Development of Open Source Seaweed Culture System Technologies on Land & Sea in the Northeast US

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Uses of Seaweeds

- Food
- Feed
- Fertilizer
- Medicine
- Cosmetics
- Textile
- Paper
- Leather
- Major sources of phycocolloids
  (alginates, carrageenans & agars)
- Biofuels

Class Phaeophyceae (Brown Seaweeds)

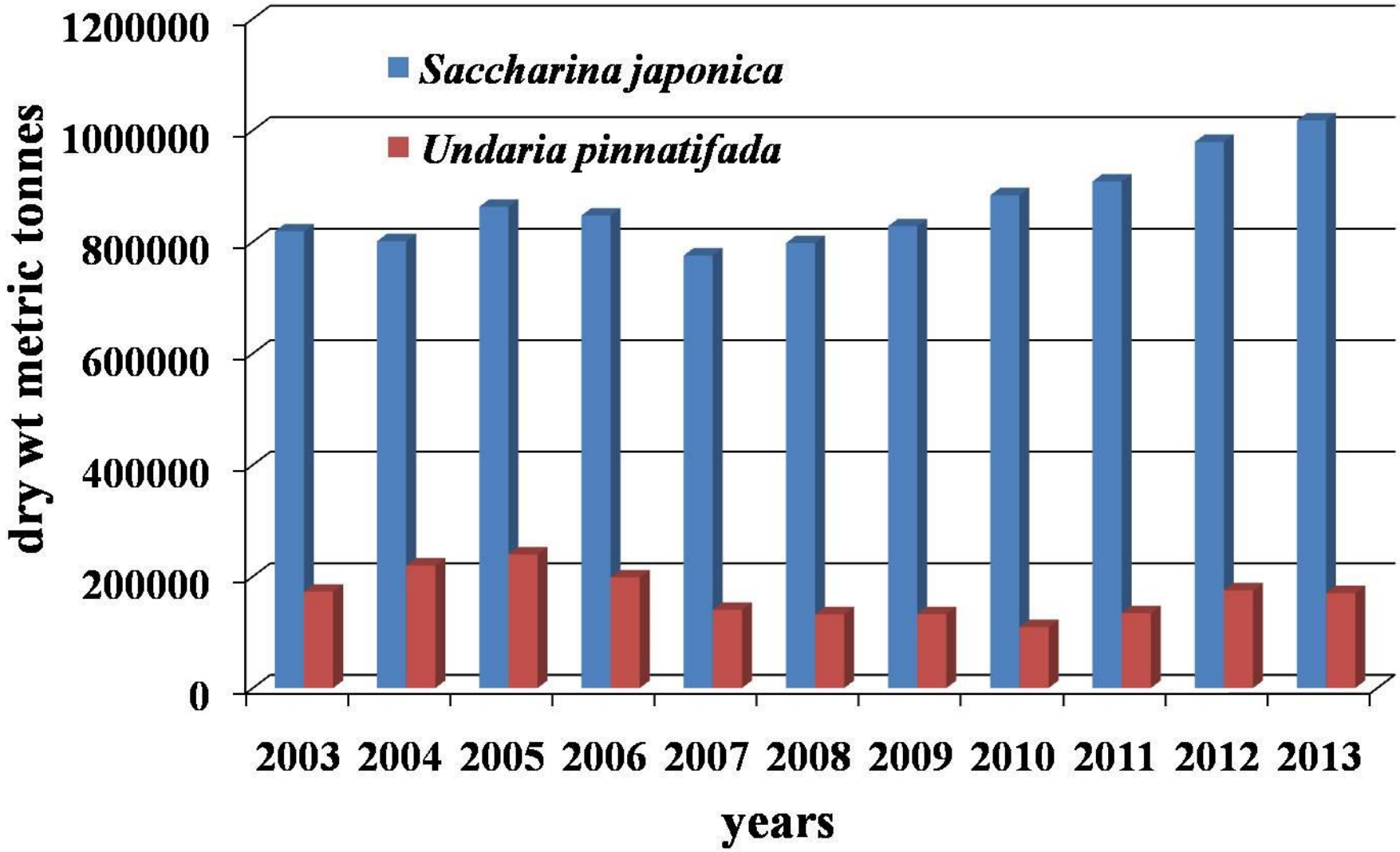
Order Laminariales

-Family Laminariaceae

-Genus: ***Saccharina***

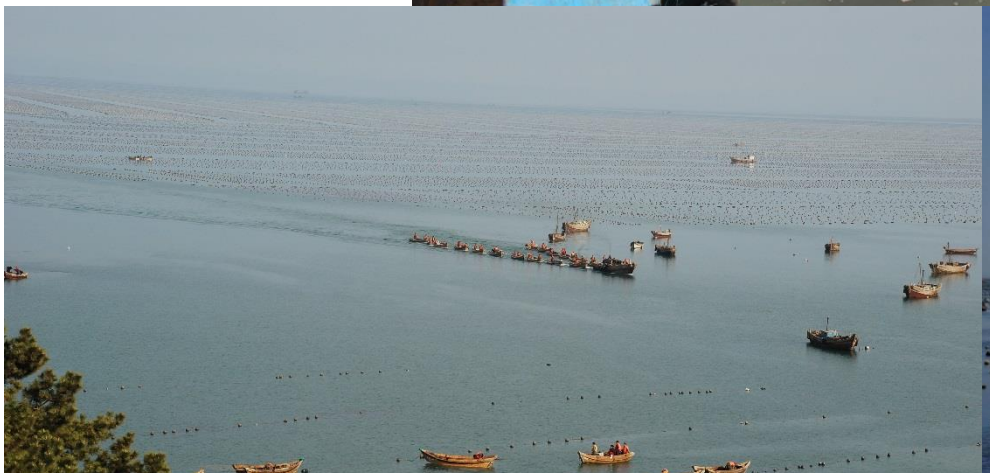
-Family Alariaceae

www.algaebase.org



Data from China Fishery Statistical Year Book (2003-2013)

Kelp Cultivation in China



Grow Out Stage

-Greenhouse:
Shallow tanks with running seawater, shade light to 25-50µE

-Laboratory/Indoor facility

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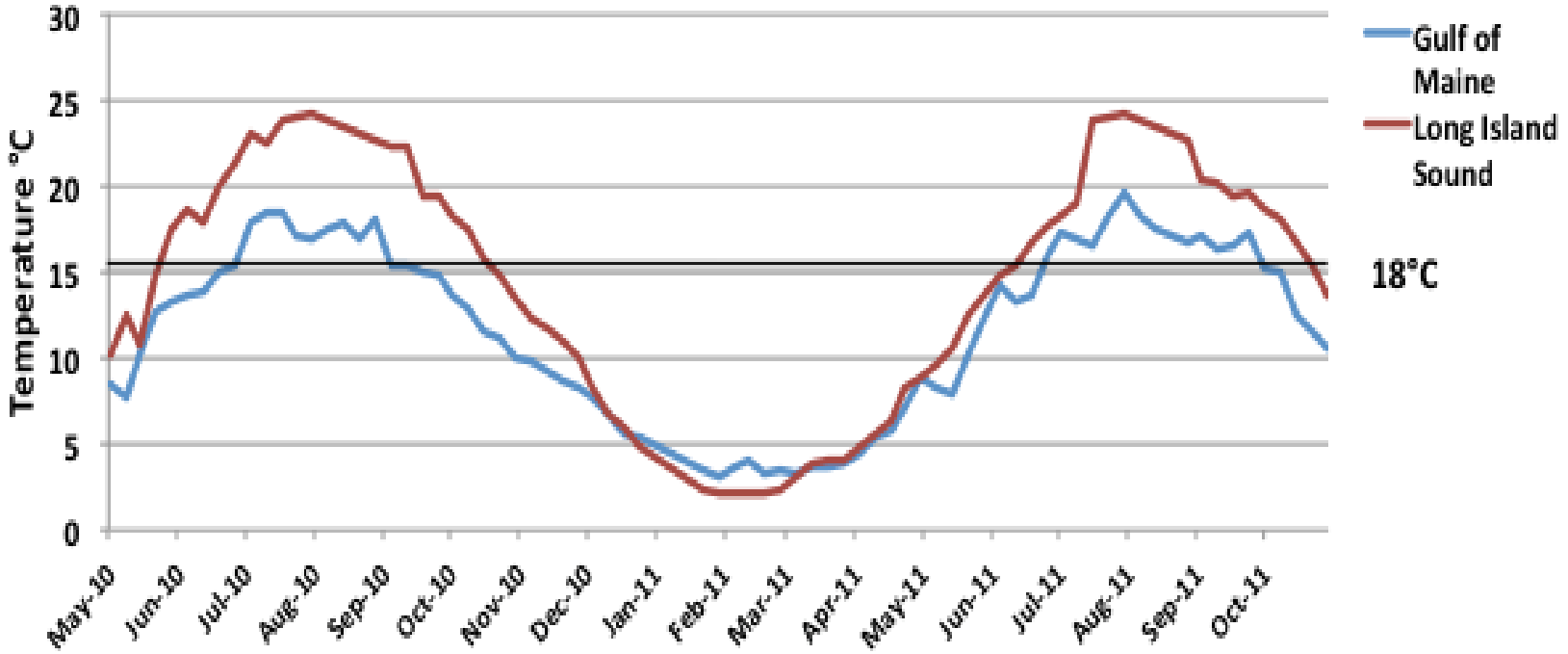
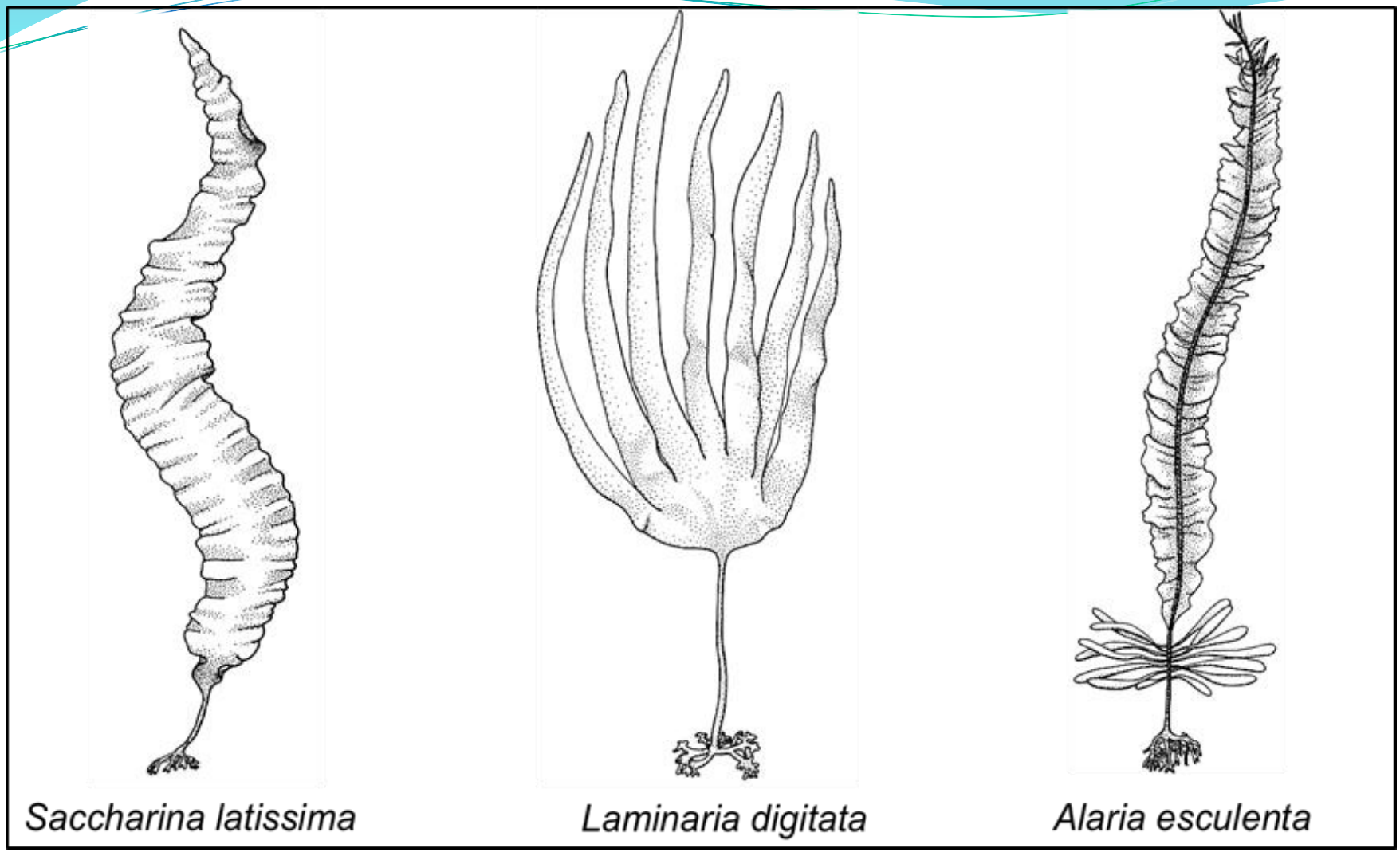
How Do You Grow Kelp?

- Initiate Laboratory Cultures
  - Collect Wild Specimens with Desirable Characters
  - Isolate Spores
  - Produce Mass Cultures of Appropriate Life History Stage
- Induce Spore Release or Hybridization
- Seed Lines for Out-planting
- Grow Out
- Harvest

Average Water Temperatures for New England



Lab Phase	Open Water Phase		Harvest
	Outplant Temp <18°	{Growth Peak}	Temp <18°C



Economically and ecologically important kelps of the Northeast.

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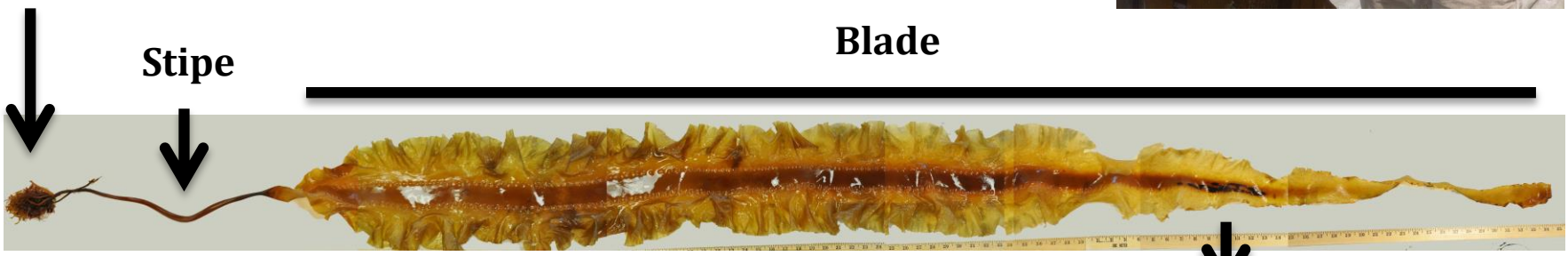
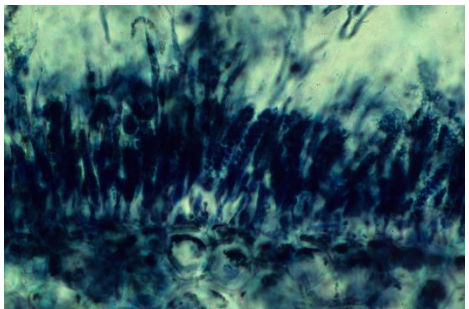
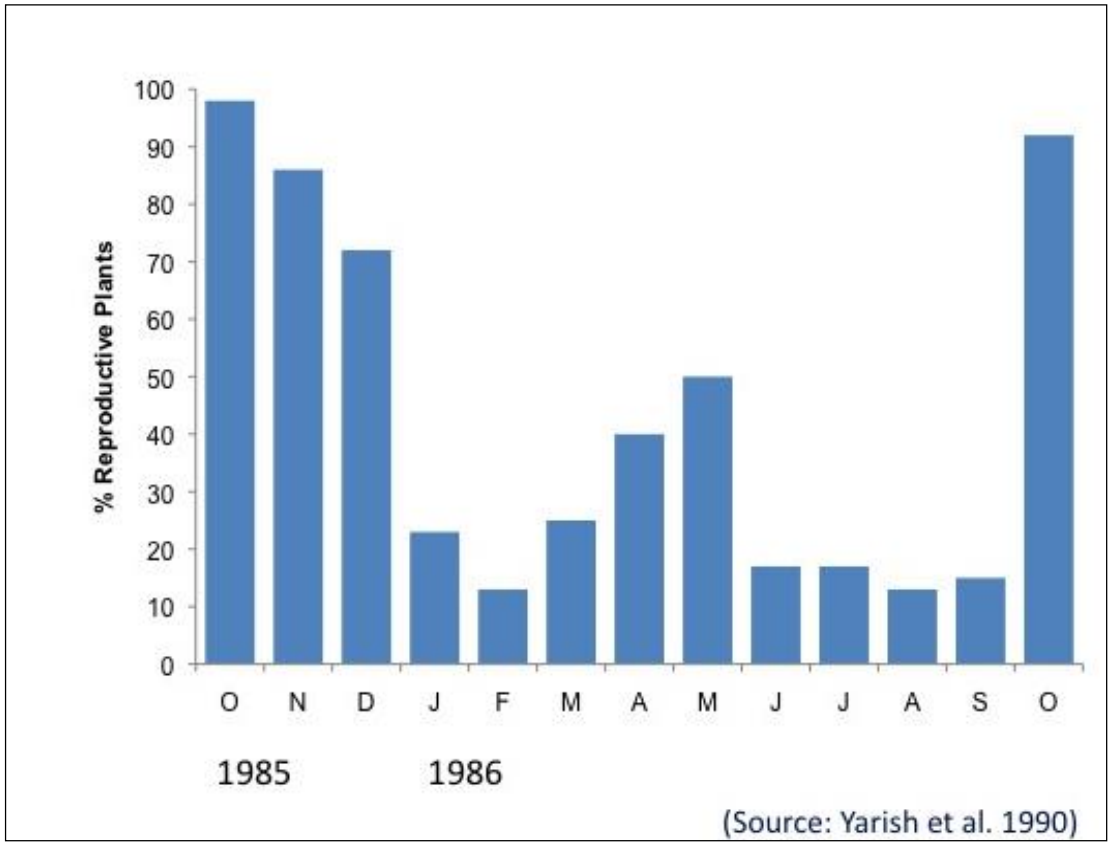
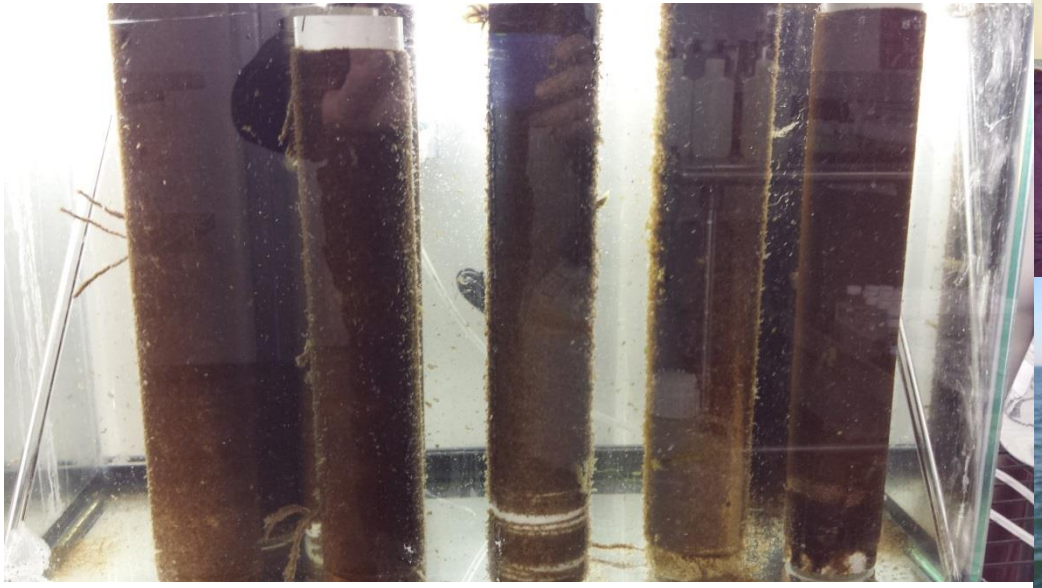

Holdfast
Stipe
Blade
Intercalary Meristem
Sorus Tissue





Percent of *Saccharina latissima* sporophytes with sorus tissue. Data derived from tagged populations in Long Island Sound. (Yarish et al, 1990)

Wild-sourced seeding with meiospores



Productivity

~ 1,752 kg per 100 m longline (Dec. – May growing season)

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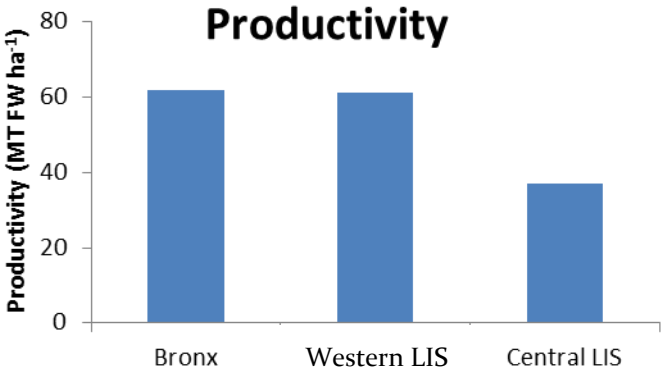
Productivity (sugar kelp)

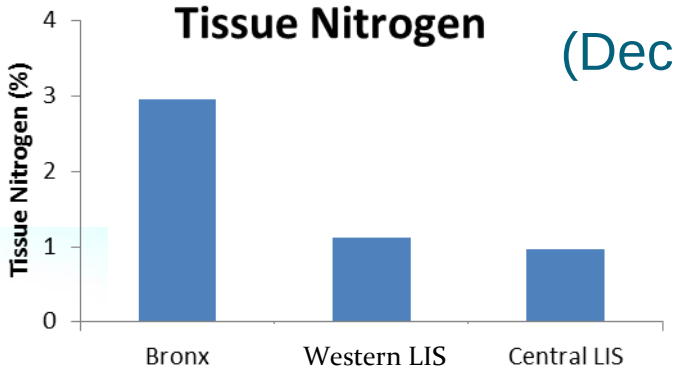
*29.2 – 116.7 MT FW ha^{-1}
(Dec. – May growing season)

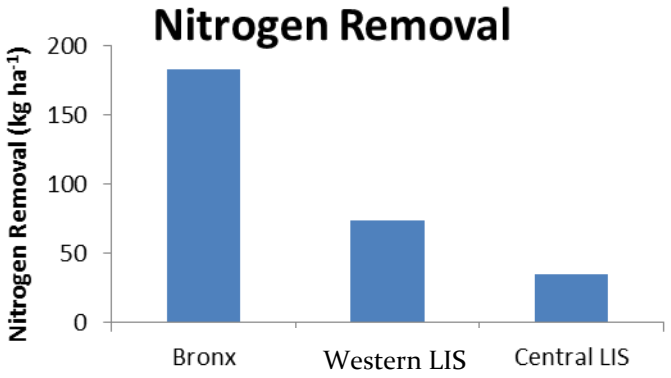
* Assumption: 1.5 or 6.0 m spacing between longlines

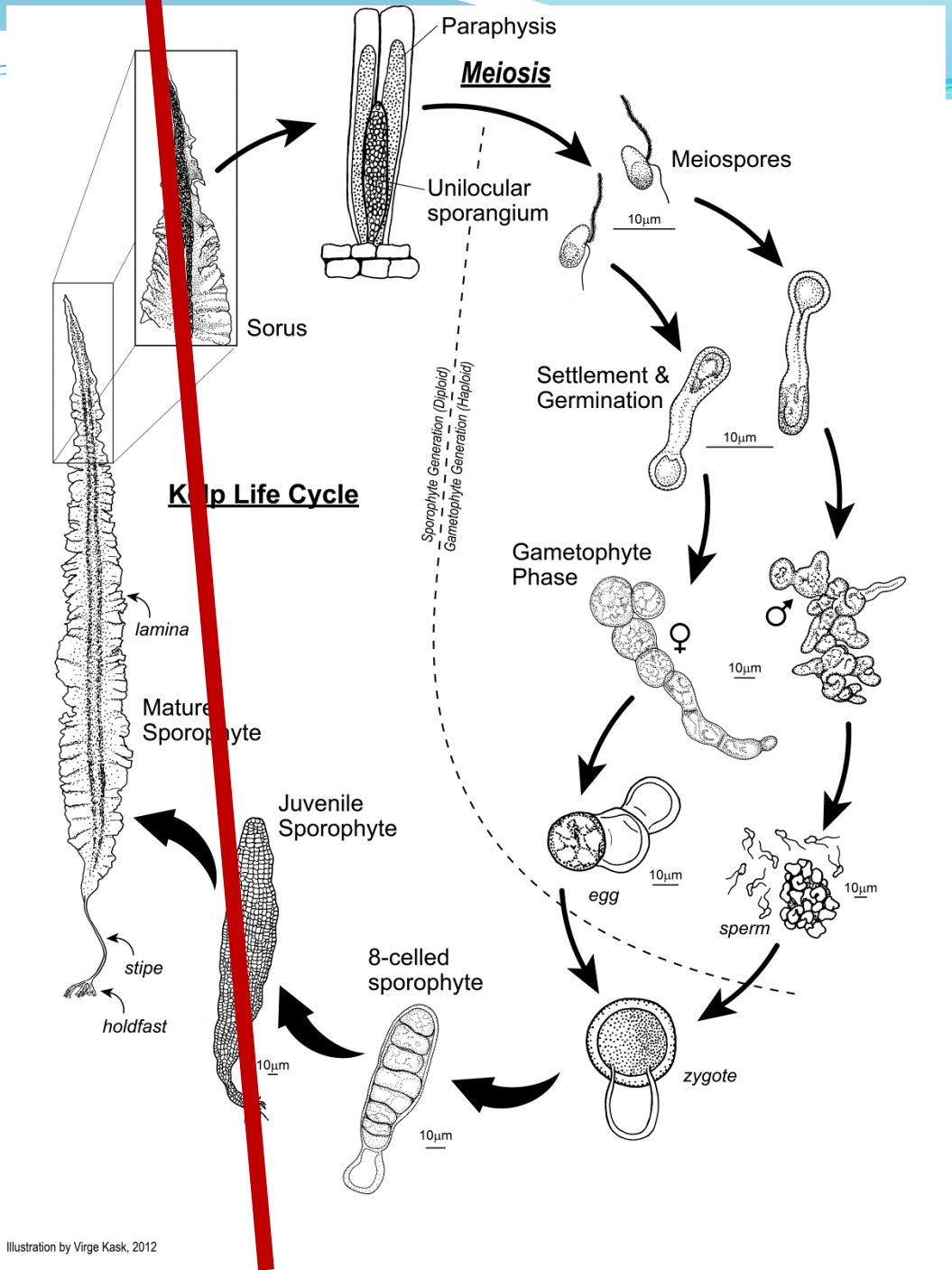
Productivity, Tissue Nitrogen and Nitrogen Removal



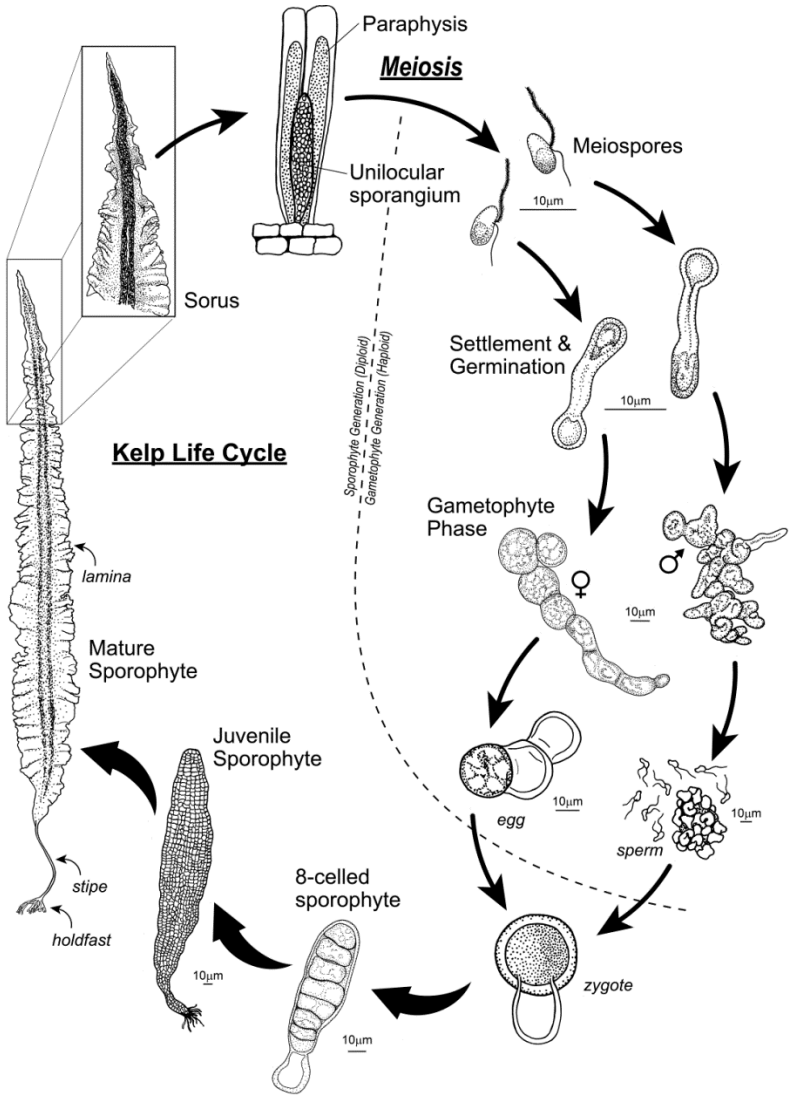
- *Saccharina latissima*
- 2012-2013 growing season
- 1.5 m spacing of lines
- Sugar kelp: ~180 kg N ha^{-1} (Dec. – May)



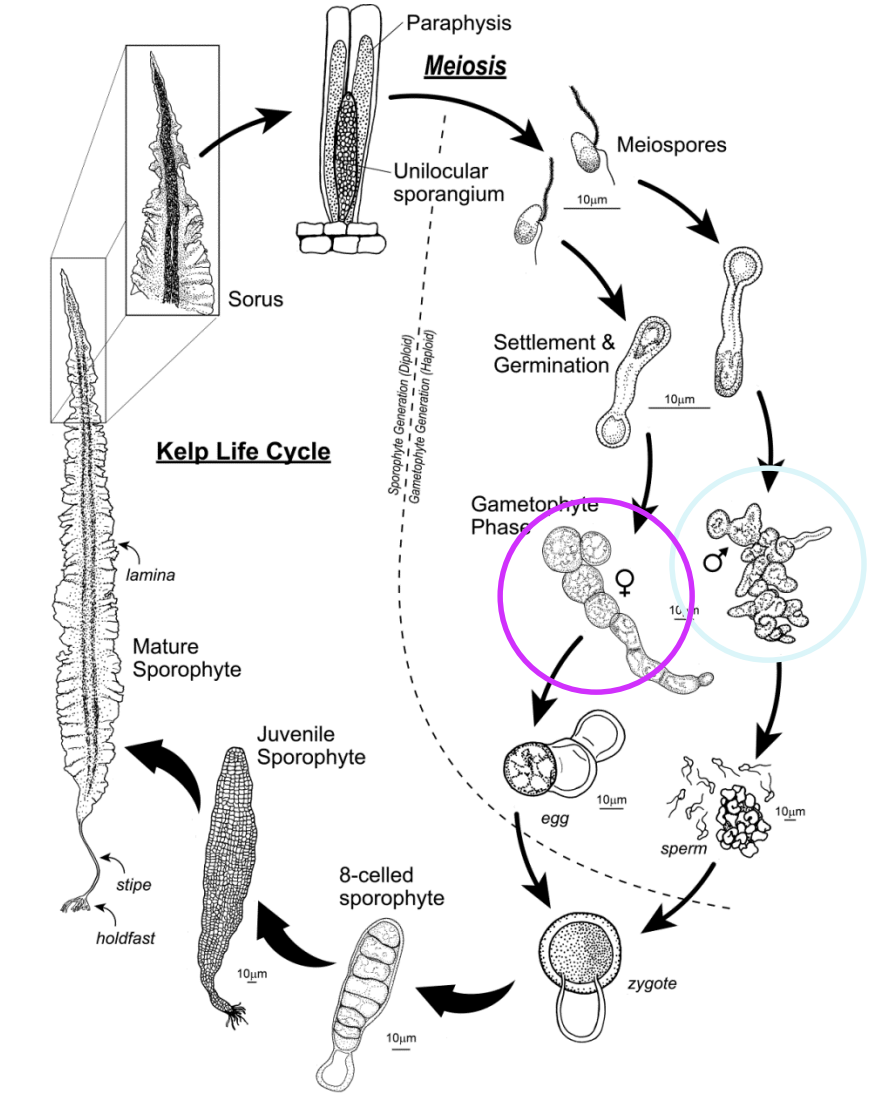



Paraphysis
Meiosis
Unilocular sporangium
Meiospores
10μm
Sorus
Settlement & Germination
10μm
Sporophyte Generation (Diploid)
Gametophyte Generation (Haploid)
Kelp Life Cycle
Gametophyte Phase
♀
♂
10μm
lamina
Mature Sporophyte
Juvenile Sporophyte
egg
10μm
sperm
10μm
stipe
holdfast
8-celled sporophyte
10μm
zygote
Illustration by Virge Kask, 2012

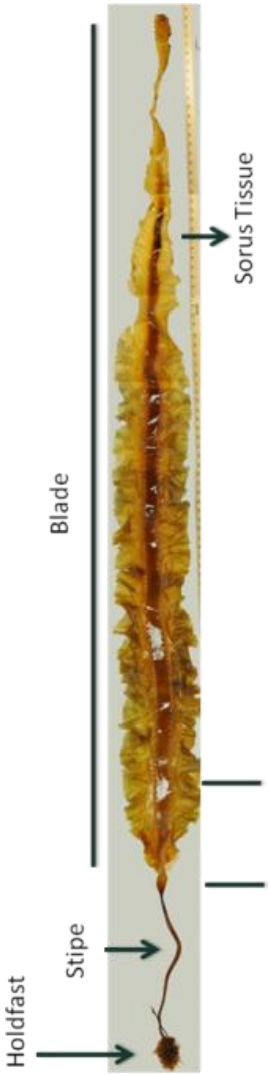
Hybridization techniques

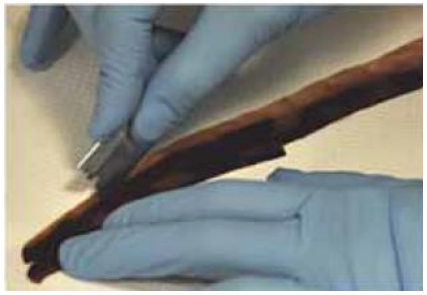


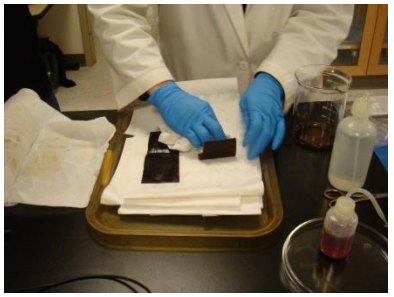
Hybridization techniques

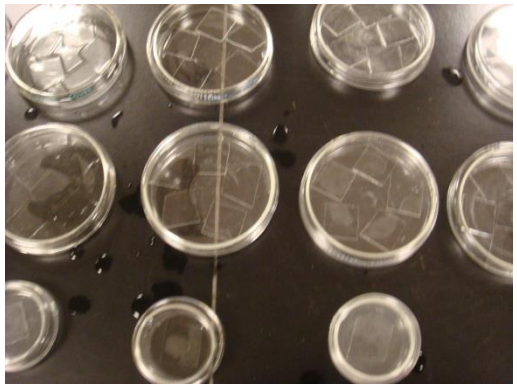


Hybridization techniques









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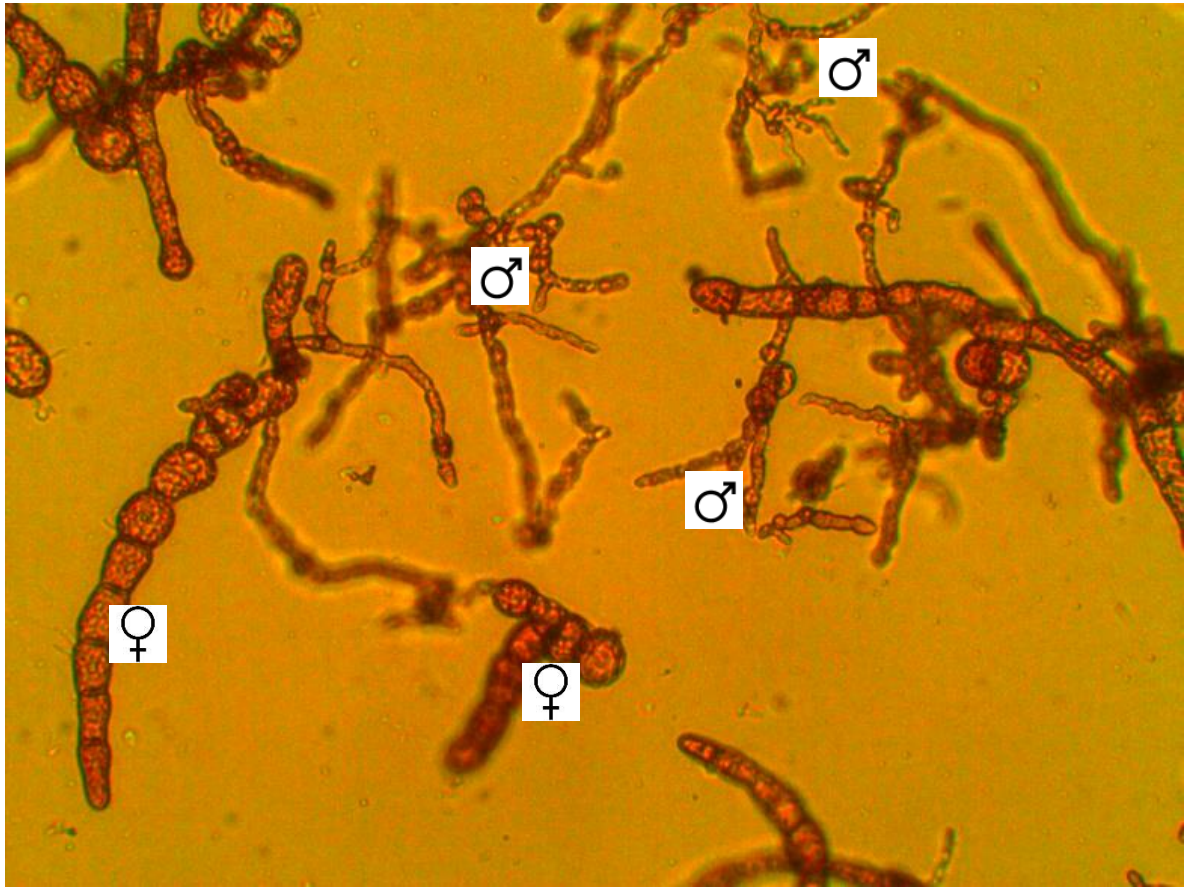
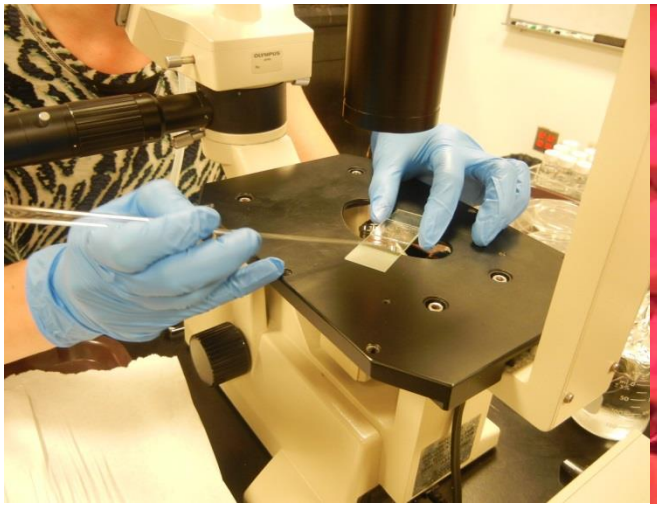
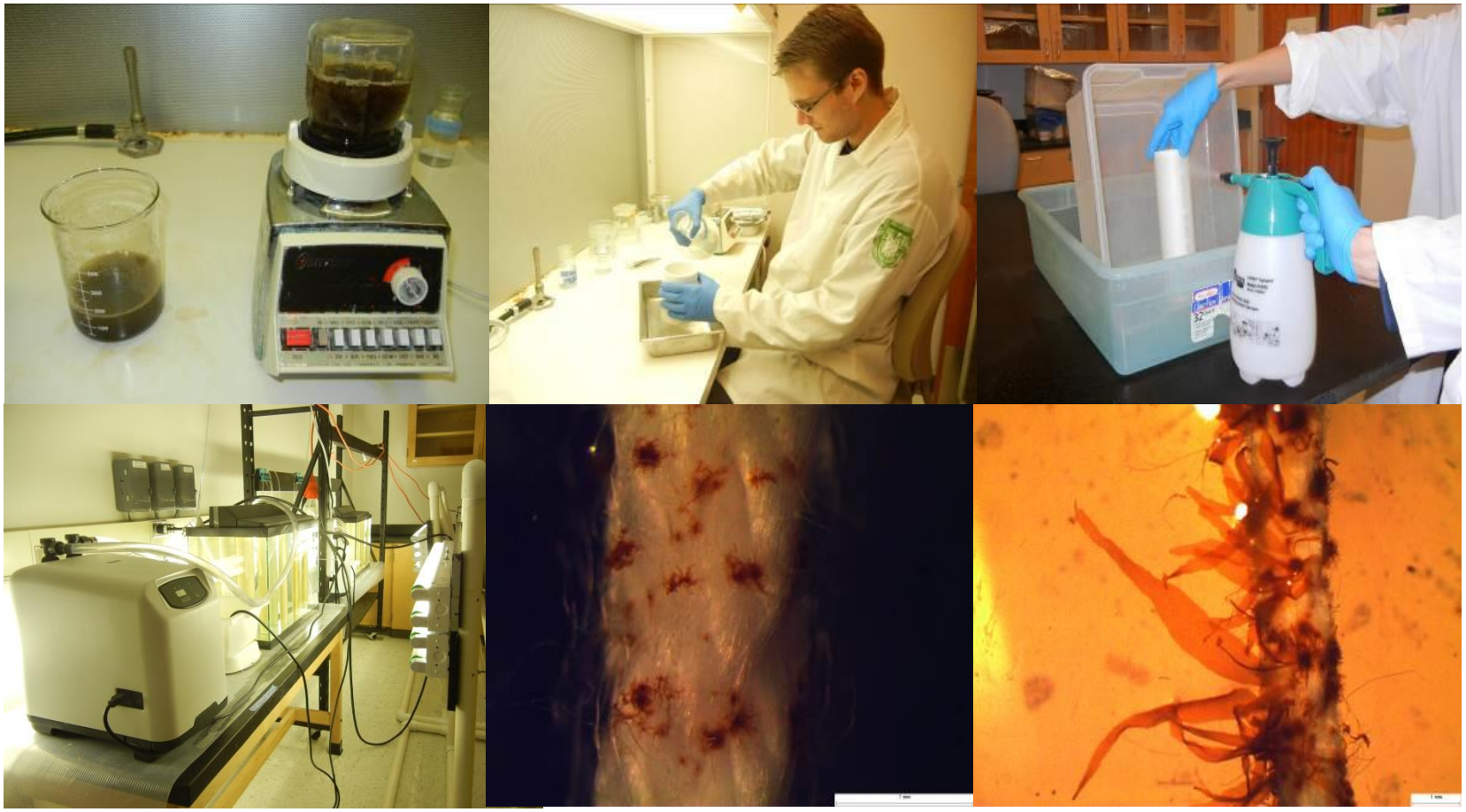
Hybridization techniques



Hybridization techniques

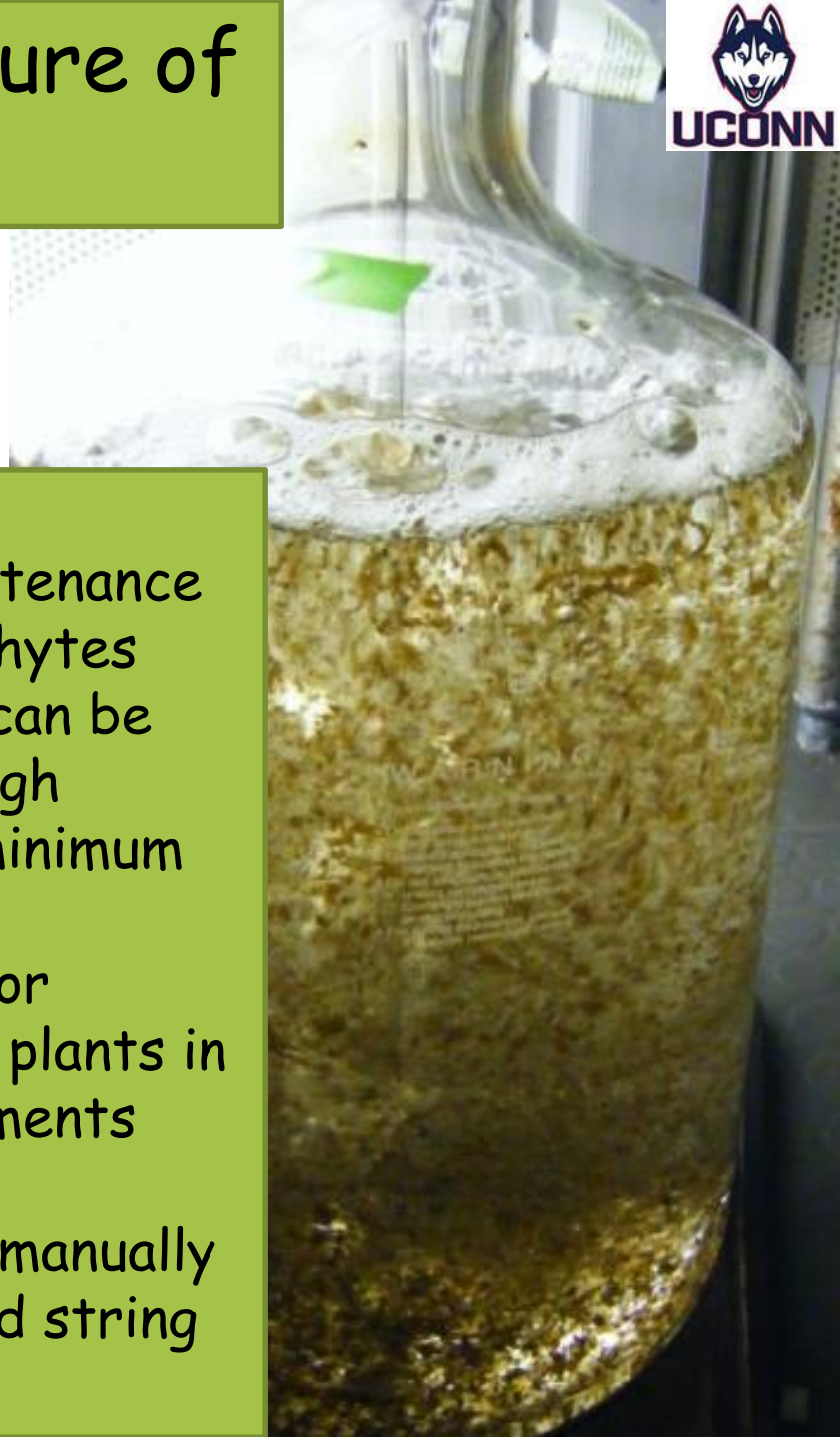


Hybridization techniques



Hybridization techniques

Tumble Culture of Kelp



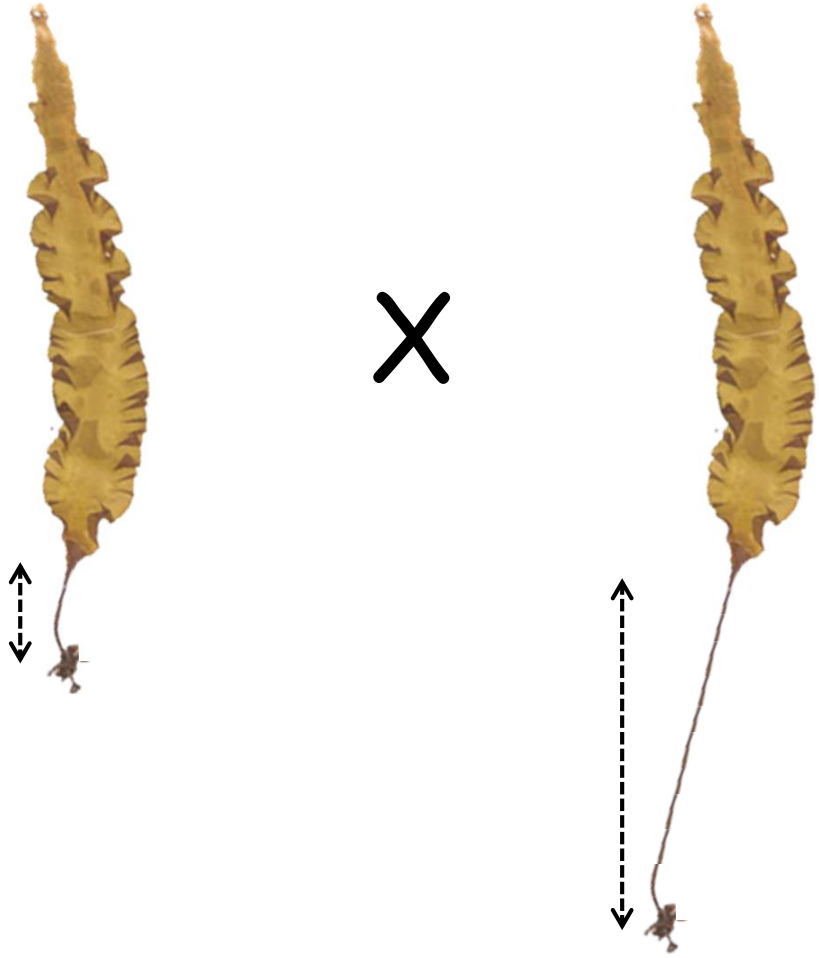
Advantages:

- Long term maintenance of young sporophytes
- Clean cultures can be maintained at high densities with minimum maintenance
- Use to select for fastest growing plants in crossing experiments

Disadvantages:

- Plants must be manually attached to seed string for out-planting

Hybridization techniques



Hybridization techniques

X

S♂ S♀ L♂ L♀

Hybridization techniques

S♂ S♀ L♂ L♀

Crosses:

S♂ XS♀ L♂ XS♀

S♂ XL♀ L♂ XL♀

Hybridization techniques

S♂ XS♀

L♂ XS♀

S♂ XL♀

L♂ XL♀

Hybridization techniques

S♂ X S♀

L♂ X S♀

S♂ X L♀

L♂ X L♀

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Hybridization techniques

S♂ X S♀

L♂ X S♀

S♂ X L♀

L♂ X L♀

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Saccharina latissima forma *angustissima* from southern Maine

Saccharina latissima forma *angustissima* from southern Maine

Wild-sourced seeding vs. Hybridization

Wild-sourced seeding	Hybridization techniques
Nursery technology	complex

Wild-sourced seeding vs. Hybridization

	Wild-sourced seeding	Hybridization techniques
Nursery technology		complex
Seeding timing	depending on wild material	flexible

Wild-sourced seeding vs. Hybridization

	Wild-sourced seeding	Hybridization techniques
Nursery technology	simple	complex
Seeding timing	depending on wild material	flexible
Offspring morphology	unpredictable	predictable

Where to buy and how much?

New England Seaweed Culture Handbook

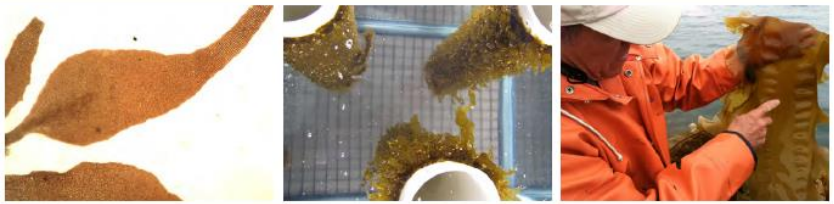
Nursery Systems

Sarah Redmond, Lindsay Green
Charles Yarish, Jang Kim, Christopher Neefus
University of Connecticut & University of New Hampshire

CTSG-13-03
Connecticut Sea Grant 2013

Kelp Farming Manual

A Guide *to the* Processes, Techniques, and Equipment for Farming Kelp in New England Waters



Katie Flavin
Nick Flavin
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WRACK LINES
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Video Series Shows How to Start Growing Seaweed

Ever wonder what it would be like to grow seaweed? Connecticut Sea Grant has posted a six-part educational video playlist series on YouTube, to show people how to culture and grow four different species of economically important seaweeds. Part One, the introduction to the "Handbook for Seaweed Culture in New England" offers a broad overview of seaweeds and uses in New England. Other chapters describe how to set up a laboratory to culture seaweed, and seaweed nursery culture for native New England species of Kelp, *Gracilaria*, *Chondrus*, and *Porphyra*. The videos are close captioned for accessibility.

This project was funded through NOAA's Sea Grant programs in Connecticut and New Hampshire. Research was conducted at the UConn Marine Biotechnology Laboratory in Stamford (Charles Yarish) and at the University of New Hampshire, Durham (Chris Neefus).

Link for the entire Seaweed Handbook playlist: http://s.uconn.edu/seaweedplaylist

Links to Individual Chapters:

Part 1 Introduction http://youtu.be/zQr-ZoYu1SE
Part 2 Laboratory http://youtu.be/7Ay0NFS1Olg
Part 3 Kelp http://youtu.be/y-k3eseEJFs
Part 4 *Gracilaria* http://youtu.be/cd5jDPbx63g
Part 5 *Chondrus crispus* http://youtu.be/AKEk6MQ9fHs
Part 6 *Porphyra* http://youtu.be/RGUrPJs_Vj8

YouTube

Project Partners

- **GreenWave** & Noank Aquaculture Cooperative
- Marine Biology Laboratory (Scott Lindell)
- C.A. Goudey & Associates (Cliff Goudey)
- Bridgeport Regional Aquaculture Science and Technology Education Center (BRASTEC)
- Growers: Ocean Approved, Thimble Island Oyster Co., DJ King Lobsters, Maine Fresh Sea Farms, Maine Coast Sea Vegetables
- Norwalk Community College
- UCONN School of Business
- Woods Hole Oceanographic Institution (Hauke Kite-Powell)
- Purchase College
- Rocking the Boat

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- U.S. Department of Agriculture, National Institute of Food and Agriculture (NIFA)
- University of Connecticut

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National Fish and Wildlife Foundation

Sea Grant
Connecticut

Long Island Sound Study
A Partnership to Restore and Protect the Sound

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

USDA

Sea Grant
Maine
at the University of Maine