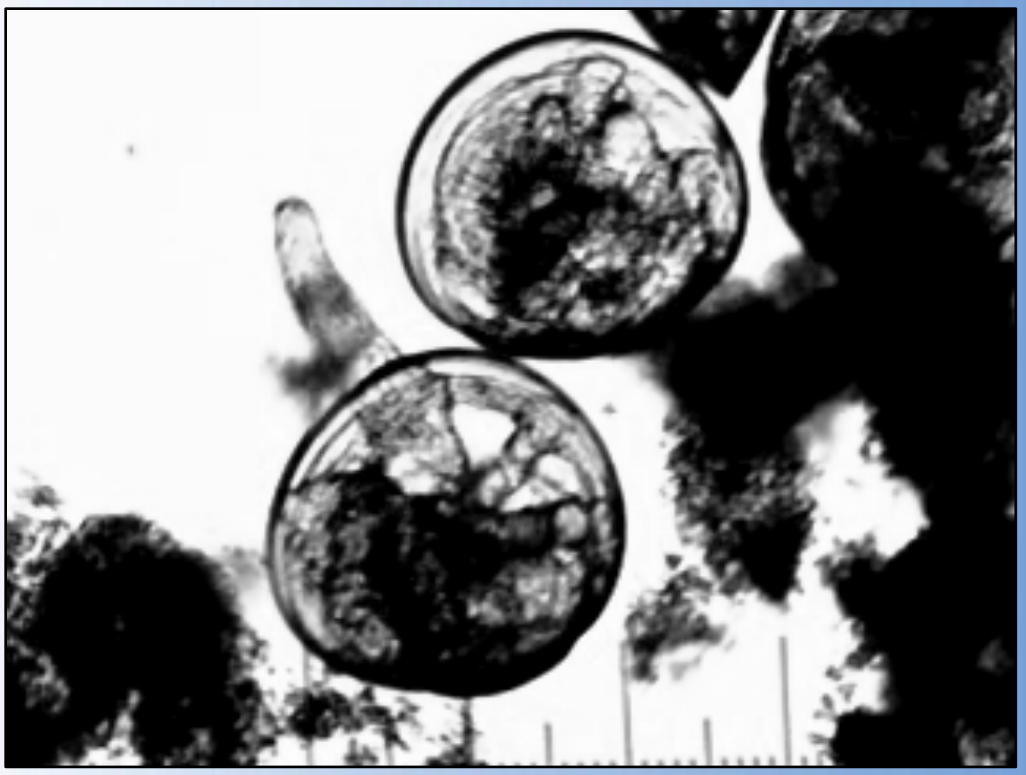
~ Day 25 | Pediveliger Larval Stage | Part 1



- Ready for settlement at 3-4 weeks
- Foot is extending & searching for proper substrate
- Byssal glands are developing
- Gill filaments are visible (at metamorphosis into juvenile state, particle collection function is transferred from velum to gill)

Biology of Mussel Hatchery Culture

~ Day 25 | Pediveliger Larval Stage | Part 2



Video of larva extending foot

Mussel Seed Supply & Hatchery

spawning

~20 days

settlement

30-40 days

out-planting

3-5 months

6-10 months

re-socking

harvest

Woods Hole Oceanographic Institution
Scott Lindell
February 23, 2017

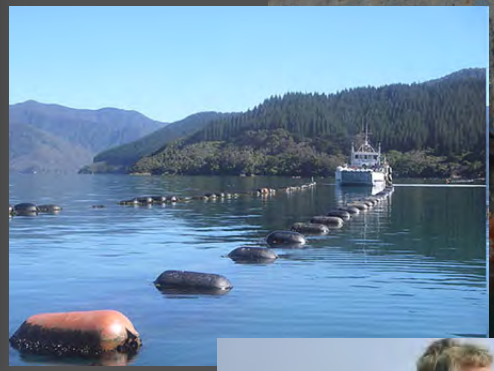
LONG-LINE MUSSEL FARMING
Ventura Shellfish Enterprise Workshop 2

Offshore Grow-out Technologies and Considerations

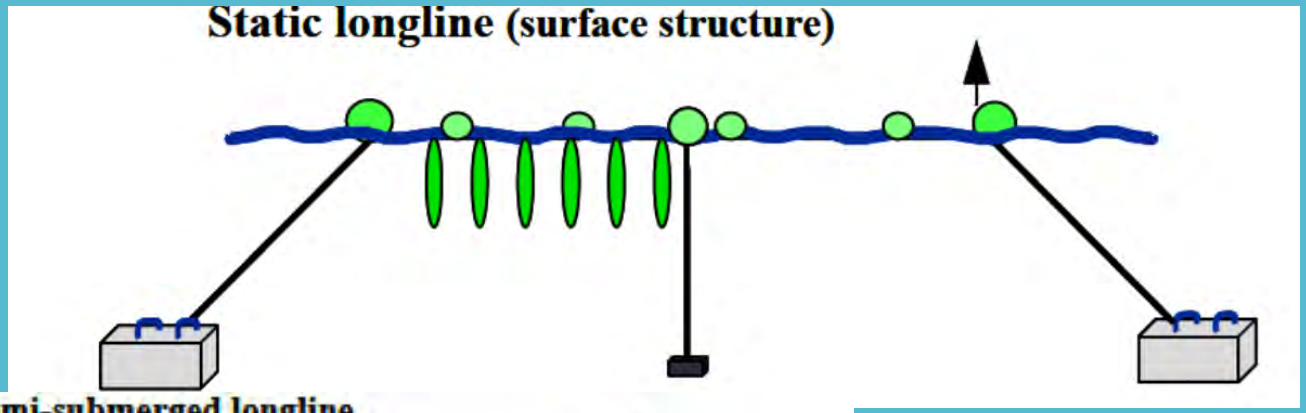
Mussel Farming Video

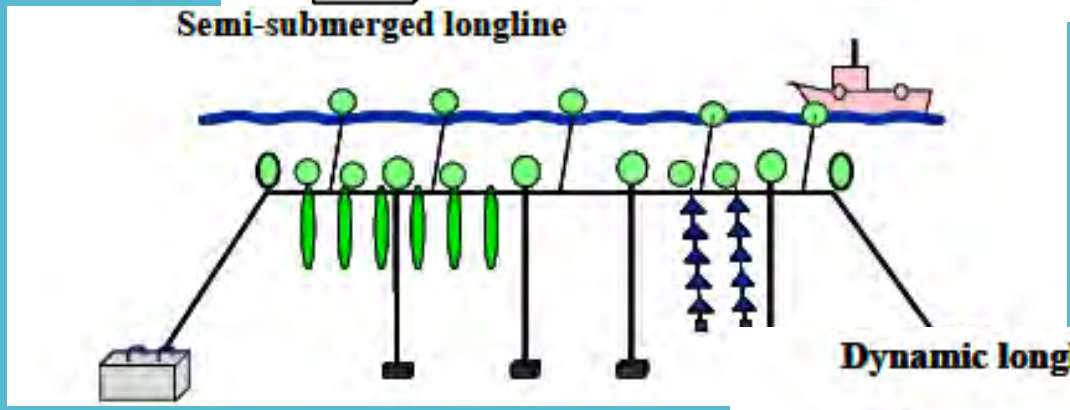
New Zealand Mussel Farming video can be viewed on <Resource Center> page of VSE website

Mussel Farming Around the World



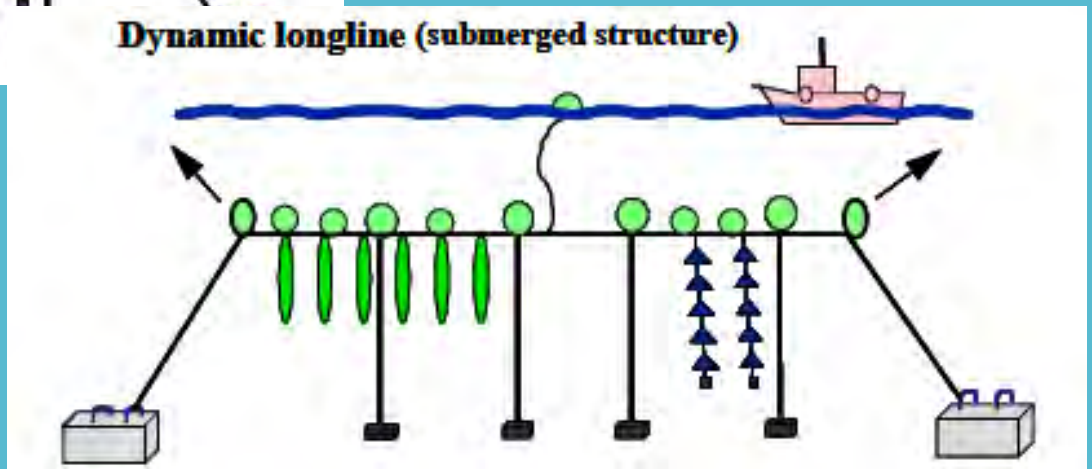
Surface and submerged longlines





Up to half buoyancy on surface

All buoyancy submerged



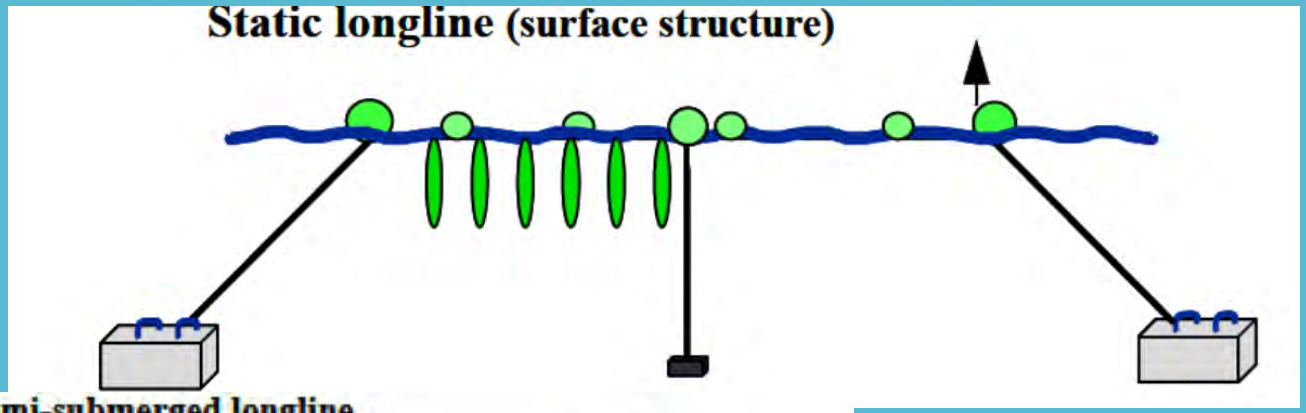
BACKGROUND – Siting considerations

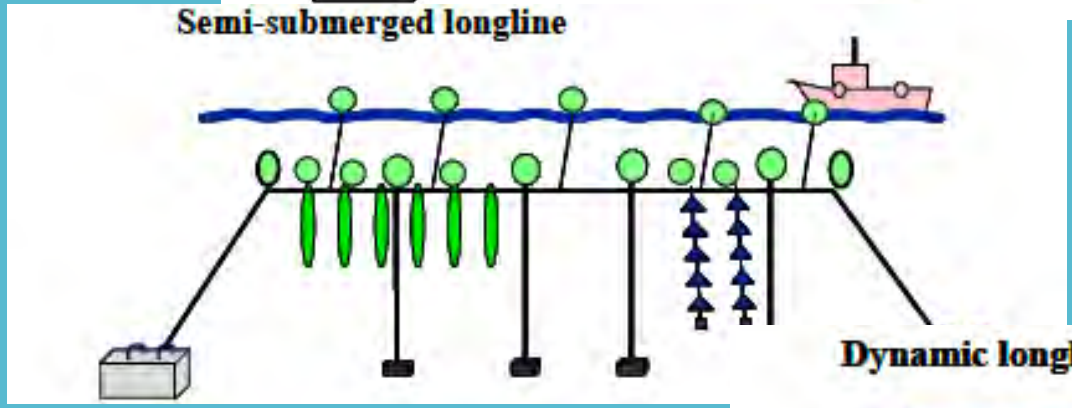
- Depths - anchors (20 to 60 m) and headropes (3 to 15m)
- Bottom types – selection of anchors to suit soft or hard bottoms
- Waves – hard to work in seas > 2 m (depends on boat)
- Wind – hard to work when > 30 km/h (depends on boat)
- Currents - Optimum (10 – 80 cm/sec) and maximum (1m/sec)
- Orientation of lines – almost parallel to prevailing wind and/or longshore current

Mussel farming technology choices

- Architecture of culture lines (Longlines)
- Anchors and buoys
- Socking and associated machinery
- Boat and boat design
- Processing

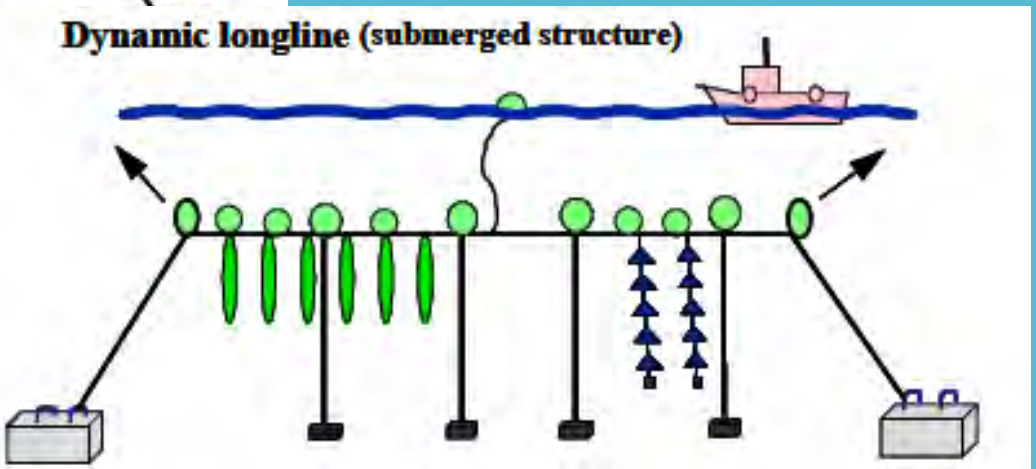
Semisub. or submerged longlines?





Up to half buoyancy on surface

All buoyancy submerged

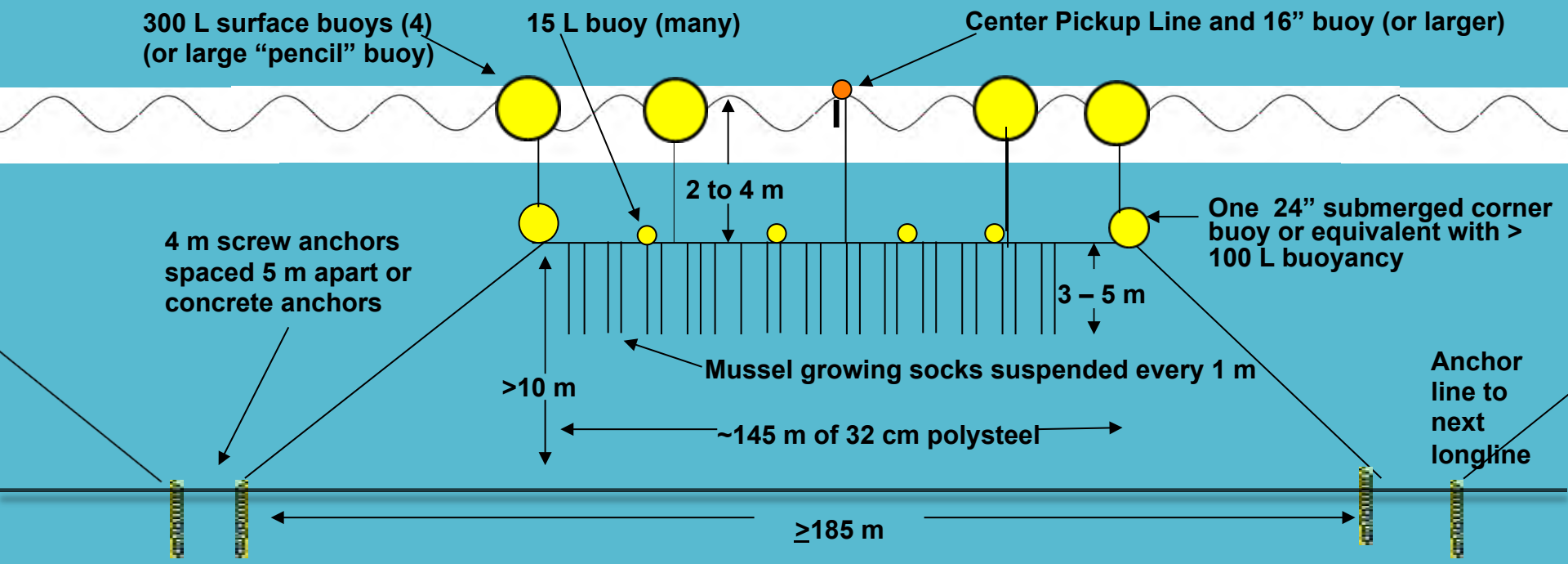


Advantages & disadvantages of surface buoys

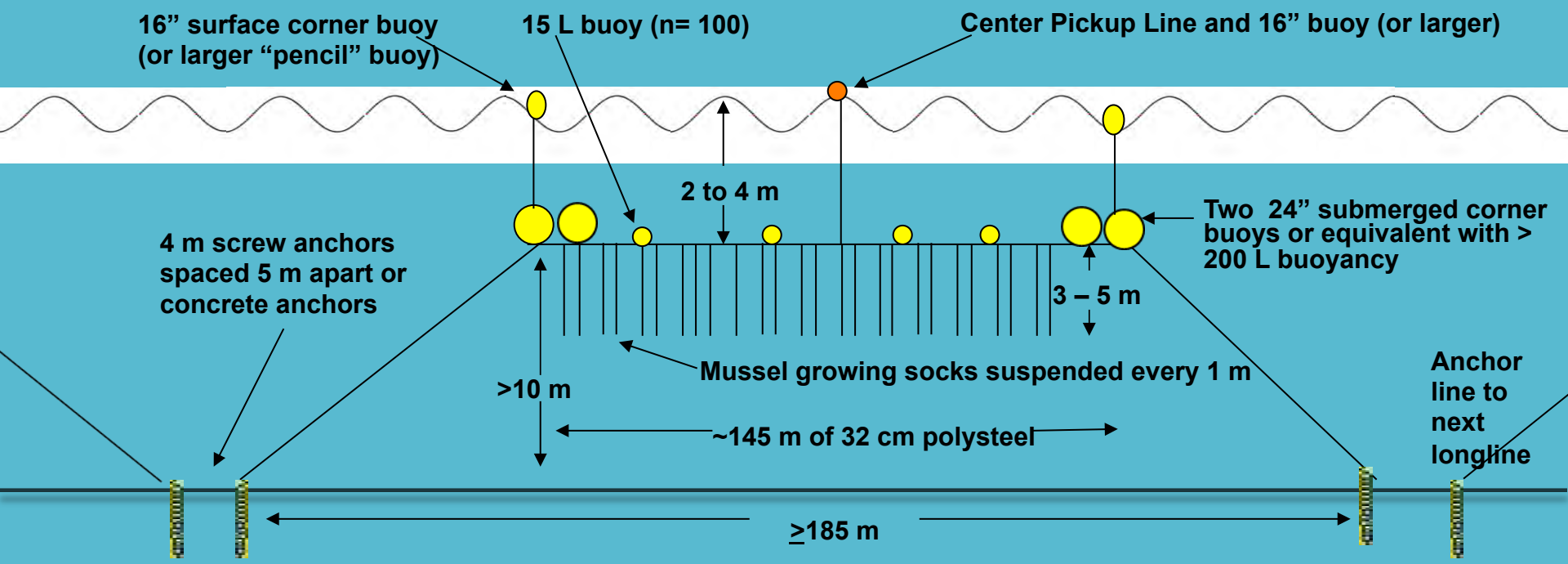
- ✓ Lower cost – less robust
- ✓ Easier to detect problems below

- Higher risk of storm damage, advert for duck predation
- **Not suitable to only use surface buoys in unprotected coastal waters. Best to minimize.**

General plan for **semi-submerged** longlines



General plan for **submerged** longlines



1. Anchor lines should have 3:1 scope from anchor to submerged corner buoy
2. Submerged buoyancy keeps lines tight despite surface waves and storms

Mussel growing technology choices
Longline materials

Long lasting, workable lines – “poly steel”

- For anchor and headrope
- Attach via splices and knots
- Avoid chain and shackles

Twine (4mm poly) for attaching socks to line
(< 1,000 pounds breaking strength)

Mussel growing technology choices

Anchors

- Must consider sediment type, depth, wave and current exposure

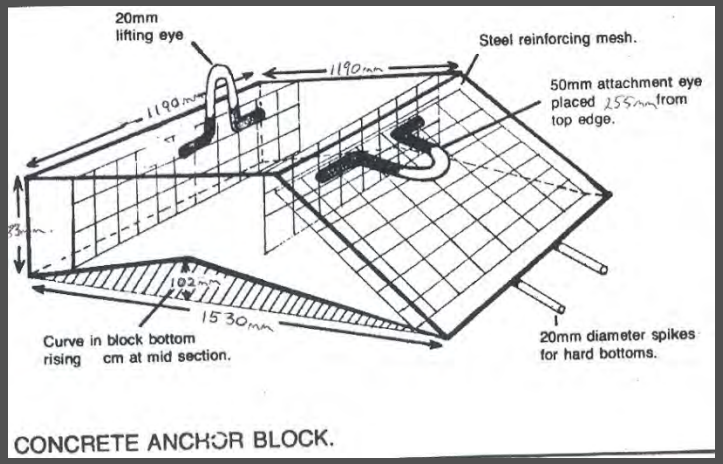
- Cheapest = deadweight concrete block
  - But only 55% of weight underwater
  - Typically shift even in soft sediment

- Drag embedment type anchor
  - Deployable from small boats
  - Also prone to failure in storms

Mussel growing technology choices

Anchors

- Shaped concrete anchor = cheap and effective



CONCRETE ANCHOR BLOCK.

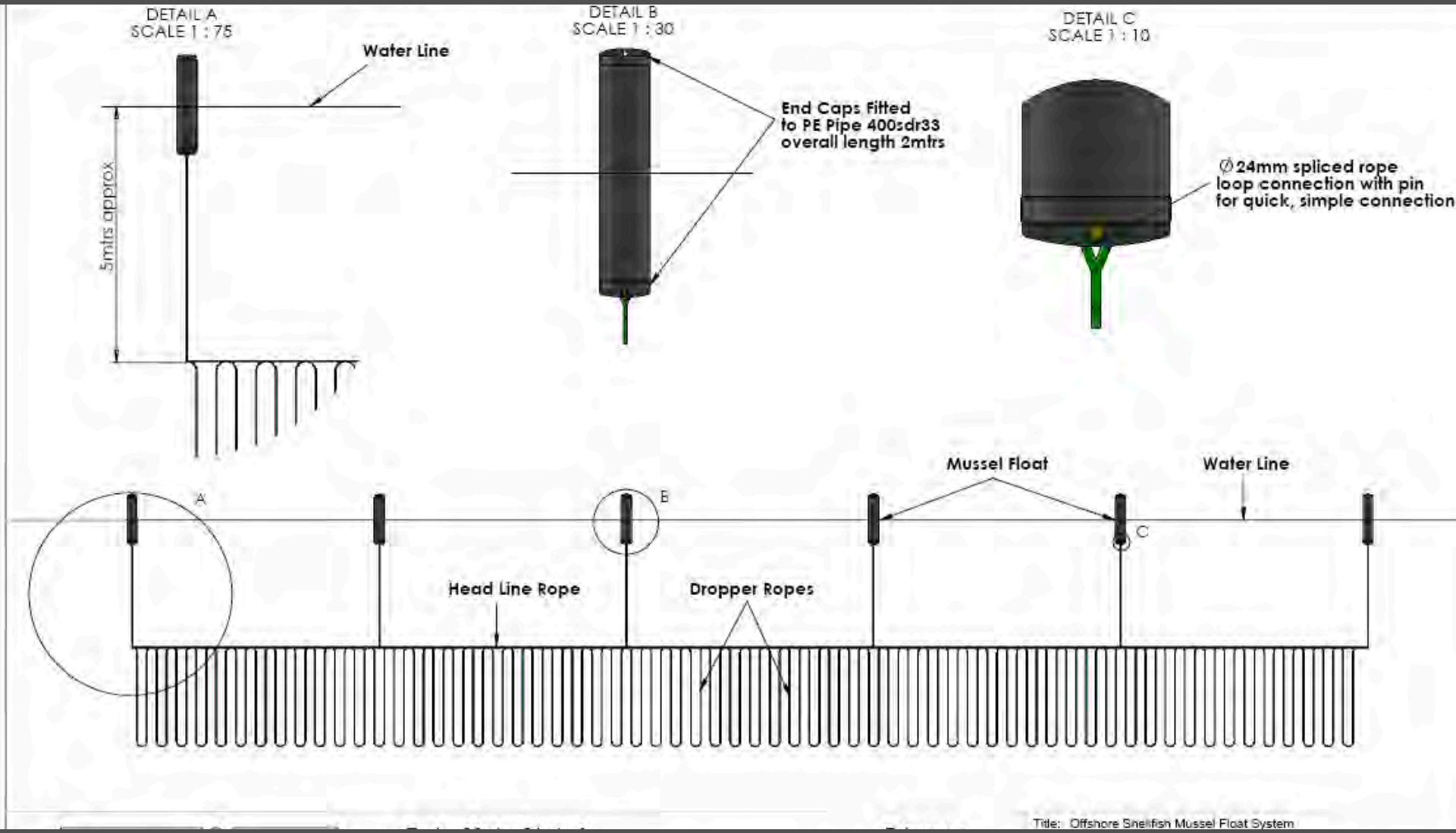
- Screw anchors = most effective

3 m to
6 m deep

Mussel growing technology choices
Buoys, floats

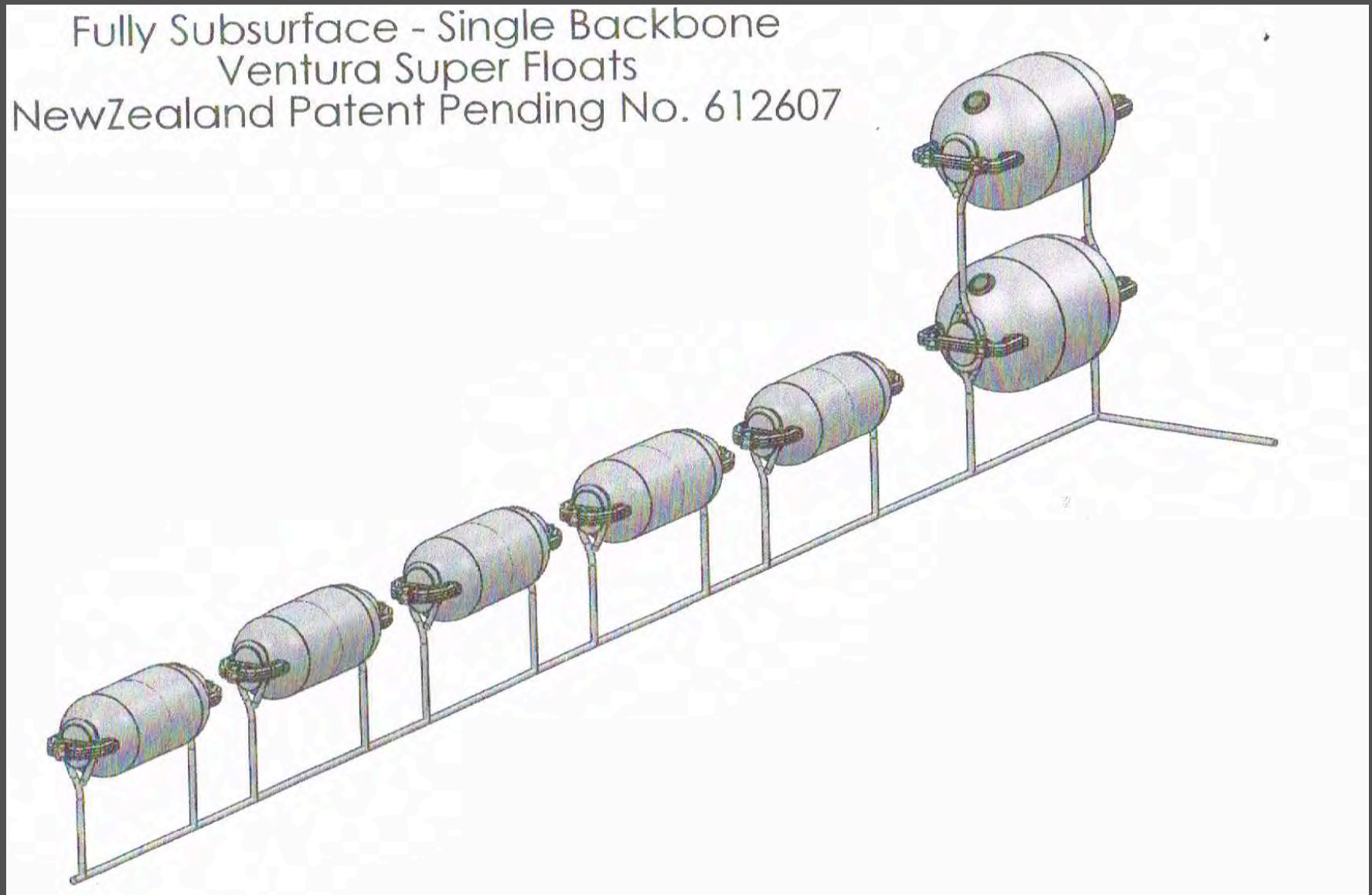
- Durable, submersible, strong attachment point
- Double attachment best
- 200 to 300 L corner buoys
- Custom pressurizable

UK 200 Liter Pencil Buoys



Surface view of Pencil Buoys

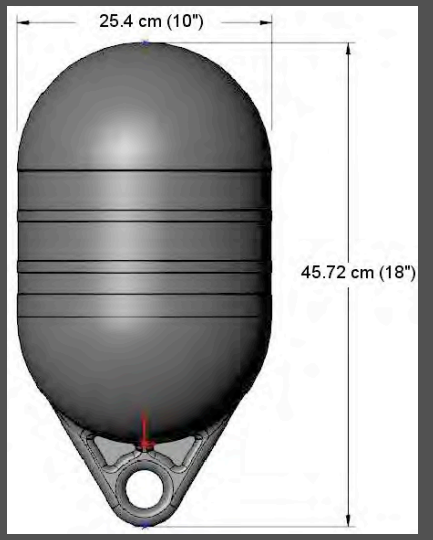
NZ Corner Buoy Example



Mussel growing technology choices

Buoys, floats

- Big investment
  - Need at least 2,000 L per line (10’ socks)
  - Estimate of 3 L for every 10 kg of mussels



- Even distribution is important – 70 x 15 L buoys
- Plan for successive additions thru grow-out cycle
- Surface marking “high-flyers”

Mussel growing technology choices
Continuous socks or droppers

Choose between pegged ropes,

loopy rope or mesh tubes

Each requires different investment of

machine and labor

Mussel growing technology choices
Continuous socks

- Consider machines and boat size for installing and working

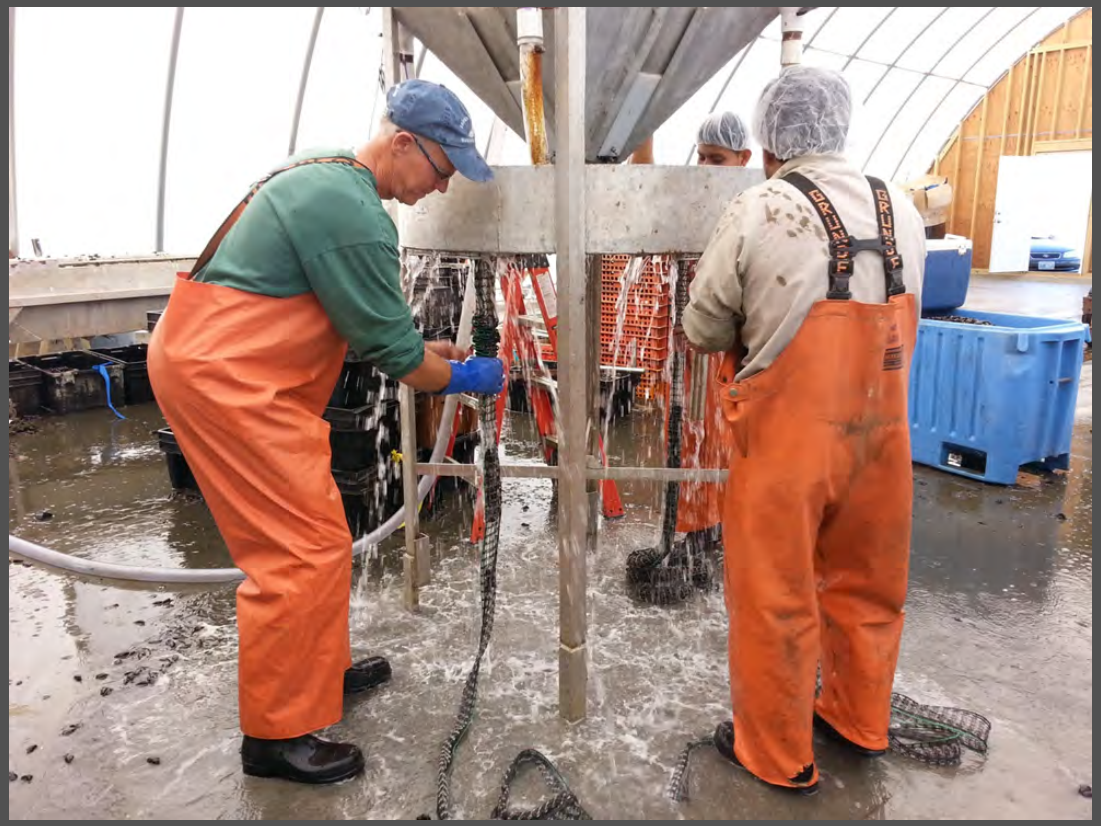
- NZ machine more automated and faster
  - –Bigger and more costly, too

- Spanish machine more versatile
  - –With or without pegs
  - –Continuous or single droppers
  - –Compact – fits on small boat

Mussel growing technology choices
Single droppers – "Canadian" socking

- Shore-side socking is an option
- Canadian 4-person socking table
  - Requires good grading of seed before hand
  - Slower but consistent

Slower to harvest, too



Mussel growing technology choices

Considerations for continuous socks or single droppers

Consider need for pegs or discs to stop drop-off

Consider need to stop predation (sea ducks) with longer lasting cotton or protective mesh (or lowering depth of headrope where practical)

Consider length of droppers vs. the weight that the boat can safely lift

Mussel growing technology choices

Work boat requirements and design

- Minimum size (12 to 15 m) for stability
- Hauler at a minimum, on a crane is best
- Starwheels on rail
- Sonar/depth finding device
- Deck space for socking and harvest

Hydraulic Starwheel

Free Wheel

Re-purposed fishing vessel

Mussel growing technology choices

Work boat requirements and design

Need large deck space for machinery and product
Deck crane is very useful

Same boat fully loaded with market product

Mussel growing technology choices

World class work boat designs

New Zealand

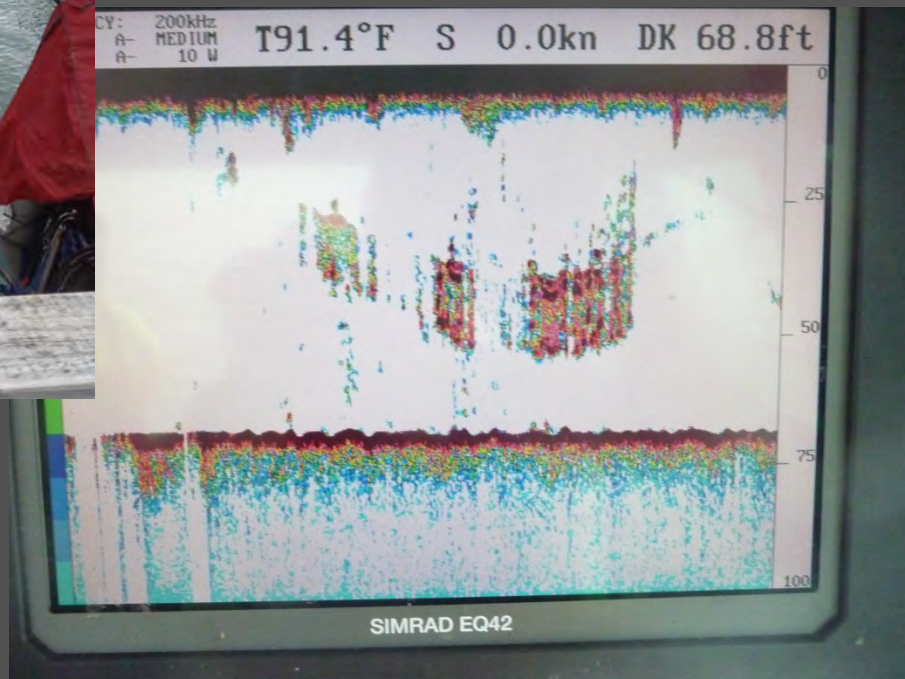
U.K.

Mussel growing technology choices

Work boat requirements and design

NZ boat deck close-up

Depth sounder view of line



Equipment Needs

- **To own, to share or to contract?**
- Stripper, washing, cleaning (mussels and rope)
- Declumper/grader for seed AND market mussels
- Socking Machine
- Debyssing machine
- Bagging and weighing
- Shore facilities (storage, ice, depuration?)

Farm and Process Equipment – Low End ~$25,000

Spanish socking machine

Spanish Declumper and Grader Machines
0.5 ton per hour capacity

Farm and Process Equipment – Hi End ~$150,000

NZ socking machine

NZ Declumper and Grader Machines
2 to 3 tons per hour capacity

The future of mussel farming??

Current PEI = 10,000 acres, 38 Million pounds/yr, $23M value
NZ = 12,000 acres leased, 190 Million pounds/yr, $185 M Export

Offshore Mussel Farming Examples Worldwide

Where	Who	Lease	No. of lines
England	Offshore Shellfish Ltd.	3,805 acres	100 lines (800)
Iceland	Blueshell	9,768 acres	172 long lines (closed)
NZ, Opotiiki	Whakatohea Ltd.	9,500 acres	150 lines (1,000)
Portugal	Testa & Cunhas	400 acres	180 lines
NH, USA	2 fisherman	20 acres	6 lines
RI, USA	2 fishermen	10 acres	10 lines
MA, USA	1 fishermen	40 acres	5 lines (10)
Offshore MA	fisherman, SSU	2 x 30 acres	1 line (50)

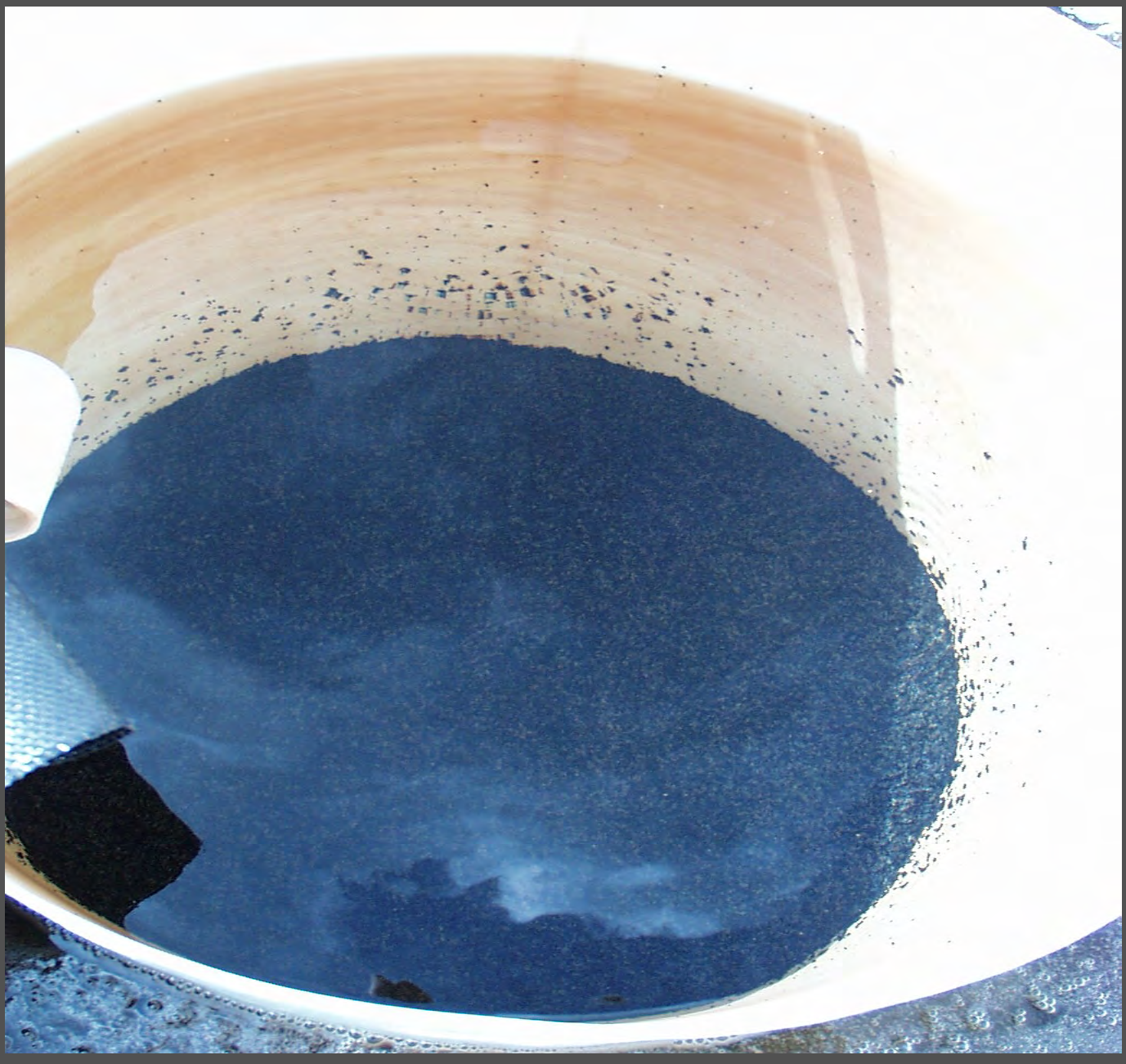
Conclusions

- It is easy to start-up with minimal cost
- It takes plan & investment to be cost-effective
- Consider available marine resources & markets
  - Boat sizes and labor force/costs
- Integrate more mechanization with expansion

Suspension Culturing Mussels.

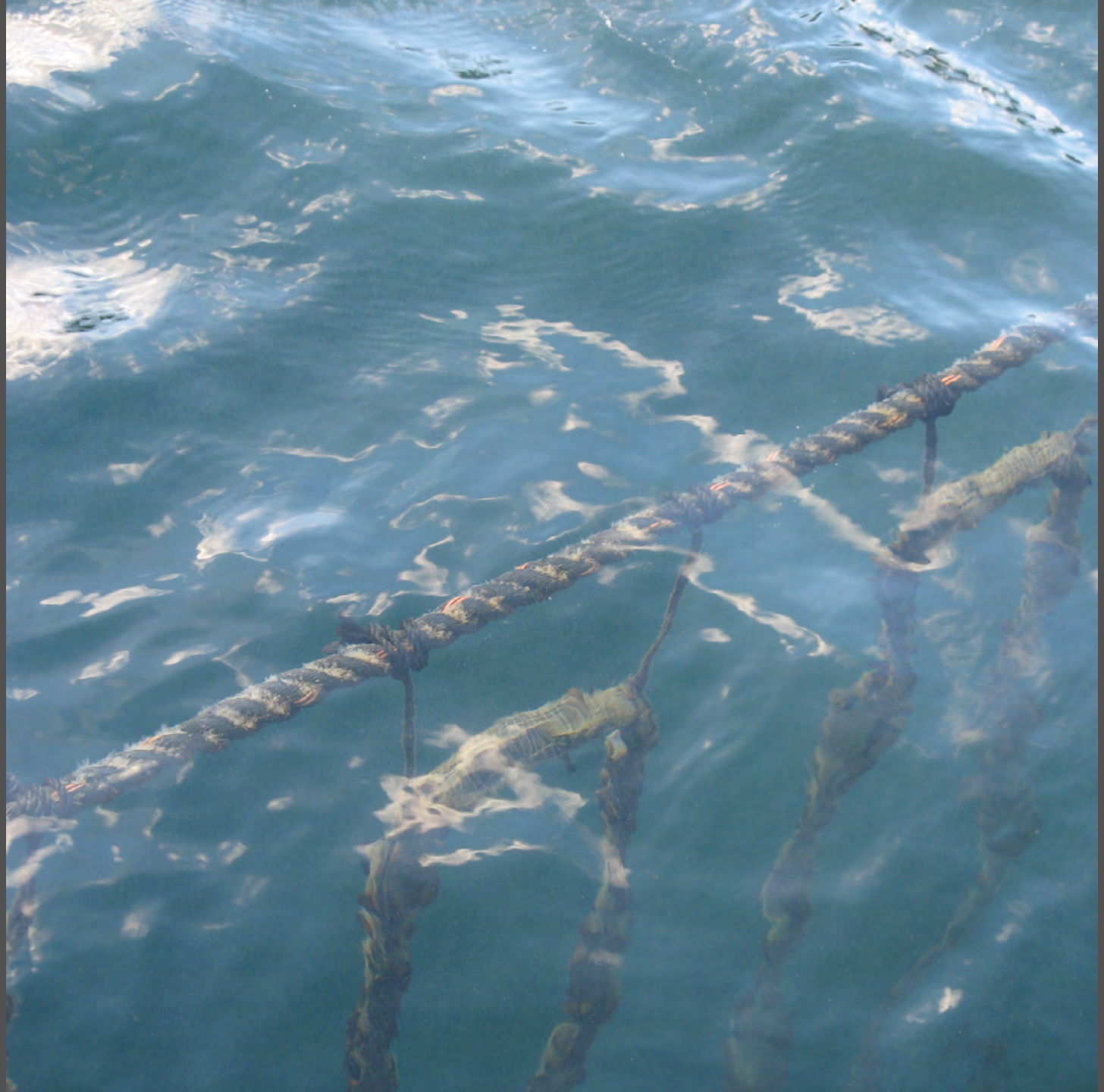
Gordon King
Taylor Shellfish Inc.

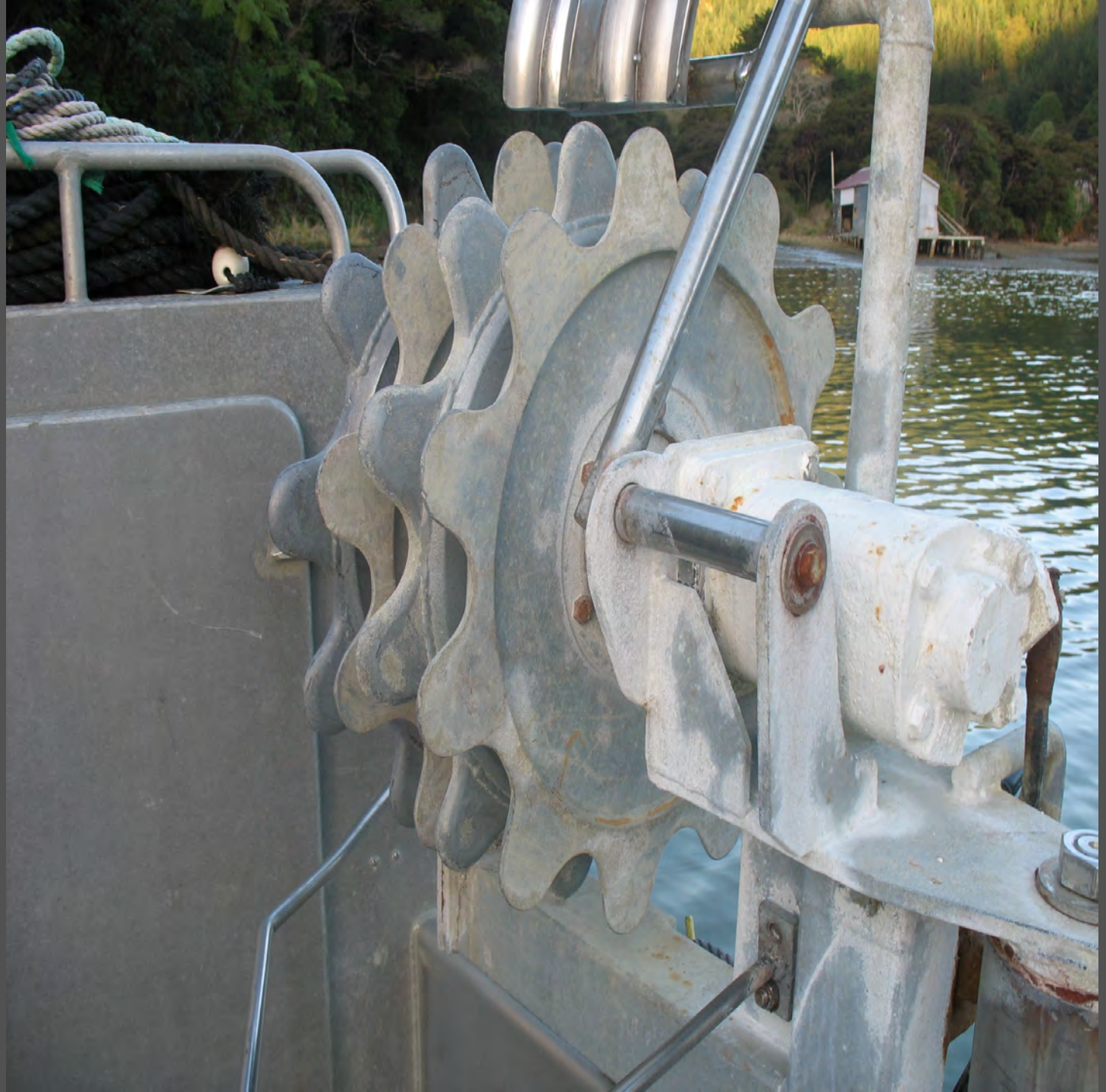
Hatchery Seed




CAROLINA

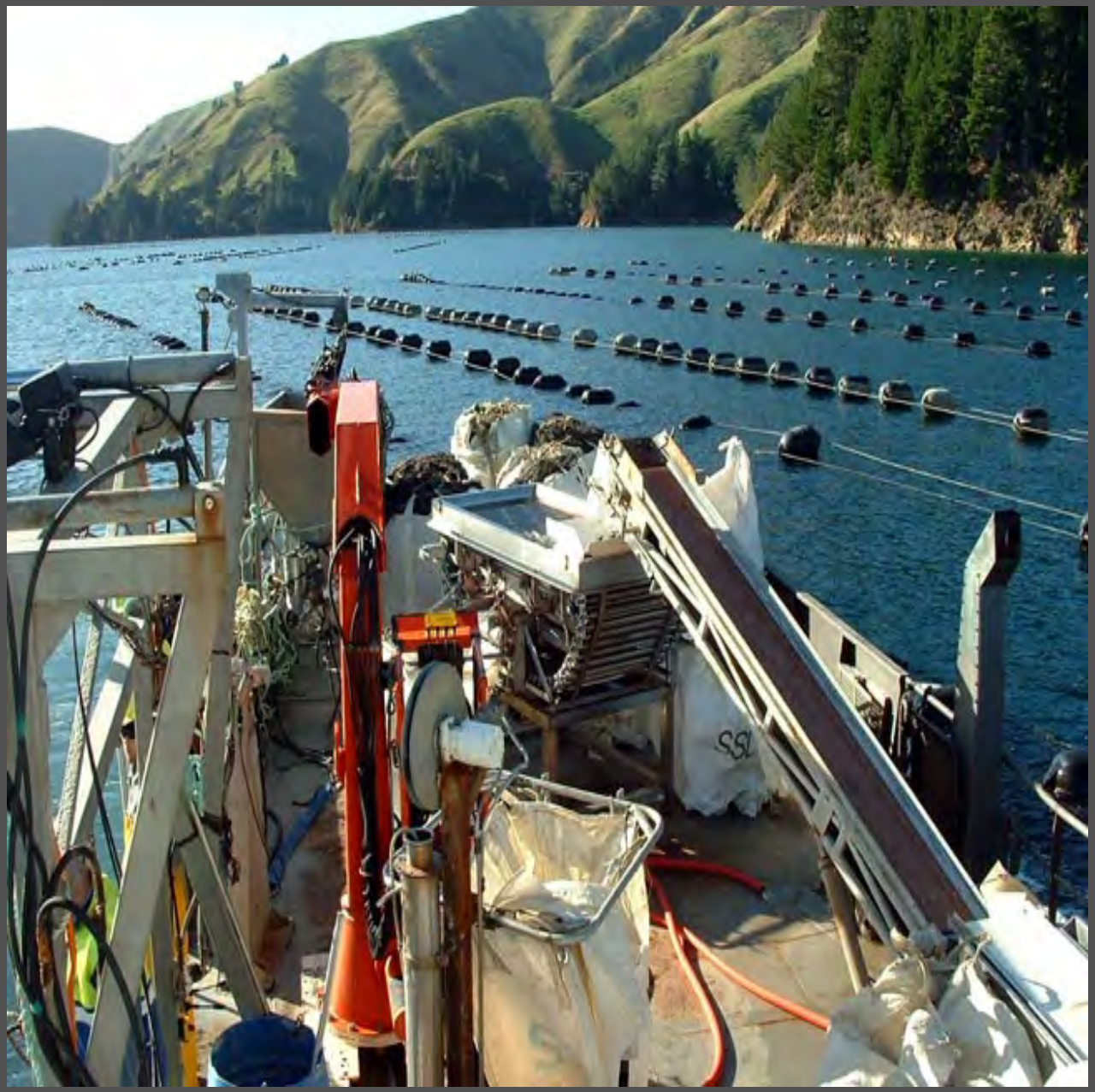

SPEEDO



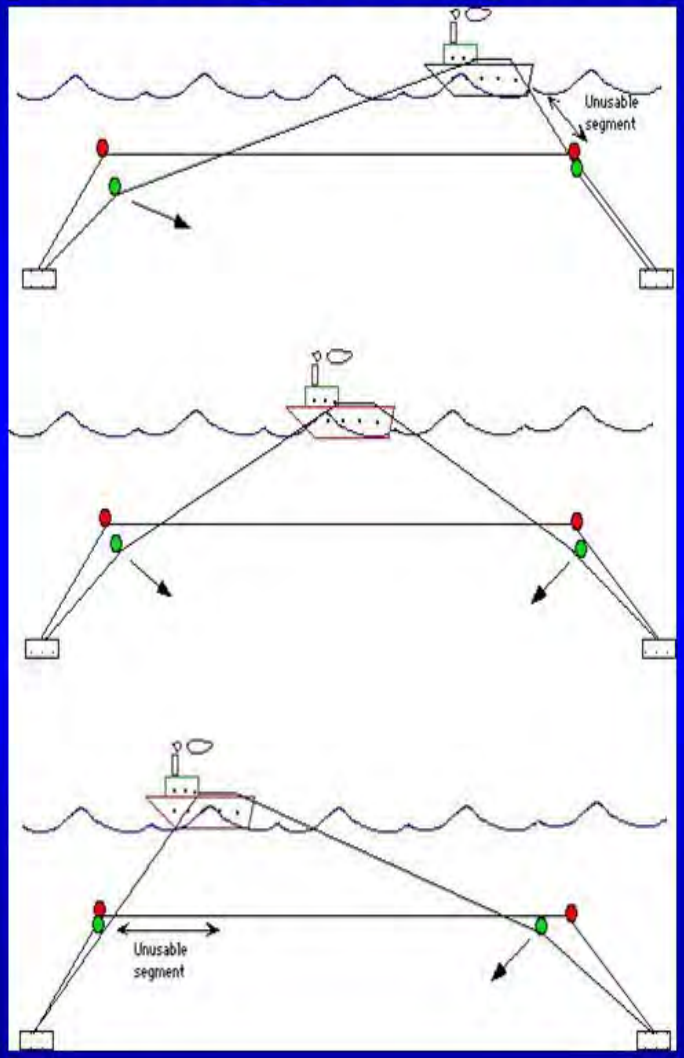



TE A


YAMAHA
V6 200



Submerged Longlines



cinemar

Q & A | Community Discussion

Please try to keep your questions and comments under 3 minutes so that everyone has a chance to provide their input and feedback

Please use the portable microphone so that your questions can be heard in the video being captured by CAPS Media

Registration/Sign-In

Registration cards can be placed in the white drop box near the main entrance


Workshop Registration

Email Address

Affiliation

First Name

In which state do you reside?

Last Name

In which city to you reside?

With which stakeholder group do you most closely identify?

How did you hear about the workshop?

Suggest a future workshop topic?

Join Mailing List? Y N

Why register?

Reserves a seat at future VSE workshops

Puts you on our mailing list to receive project news and updates

Helps us plan ahead for future workshops

Links you to our survey system, where you can offer anonymous feedback and express your views on any aspect of the VSE project

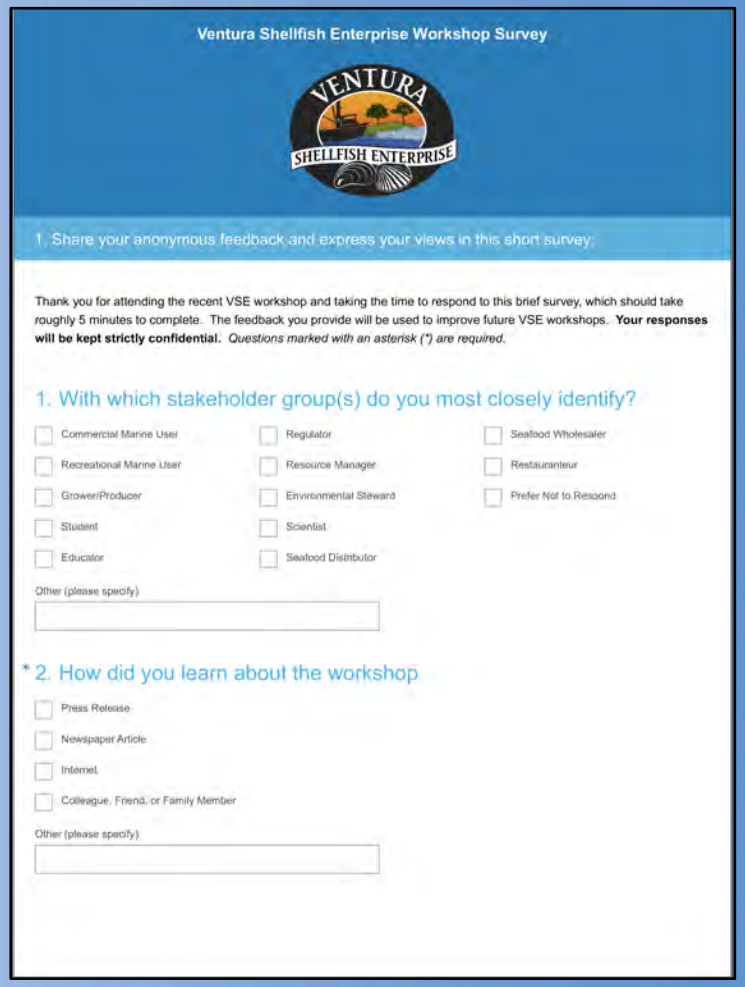
Online Survey

www.venturashellfishenterprise.com

Your feedback is central to the success of the VSE

Registered guests will receive a link to a brief online survey

- Survey is anonymous
- Takes ~ 5 minutes to complete
- Allows you to rate certain aspects of this workshop
- Provides an opportunity for you to express your views on any aspect of the VSE project



Ventura Shellfish Enterprise Workshop Survey

1. Share your anonymous feedback and express your views in this short survey.

Thank you for attending the recent VSE workshop and taking the time to respond to this brief survey, which should take roughly 5 minutes to complete. The feedback you provide will be used to improve future VSE workshops. **Your responses will be kept strictly confidential.** *Questions marked with an asterisk (*) are required.*

1. With which stakeholder group(s) do you most closely identify?

Commercial Marine User
Recreational Marine User
Grower/Producer
Student
Educator
Regulator
Resource Manager
Environmental Steward
Scientist
Seafood Distributor
Seafood Wholesaler
Restauranteur
Prefer Not to Respond
Other (please specify)

* 2. How did you learn about the workshop

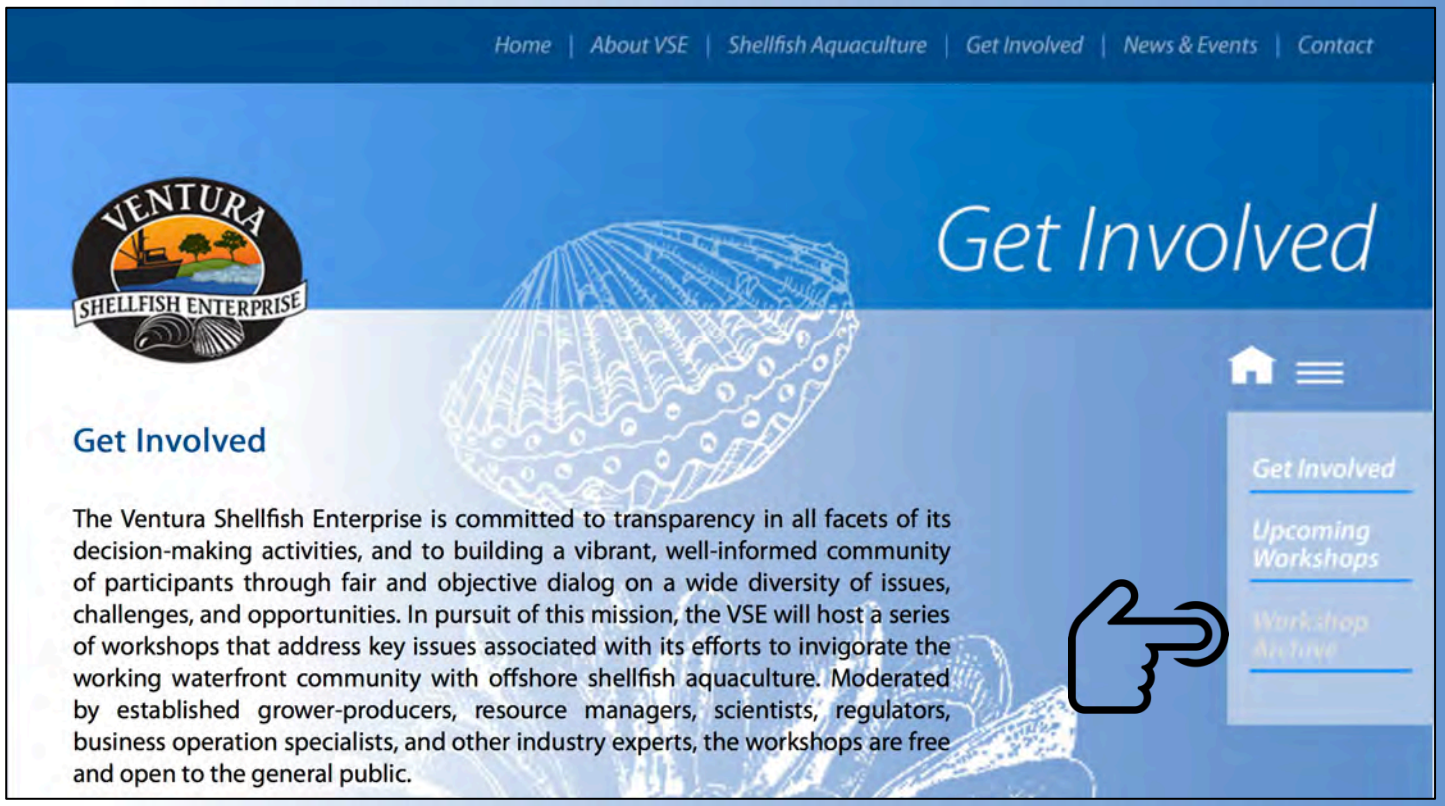
Press Release
Newspaper Article
Internet
Colleague, Friend, or Family Member
Other (please specify)

Workshop Archive

www.venturashellfishenterprise.com

Workshop Video and Presentation Slides

Workshop videos and presentation slides will be archived on the *Get Involved* page of the VSE website for future reference



Mobile Website

www.venturashellfishenterprise.com

A mobile website customized for smartphones will be available on April 1

Next Workshop

www.venturashellfishenterprise.com

VSE Economic Impacts and Benefits

March 16, 2017 | 7:00 to 8:30 p.m.
Auditorium of the Robert J. Lagomarsino Visitor Center at the CINP

Speakers

Everard Ashworth, Richard Parsons, and Brian Pendleton
Ventura Port District
Moderated by Oscar Peña, General Manager

Visit the *Get Involved* page of the VSE website for information on all workshops

Q & A | Community Discussion

Please try to keep your questions and comments under 3 minutes so that everyone has a chance to provide their input and feedback

Please use the portable microphone so that your questions can be heard in the video being captured by CAPS Media