A Comparison of Reproductive Timing of *Macrocystis pyrifera* and invasive *Sargassum horneri* on Catalina Island

Ann Bishop : Phycology Lab

Moss Landing Marine Laboratories

Climate Change has local impacts

- Increases in regional temperatures can lead to changing ecosystems.
  - Increased drought leading to forest-fires opening space for invasive grass species.

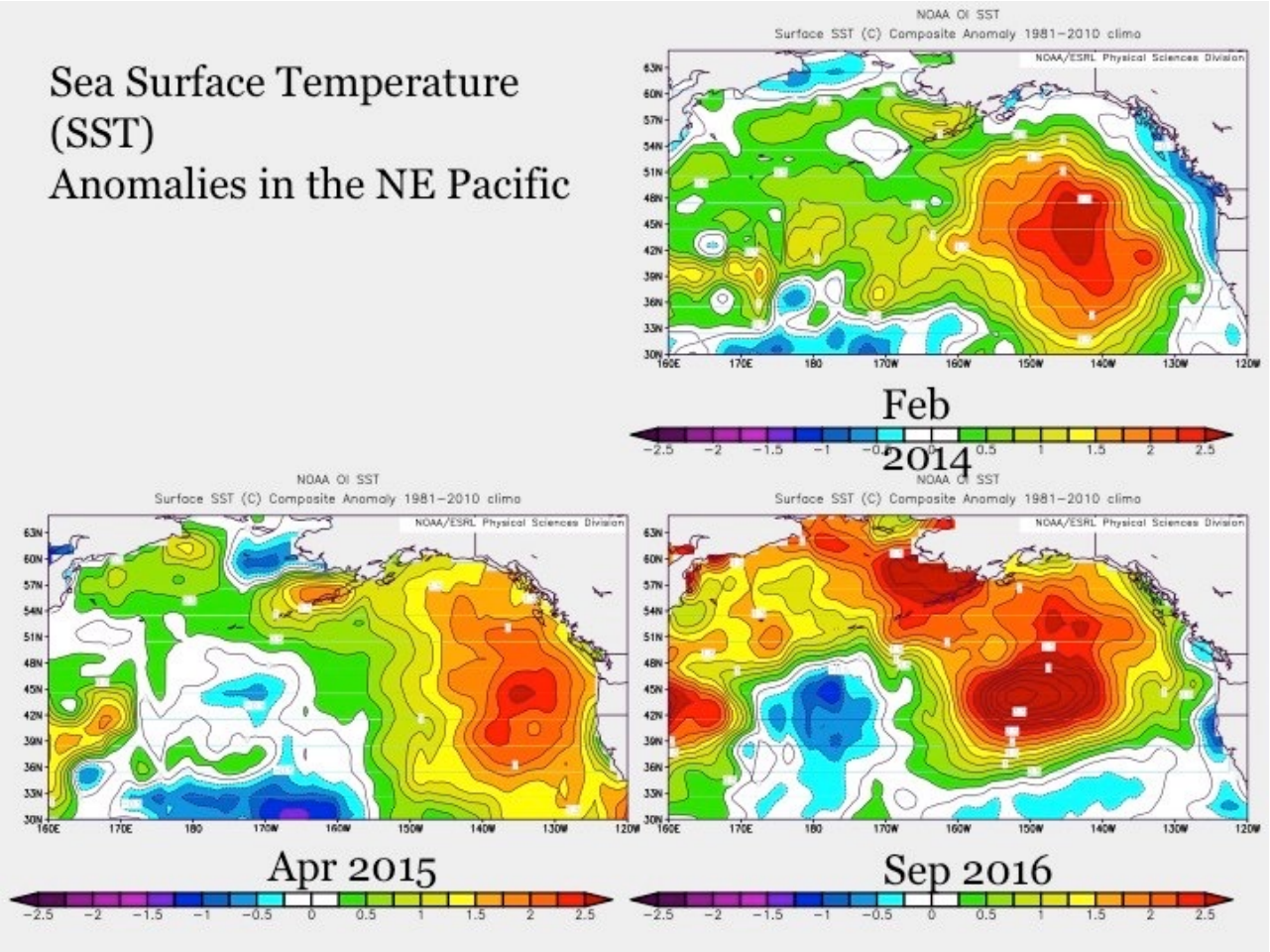
Climate Change has local impacts

- Increases in regional temperatures can lead to changing ecosystems.
  - Increased drought leading to forest-fires opening space for invasive grass species.
  - Changing flowering and pollination patterns in terrestrial species.


Photo: Ann Bishop

Climate Change has local impacts

- In the ocean
  - Marine Heatwaves
  - El Niño events
- Offer opportunities to study how marine communities may respond to climate change.



Source: National Oceanic and Atmospheric Administration/NOAA

What about in kelp forests?

- *Macrocystis pyrifera*, giant brown kelp:
    - Perennial
    - Reproduces through out the year.
    - Reproductive ability is linked to temperature and nutrient conditions.

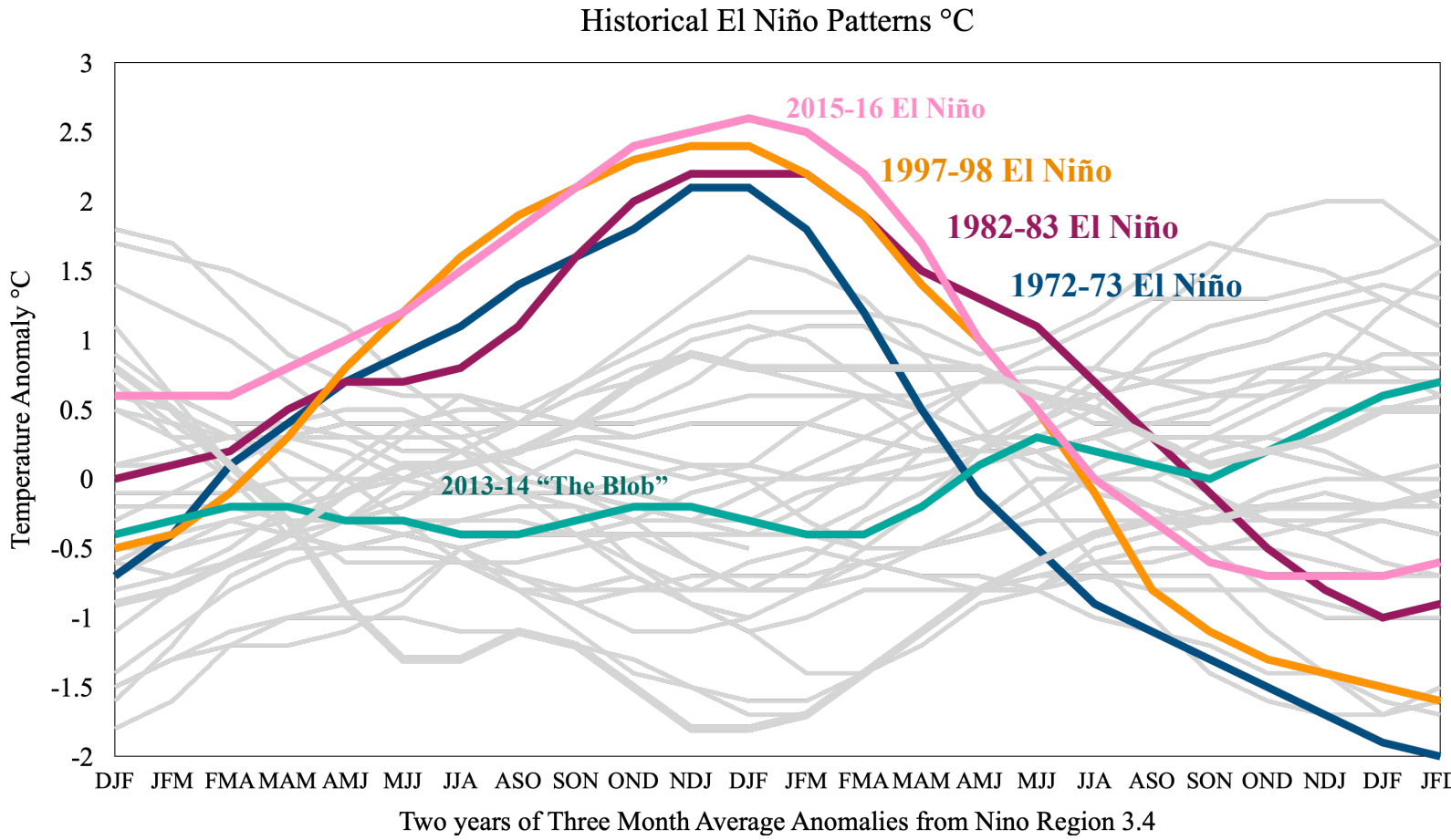
Photo: USC Wrigley

Kelp forests and El Niño

Historically, El Niño events lead to deforestation in Southern California kelp forests.

The 2015/16 El Niño was one of the hottest El Niño events on record.

Increased population of *Sargassum horneri*, an invasive fucoid.



Catalina Island

Photo: Dr. Richard Murphy aka “Murph”

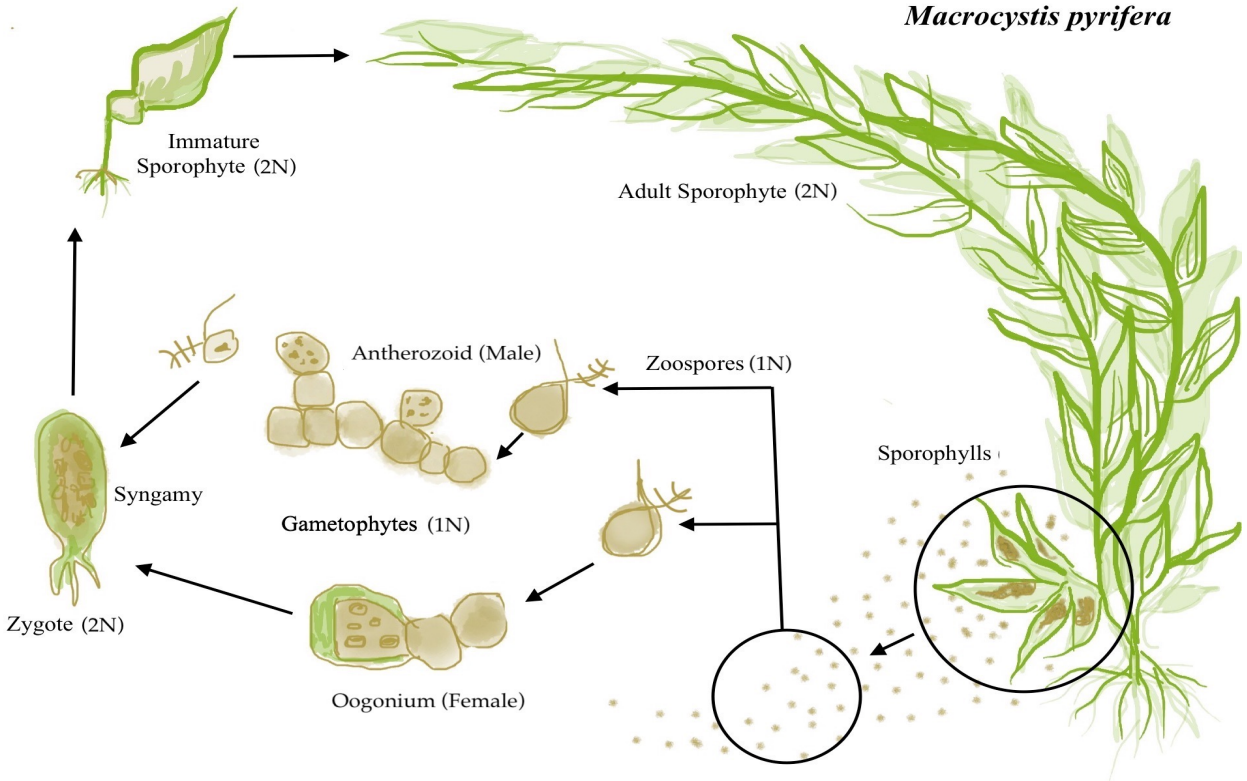
Catalina Island

Photo Ann Bishop

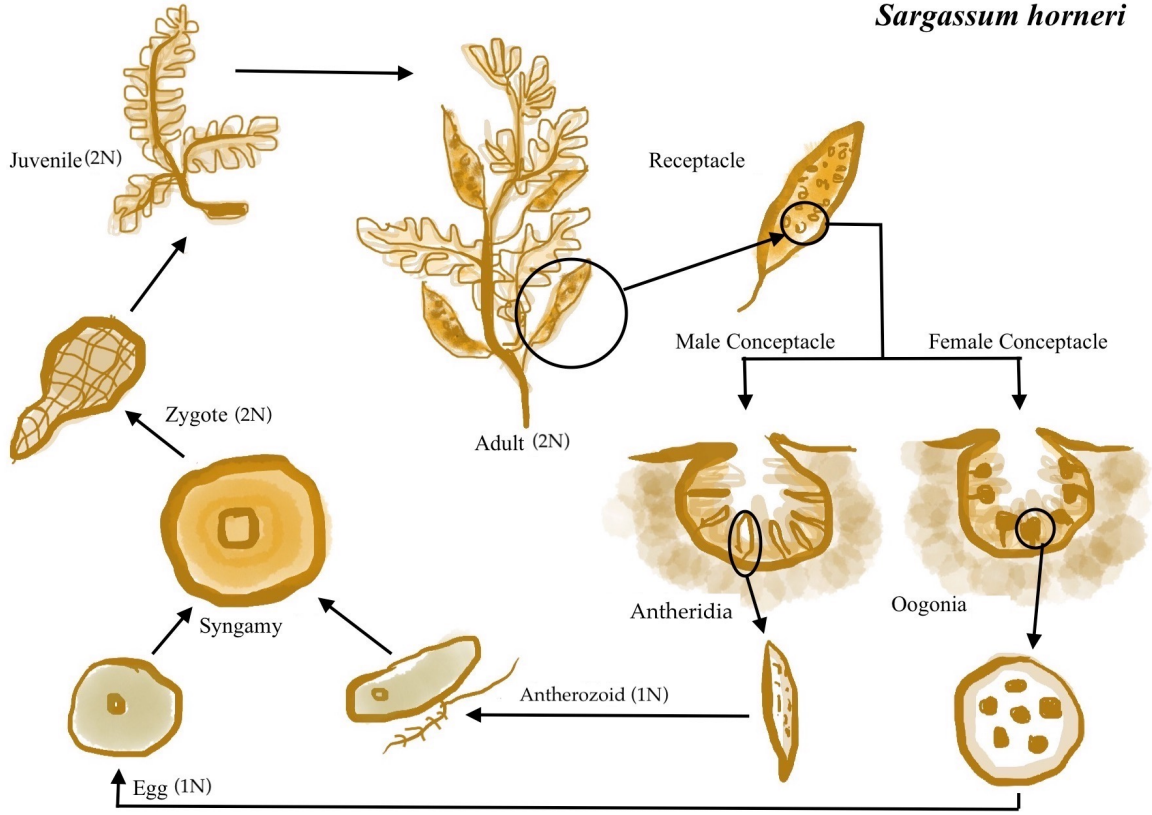
Catalina Island

Photo CELP staff

How are *Macrocystis* and *Sargassum h.* competing?



Perennial Laminariales Life History



Annual Fucoid Life History

Questions:

Population

- Question 1: How do the density and demography of *Macrocystis* and *Sargassum horneri* change seasonally?

Reproduction

- Question 2: How does the reproductive and vegetative biomass change and when is there the largest investment in reproductive material for *Macrocystis* and *S. horneri*?
- Question 3: When is peak fecundity for *Macrocystis* and *S. horneri*?

Development

- Question 4: Do the combined stressors of temperature and *S. horneri* zygote presence change the development of *Macrocystis* gametophytes?

Questions:

Population

- Question 1: How do the density and demography of *Macrocystis* and *Sargassum horneri* change seasonally?

Reproduction

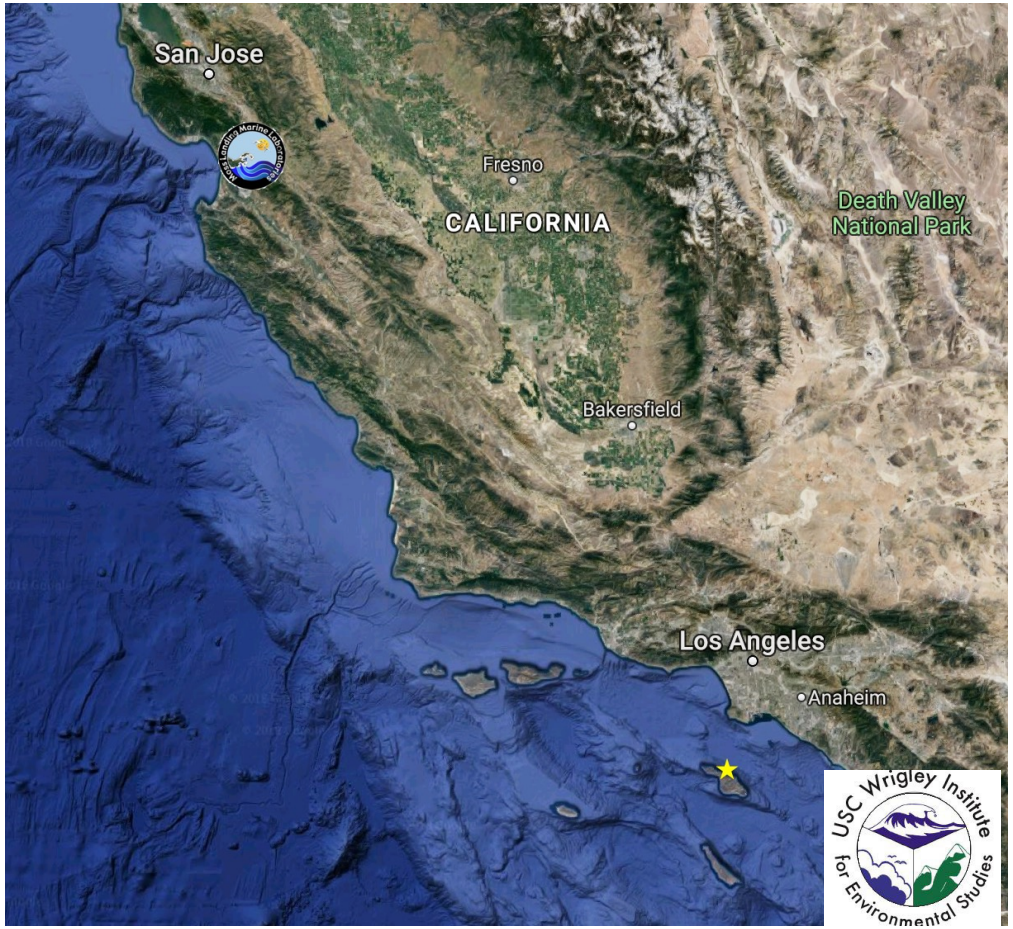
- Question 2: How does the reproductive and vegetative biomass change and when is there the largest investment in reproductive material for *Macrocystis* and *S. horneri*?
- Question 3: When is peak fecundity for *Macrocystis* and *S. horneri*?

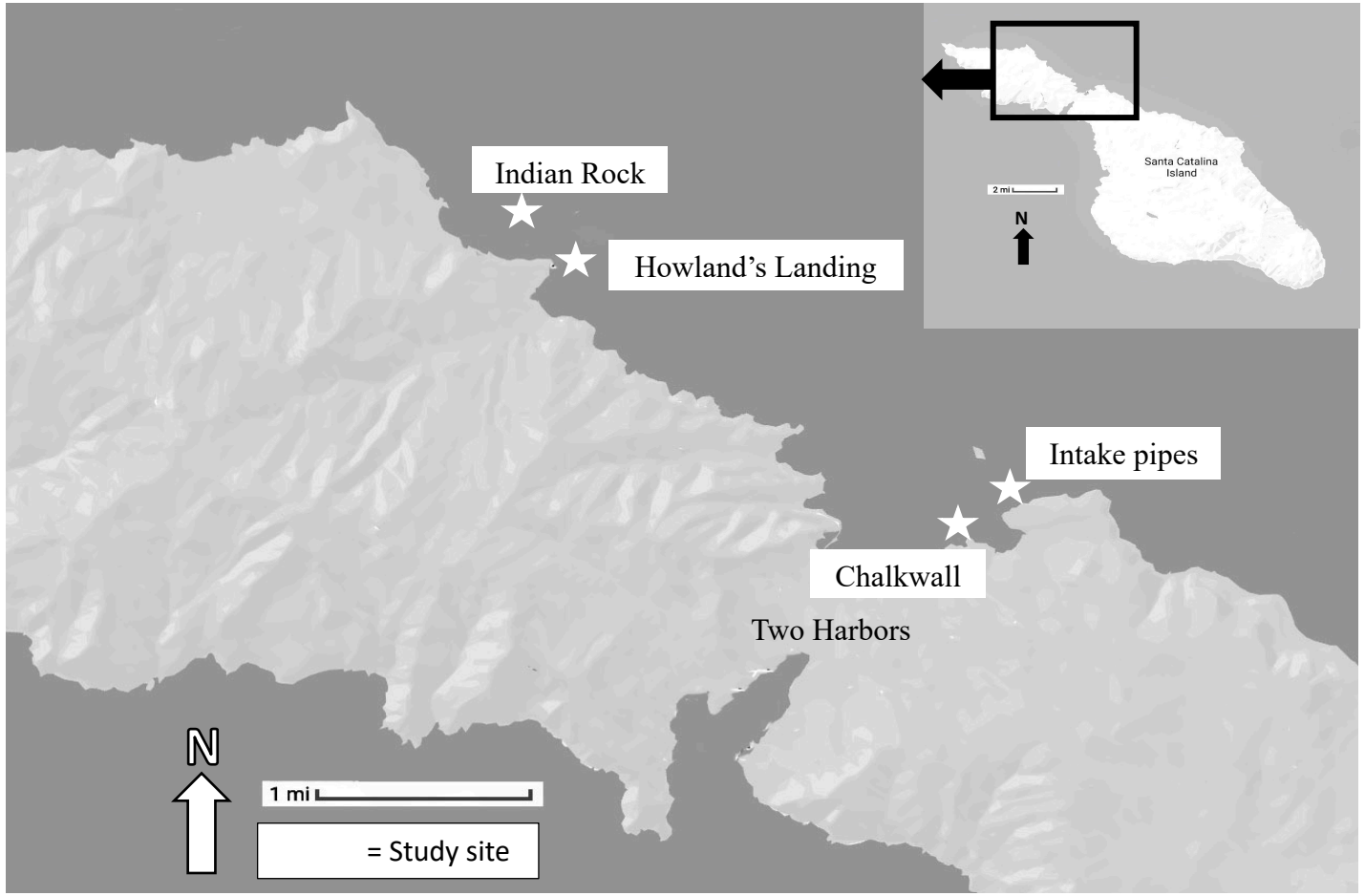
Development

- Question 4: Do the combined stressors of temperature and *S. horneri* zygote presence change the development of *Macrocystis* gametophytes?

Methods: Location

4 sites located on the Westend of Catalina Island.





Field Collections

- 3, 10x2 m transects per site to count *Macrocystis* density.
- 2, 0.25m^2 quadrats per transect to count *Sargassum h*.
- 6 individual *Macrocystis* and *Sargassum* per site measured for vegetative and reproductive biomass and output.

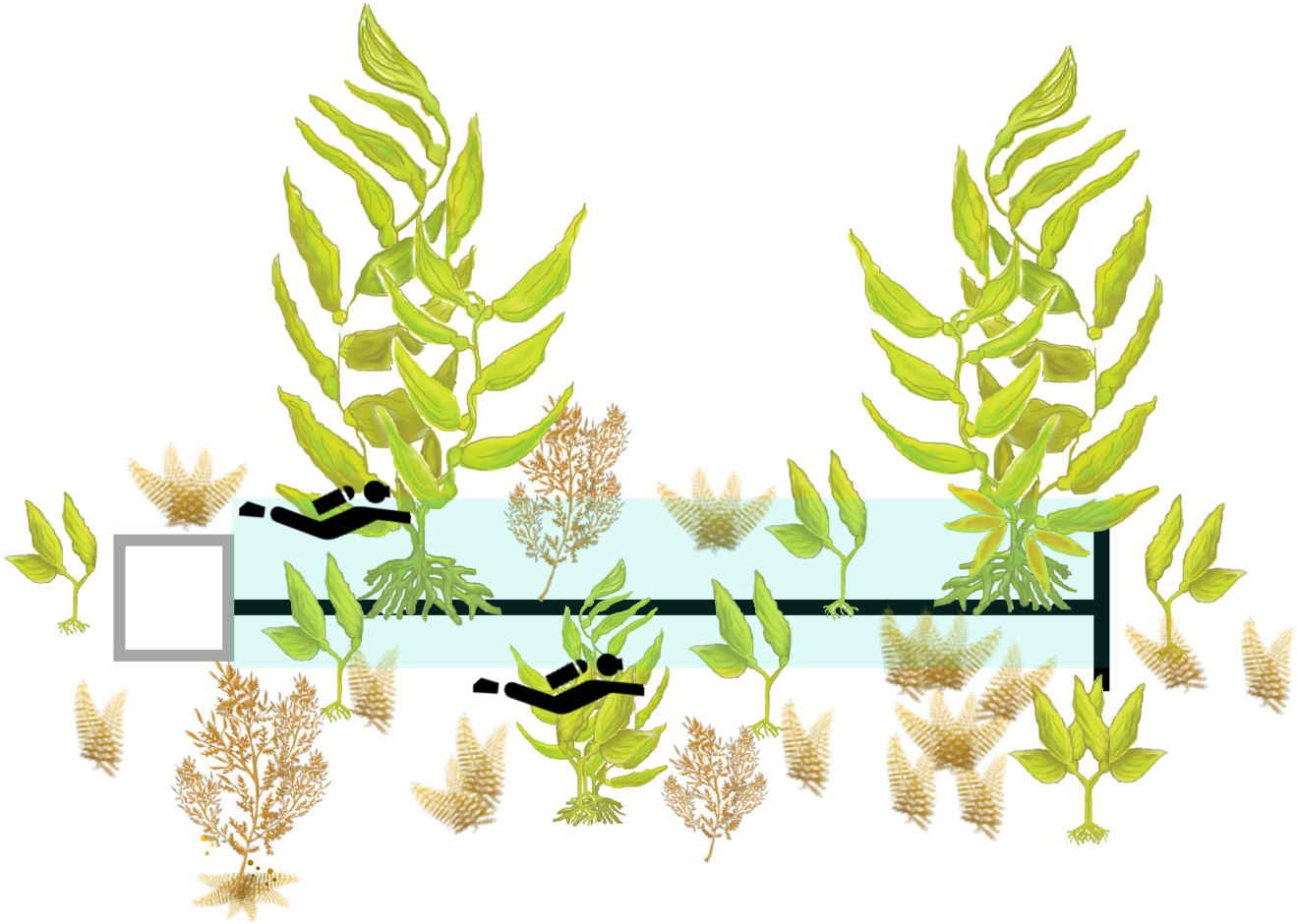


Illustration: Ann Bishop

Field Collections

- 3, 10x2 m transects per site to count *Macrocystis* density.
- 2, 0.25m^2 quadrats per transect to count *Sargassum h*.
- 6 individual *Macrocystis* and *Sargassum* per site measured for vegetative and reproductive biomass and output.

Illustration: Ann Bishop

Field Collections

- 3, 10x2 m transects per site to count *Macrocystis* density.
- 2, 0.25m^2 quadrats per transect to count *Sargassum h*.
- 6 individual *Macrocystis* and *Sargassum* per site measured for vegetative and reproductive biomass and output.

Illustration: Ann Bishop

Reproductive output

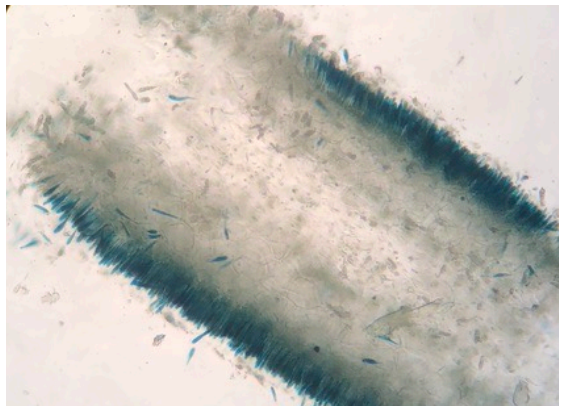
Macrocystis pyrifera

Whole sporophylls

- 5 sporophylls collected from each individual (when present)
- Whole sporophyll weighed
- Sori weight and cover estimated

Hole punches

- 5 punches from each sori
- Preserved in formalin
- Dyed
- Cross-sectioned to identify sporangia



Photos: Ann Bishop

Reproductive output

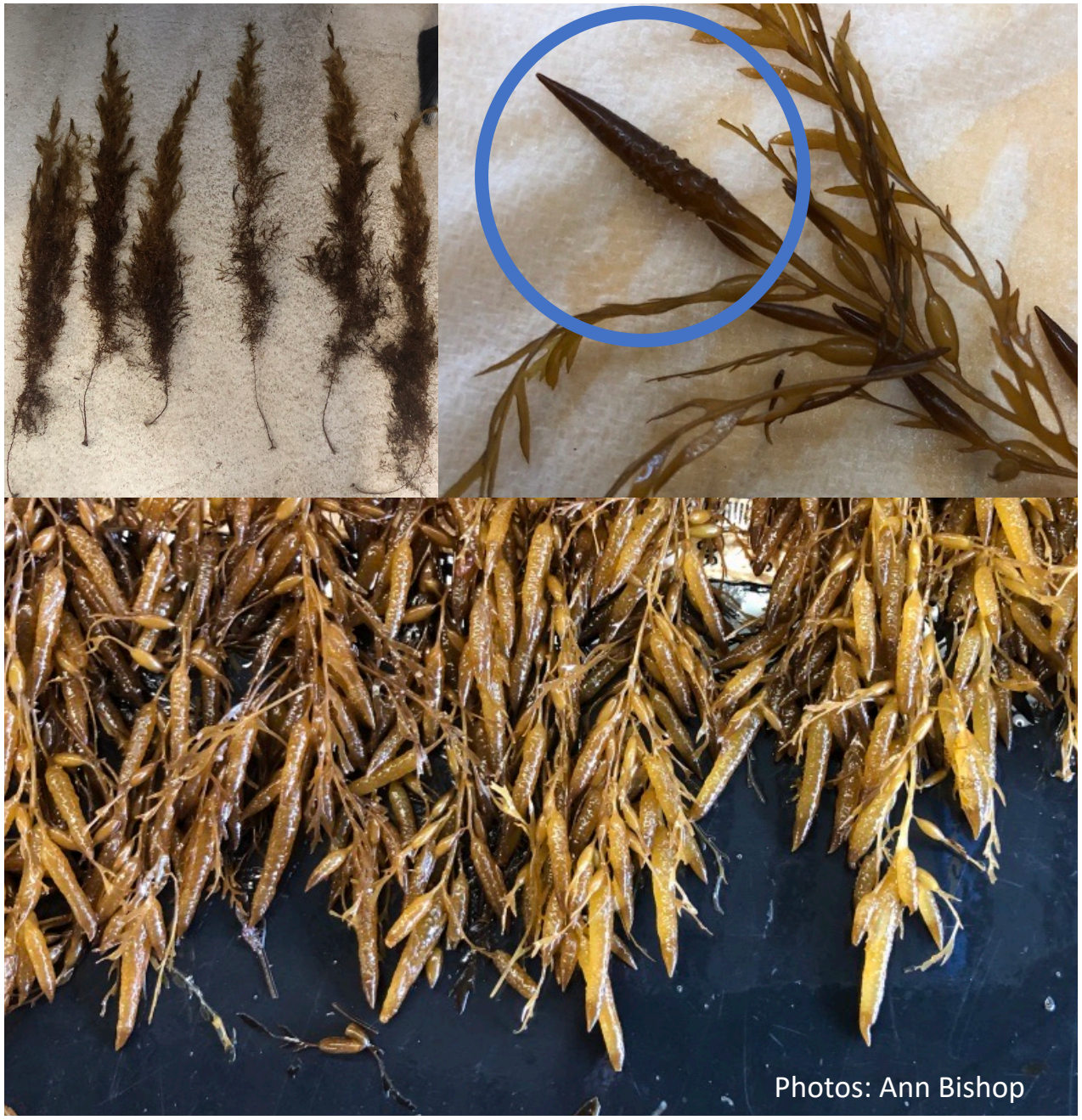
Sargassum horneri

Whole Individuals

- 6 individuals; whole alga weighed
- If individual was reproductive; receptacles removed and weighed

Preserved receptacles

- 5 random receptacles preserved in formalin
- Receptacle to conceptacle correlation
- Cross-sectioned to count #eggs per conceptacles



Reproductive output

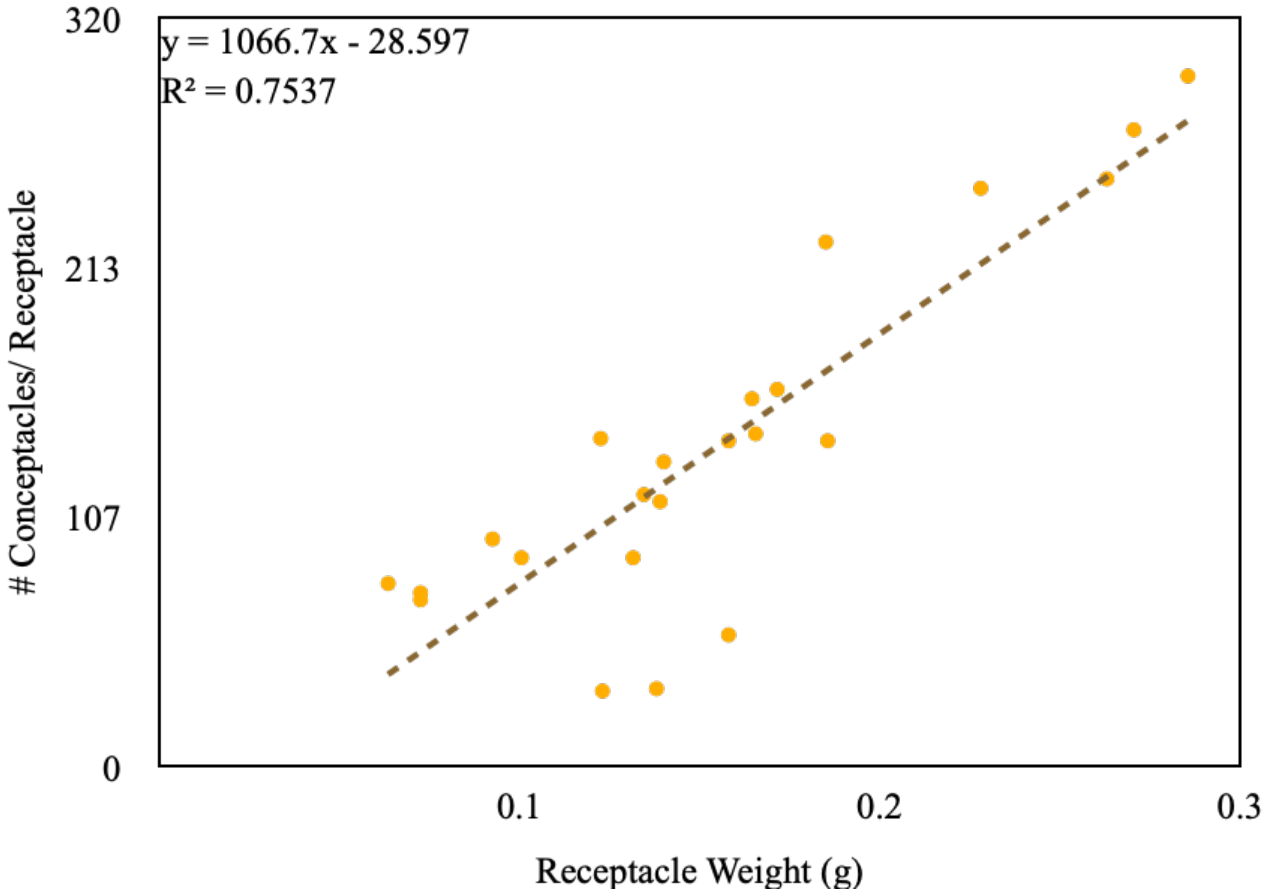
Sargassum horneri

Whole Individuals

- 6 individuals; whole alga weighed
- If individual was reproductive; receptacles removed and weighed

Preserved receptacles

- 5 random receptacles preserved in formalin
- Receptacle to conceptacle correlation
- Cross-sectioned to count #eggs per conceptacles



Macrocystis propagule scaling

- Neushul's number = **3.5×10^5 spores/mm^2**
  -When sporangia are present on both sides of a blade
- Observed in cross-sections, some sporophylls are fertile on one side and some are fertile on both sides
- 1 sori punch = 28.27m^2 , 0.02 g
- **1 gram of sori = 1.42×10^3** mm^2 or 142 cm^2

$$\frac{3.5 \times 10^5 \text{ spores}}{\text{mm2}} * \frac{1.42 \times 10^3 \text{ mm}^2}{\text{g}} = \mathbf{4.97 \times 10^8 \text{ spores/g}}$$

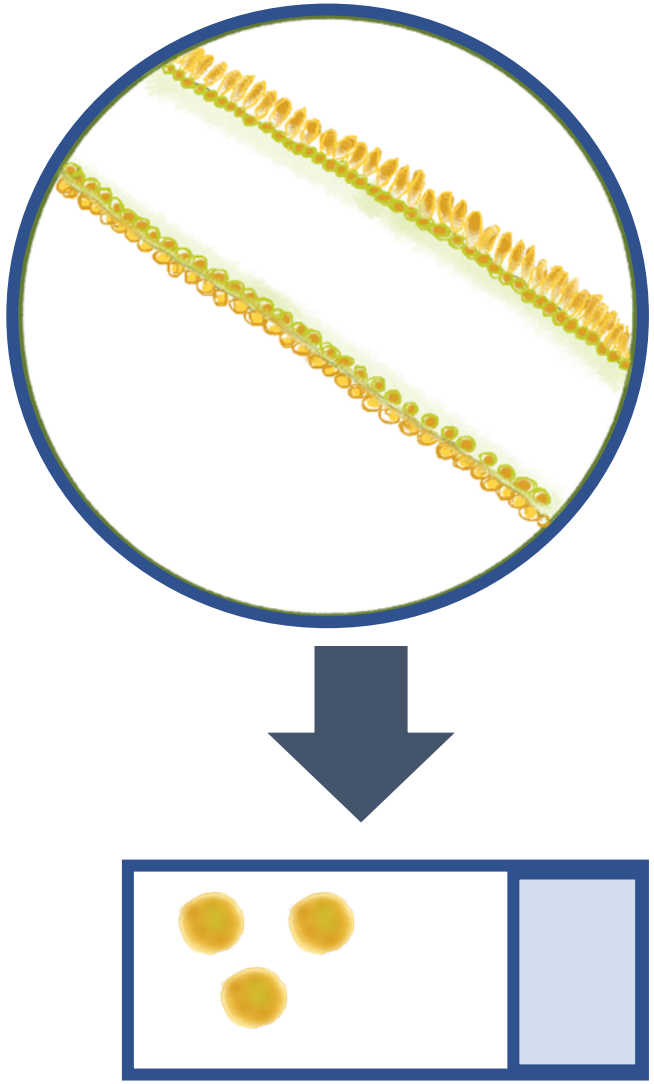
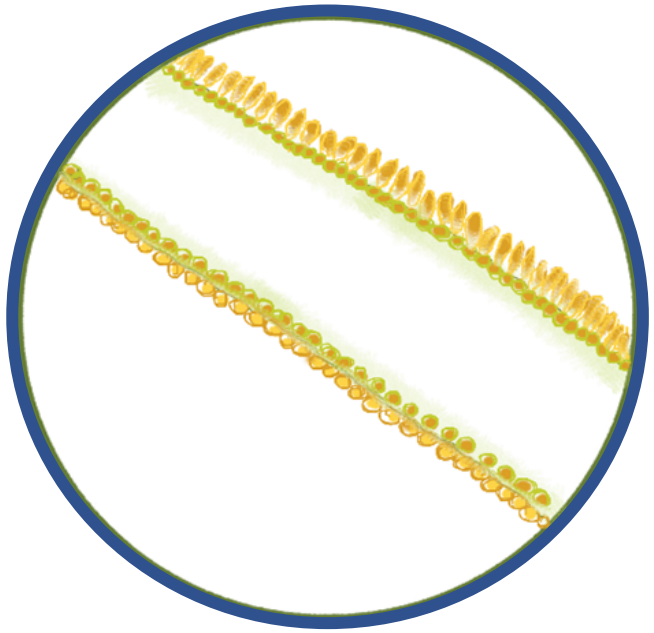


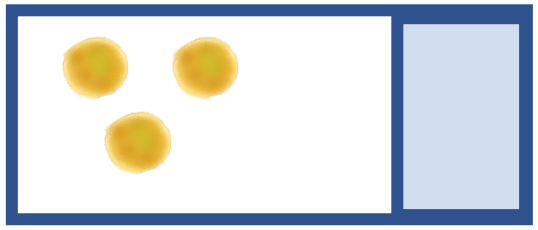
Illustration: Ann Bishop

Illustration: Ann Bishop

Macrocystis propagule scaling diagram

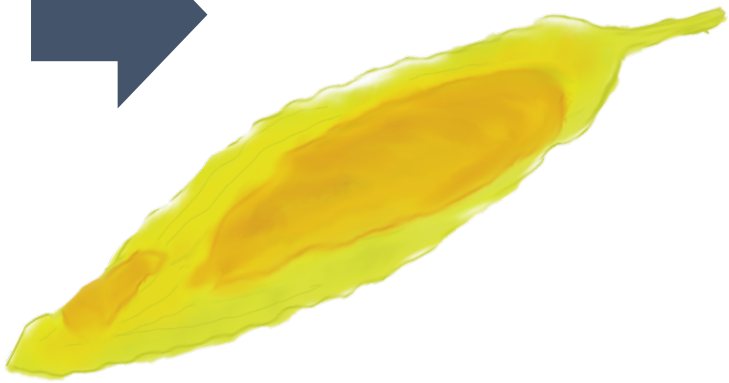


Cross-sections: Sporangia present?*



Mean **spores/g** from all punches **per sori**

Spores/sporophyll = spores/g * grams of sori



4.97 x 10^8 spores/g * 1 = sporangia present both sides

or

4.97 x 10^8 spores/g * ½ = sporangia present 1 side

Illustration: Ann Bishop

Macrocystis propagule scaling diagram

Spores/ individual =
spores/sporophyll * # of sporophylls

Spores/ site =
spores/individual * site density (#/m^2)

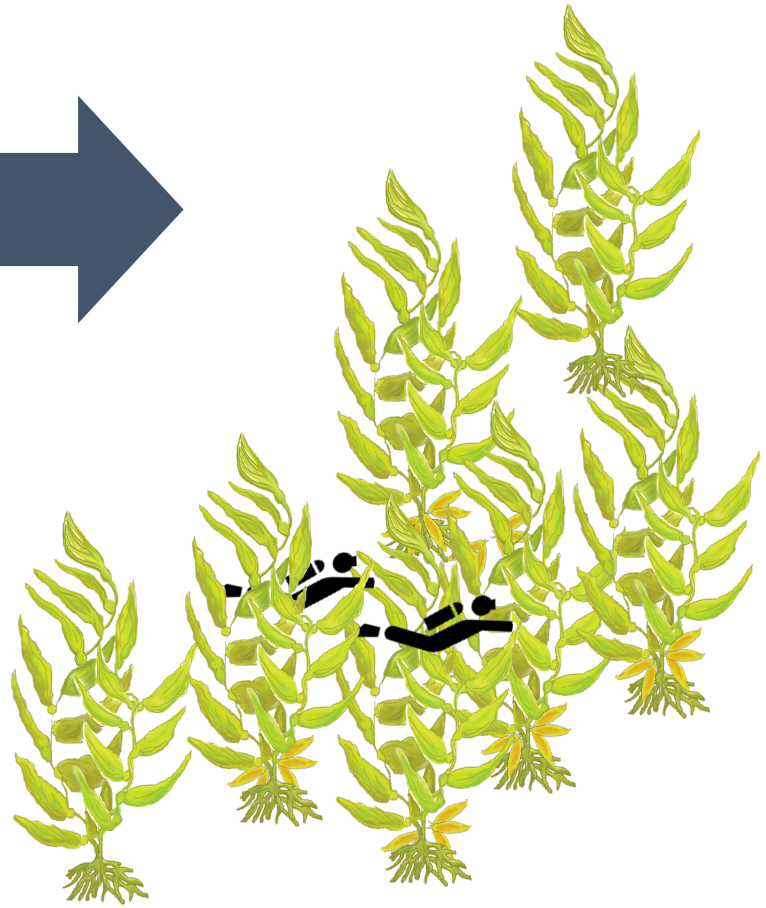
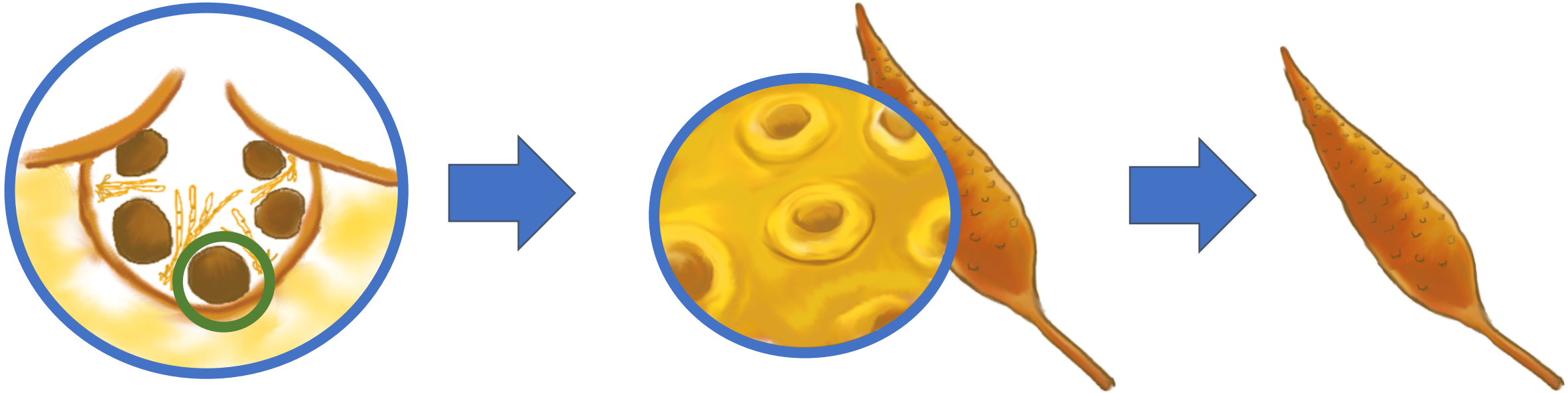


Illustration: Ann Bishop

Sargassum propagule scaling

Eggs / receptacle =
eggs / conceptacle * # conceptacles/ receptacles



Eggs / conceptacle

*Mean of 3 conceptacles from 3 receptacles

Illustration: Ann Bishop

Sargassum propagule scaling

Eggs / individual =
Eggs/receptacle * # receptacles

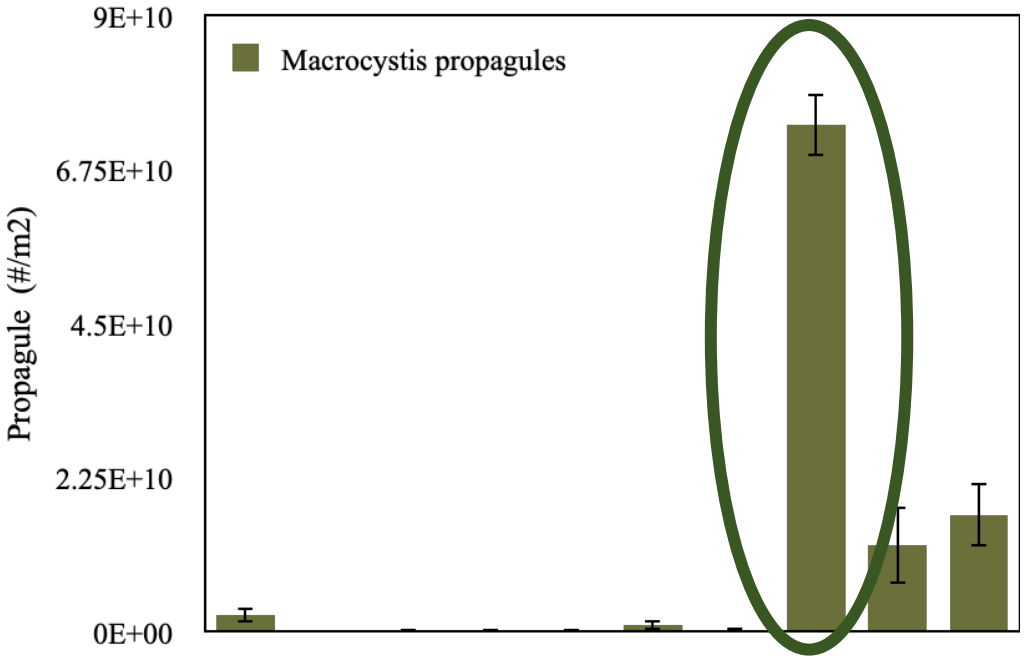
Eggs / site =
eggs / individual * site density (#/m^2)

Results

Intake Pipes

Propagules /m^2

Factors	p- value
Macrocystis x Site	0.0226
Macrocystis x Time	0.0405
S. horneri x Site	0.0054
S. horneri x Time	0.0009



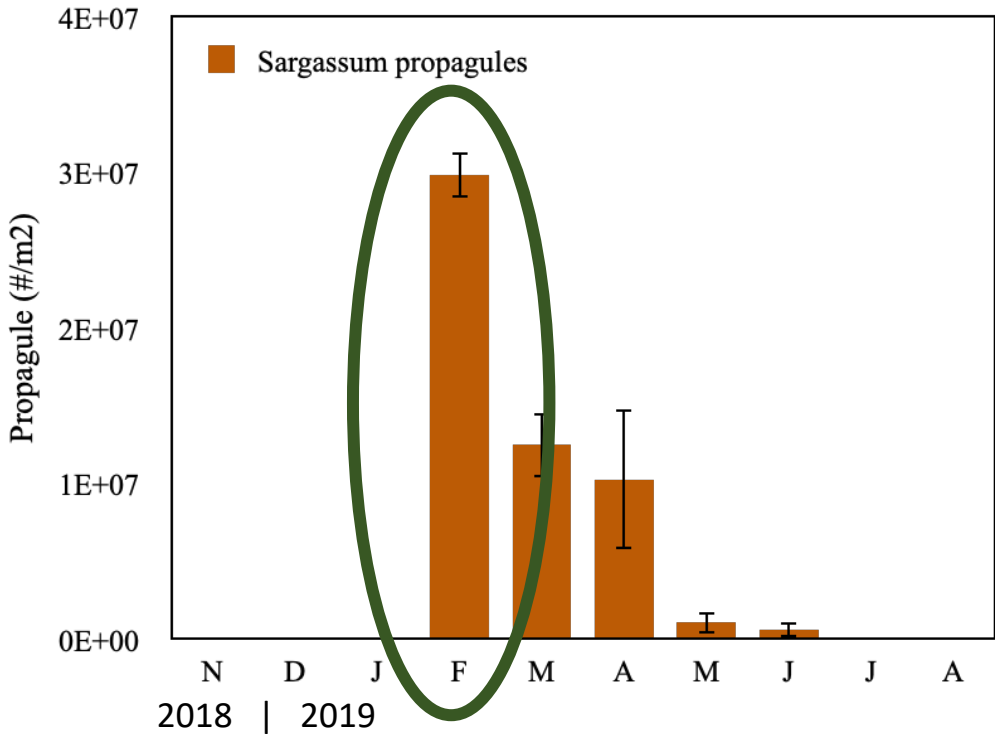
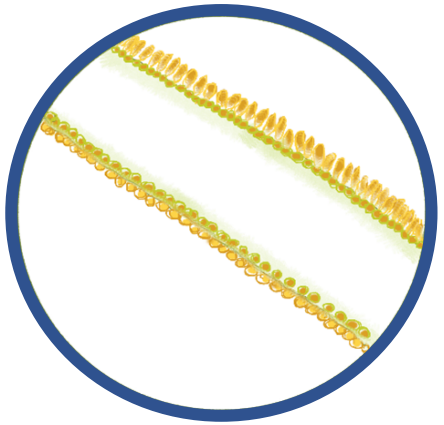


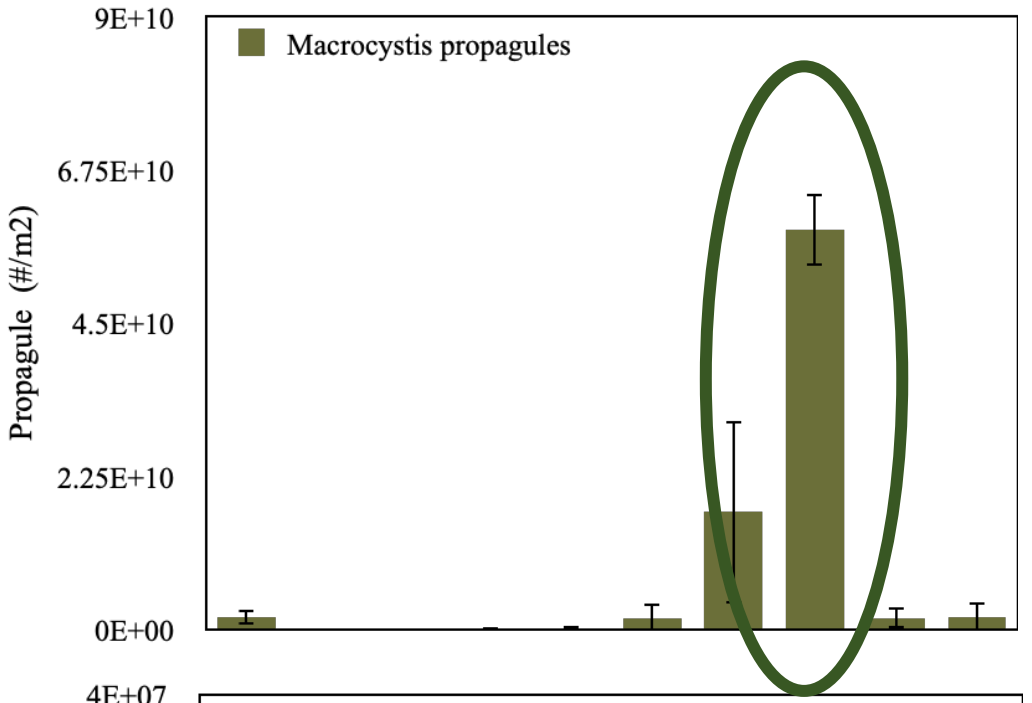
Illustration: Ann Bishop



Results

Howland's Landing

Propagules /m^2



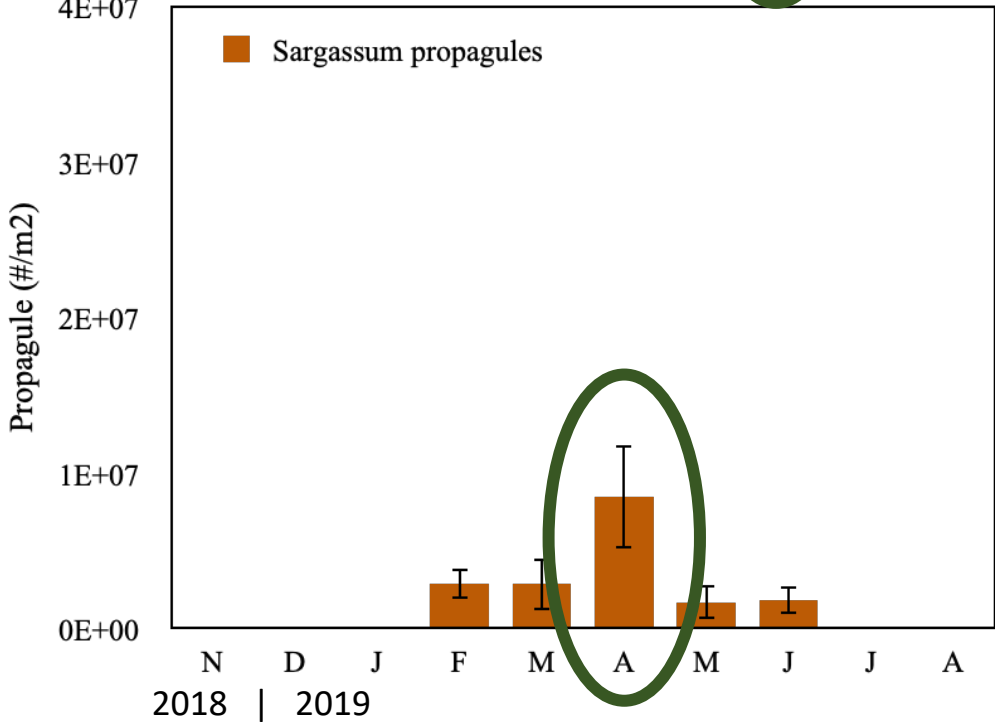
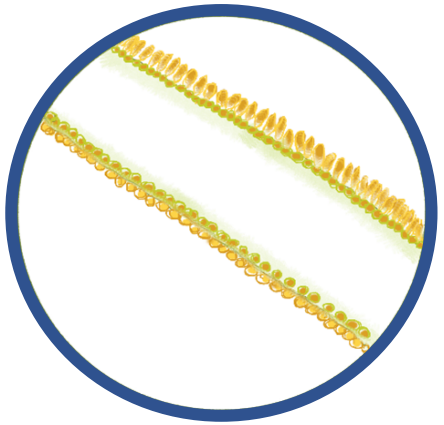


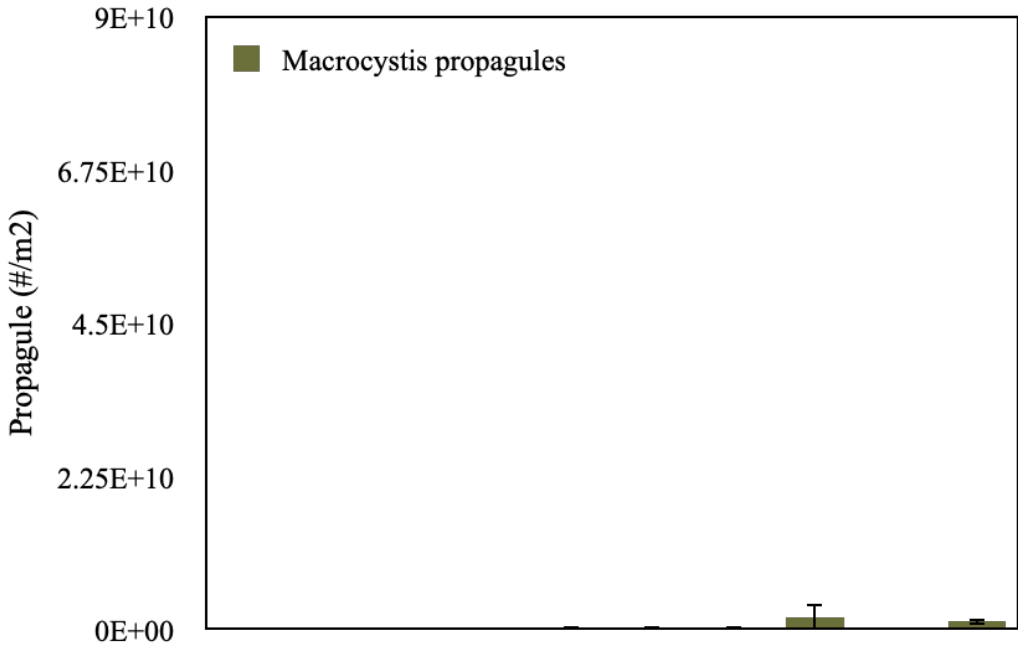
Illustration: Ann Bishop



Results

Chalkwall

Propagules /m^2



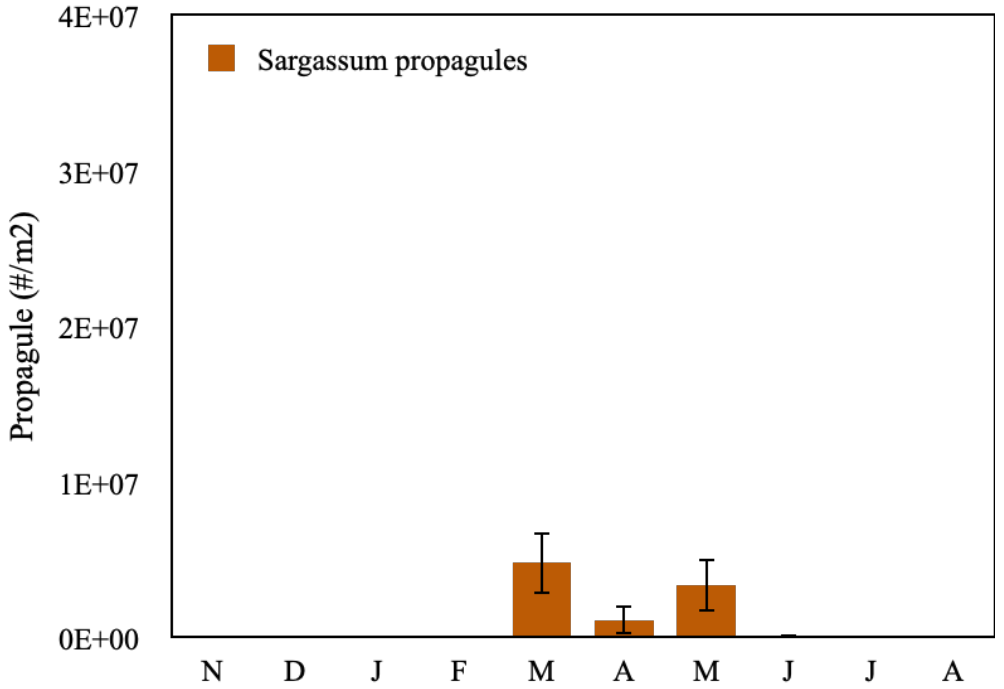
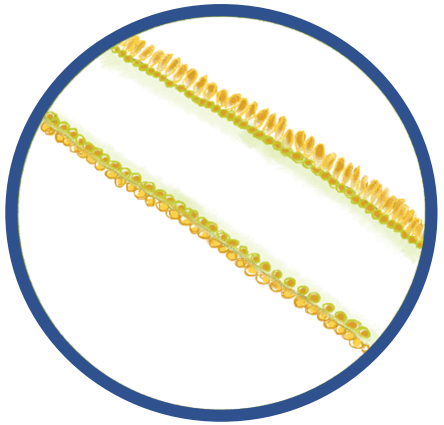


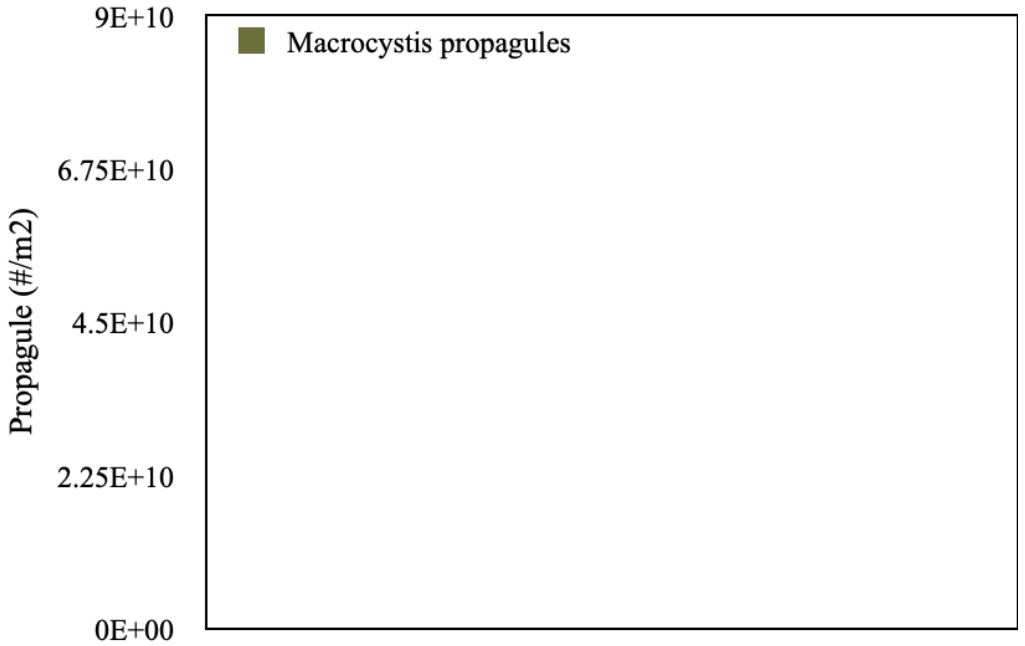
Illustration: Ann Bishop



Results

Indian Rock

Propagules /m^2



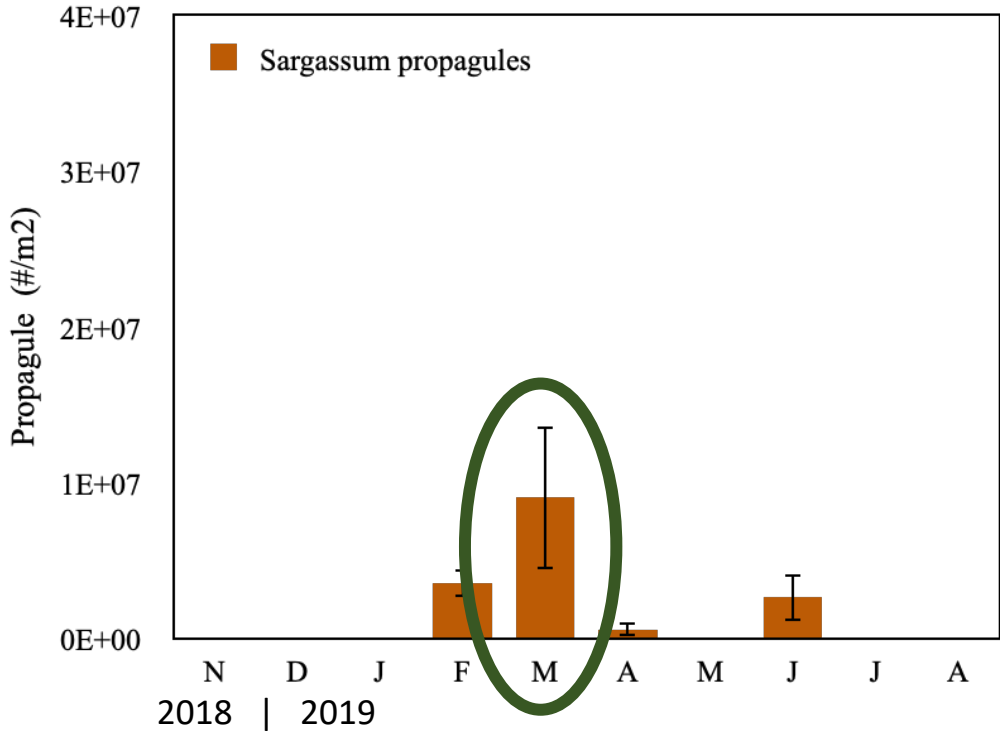
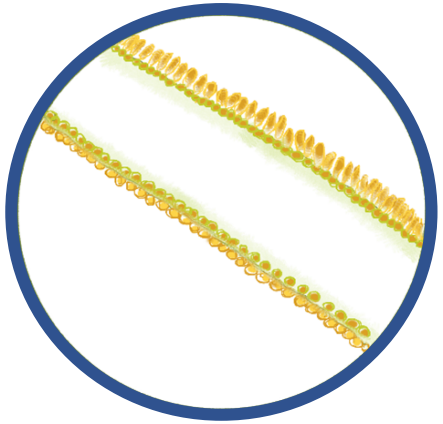


Illustration: Ann Bishop



Discussion:

Macrocystis had the highest release in the summer and early fall.

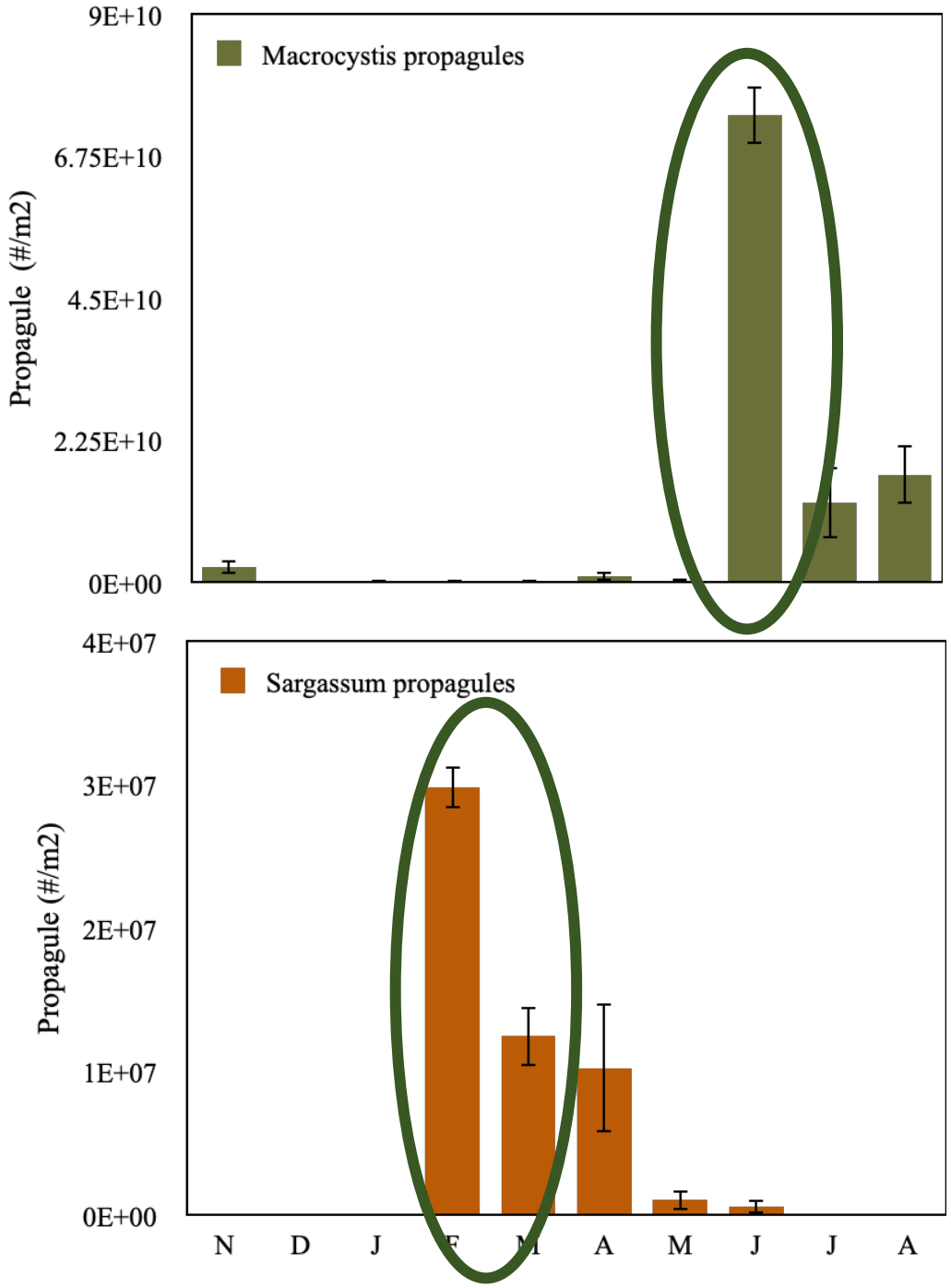
- Some sporangia production year round
- This is **different from what was expected** (Dayton and Tegner 1984 , Reed 1990, Graham 2003)
  - previous studies predicted the largest kelp reproductive window in the spring
  - cold water, nutrient rich, upwelling periods

Photo: USC Wrigley

Discussion

Sargassum horneri had the highest release in the winter and spring.

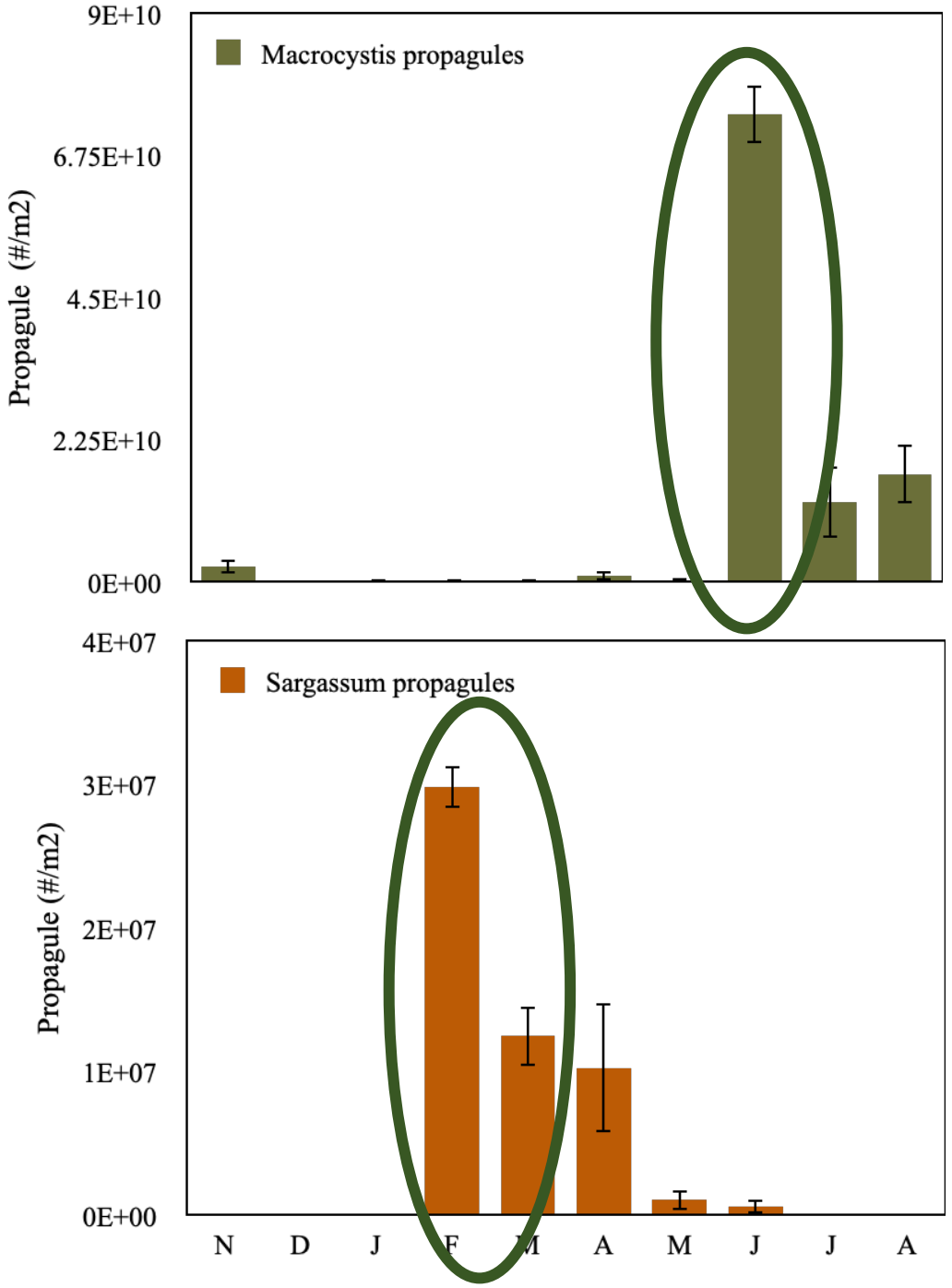
- This is **months before** the observed **peak in kelp reproduction**
- **During the expected** high **kelp reproduction**/recruitment window
- ***S. horneri* was observed reproducing** in this season prior and **during the El Niño** too. (Marks et al. 2015, 2018 and Clayton 2017)



Discussion

Sargassum horneri had the highest release in the winter and spring.

- There was **no fall reproductive cohort observed 2018-2019**.
- This is **contrary to previous studies** on Catalina island between 2014-2017. (Marks et al. 2015, 2018 and Clayton 2017)



Sargassum horneri had the highest release in the winter and spring.

- There was **no fall reproductive cohort observed 2018-2019**.
- This is **contrary to previous studies** on Catalina island between 2014-2017. (Marks et al. 2015, 2018 and Clayton 2017)
- Was this because **2018-2019 was** overall **cooler**?

Photo: Sarah Jeffries

Conclusions

Macrocystis pyrifera

- **Reproduction peaked in the summer/fall**
- Not during expected spring season

Sargassum horneri

- **Reproduced in the winter/spring**
- **No fall cohort** observed in **2018/2019**
- **Develops faster** than **kelp**

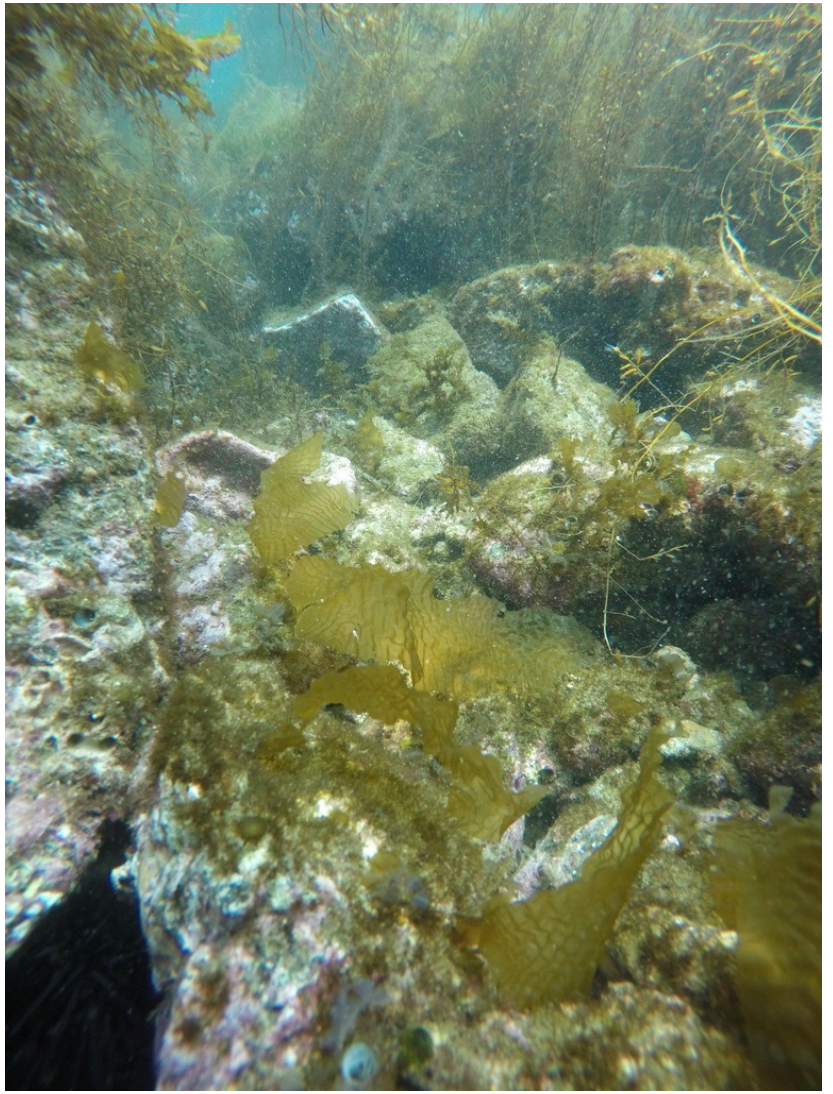


Photo: Ann Bishop

Future research:

- Were the observations of this study a sign of **shifting recruitment** windows due to **climate change**?
- How do other **kelp forests** in the Southern California Bight and other Channel Islands **compare**?
- Are there **genetic differences** between Baja, SCB, and Monterey ***Macrocystis pyrifera*** that could **support heat tolerance**?

Thank you!

Committee
Dr. Mike Graham
Dr. Diana Steller
Dr. Tom Connolly

Volunteers
Sarah Jeffries
Elizabeth Ramsay
Mina Sattari
Shelby Penn
Dan Gossard
Taylor Eddy
Mo Wise
June Shrestha
Kristen Saksa
George Jarvis
Lauren Smith
Emily Ryznar
Jack May
Maddie Heard

Wrigley Staff
Lauren Czarnecki Oudin
Trevor Oudin
Eric Castillo
Kelly Spafford
Megan MacGregor
Sean Conner
Karen, Jill, and office team

UROC Intern
Summer

The Beerpigs

Family & Sid

CELP Staff

MLML Staff
Terra Eggink
Ivano Aiello
Kathleen Donahue
Jocelyn Douglas
Katie Lage
Gitte McDonald
Jim Harvey
Michelle Keefe
Jane Webster
IT Team!
Shop Guys!

Funding & Awards
MLML Wave and Service Awards
UCSC Wrigley Fellowship
UROC