The next “killer” algae?

Risk assessment and mitigation for aquarium strains of the marine macroalgal genus *Chaetomorpha*

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Invasive Species Associated with Aquarium Dumping

Pterois volitans

Caulerpa taxifolia

If not *Caulerpa*, then something else…

Aquarium Macroalgae

- Used as biological filter
- Desirable if:
  - High nutrient uptake rates
  - Hardy (wide tolerances)
  - Easy to obtain/share

Could replacement macroalgal species become invasive?

Aquarium Macroalgae

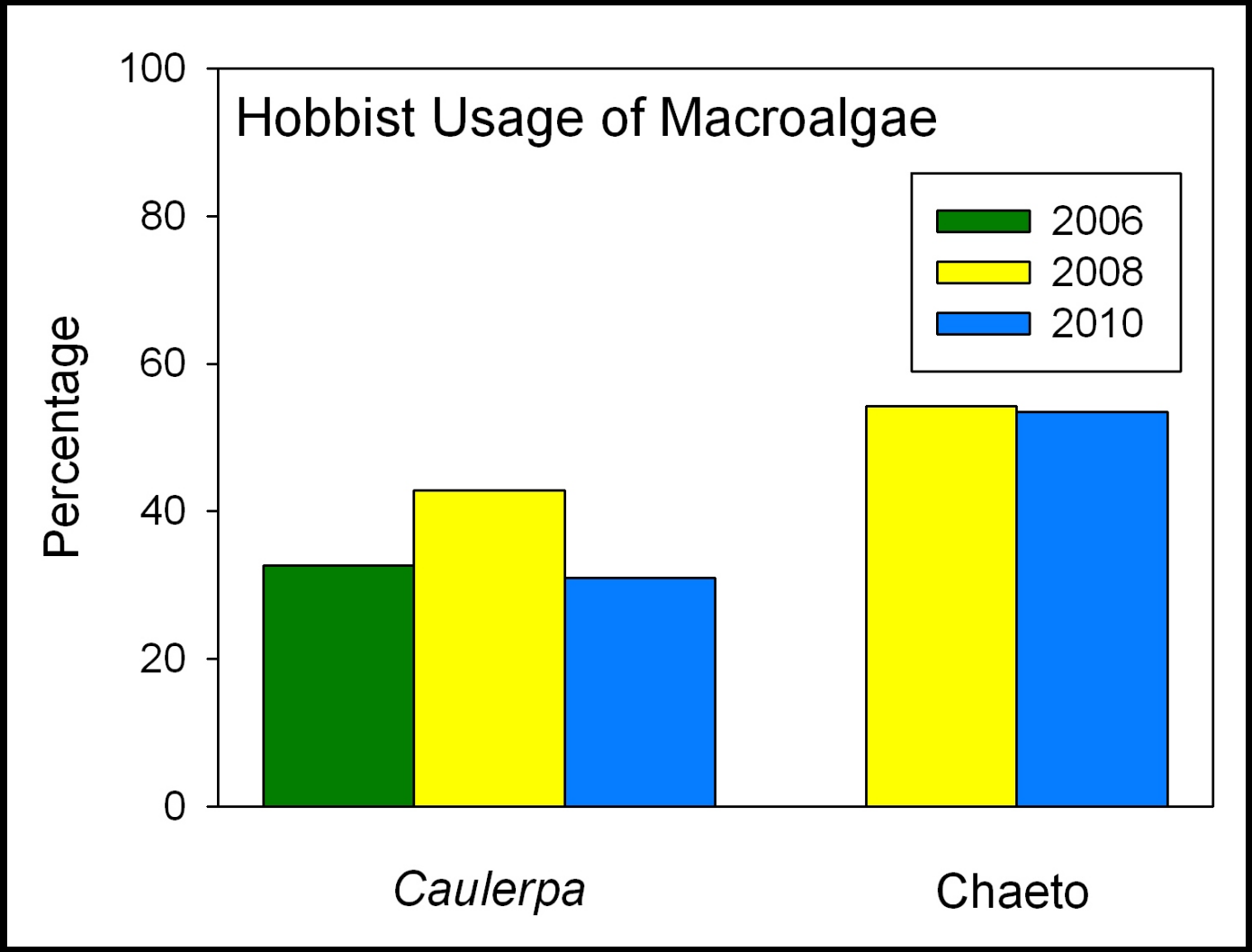
- Used as biological filter
- Desirable if:
  - High nutrient uptake rates
  - Hardy (wide tolerances)
  - Easy to obtain/share

Macroalgae: Invasability

Factors promoting invasion success

- Fast uptake/growth
- Hardy (wide tolerances)
- Vegetative reproduction

Hobbyist Usage of Macroalgae



Does *Chaetomorpha* fit the bill to be our next invasive aquarium species?

- We know very little about this alga beyond that it is "very hardy".
- Taxonomists
  - ITIS Data Base: 11 species in genus
  - AlgaeBase: 62 species in genus
- Lots of blooms, but never listed as invasive.
- Common names: Chaeto, brillo pad alga, spaghetti alga
- We should be proactive and be prepared!

MS Thesis: Rachel Odom

- (2014) *Biological Invasions* 16:2589-1597.

  A safe alternative to invasive *Caulerpa taxifolia*? Assessing aquarium-release invasion potential of aquarium strains of the macroalgal genus *Chaetomorpha* (Audience: Scientists)
- (2014) *Invasive Plant Science and Management* 7:76-83. Alternatives to release: efficient methods for disposal of excess or unwanted aquarium mancroalgae in the genus *Chaetomorpha* (Audience: Hobbyists)
- (In press) *Journal of Aquatic Plant Management*. Chemical eradication methods for aquarium strains of *Chaetomorpha* (Audience: Managers)

Fragment Generation, Survival and Growth

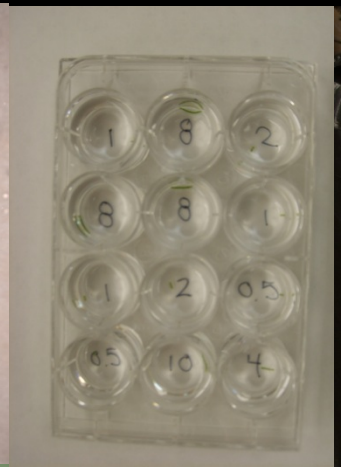
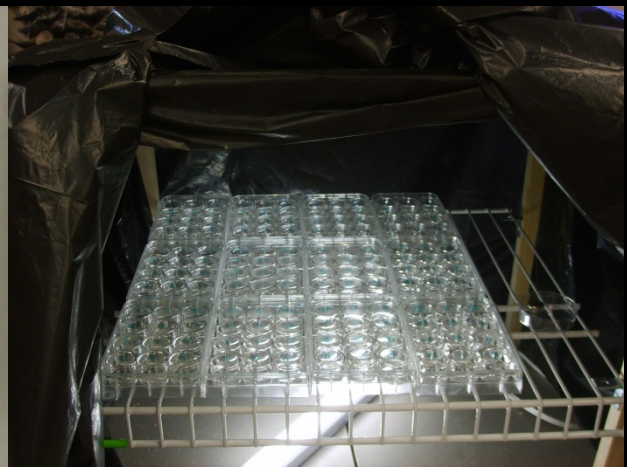
- What is the minimum viable fragment size?
- Are smaller fragments less likely to survive?
- Can fragments survive under different thermal conditions?
- How many viable fragments are generated by hobbyists?

Fragment Generation, Survival and Growth

Methods

- Purchased 10 aquarium strains of *Chaetomorpha*
  - Counted, measured fragments generated in transport
- Cut fragments to lengths 0.5 – 10 mm (n = 25)
  - Exposed to 5, 22 and 30°C
- Monitored survival and growth over 2 weeks



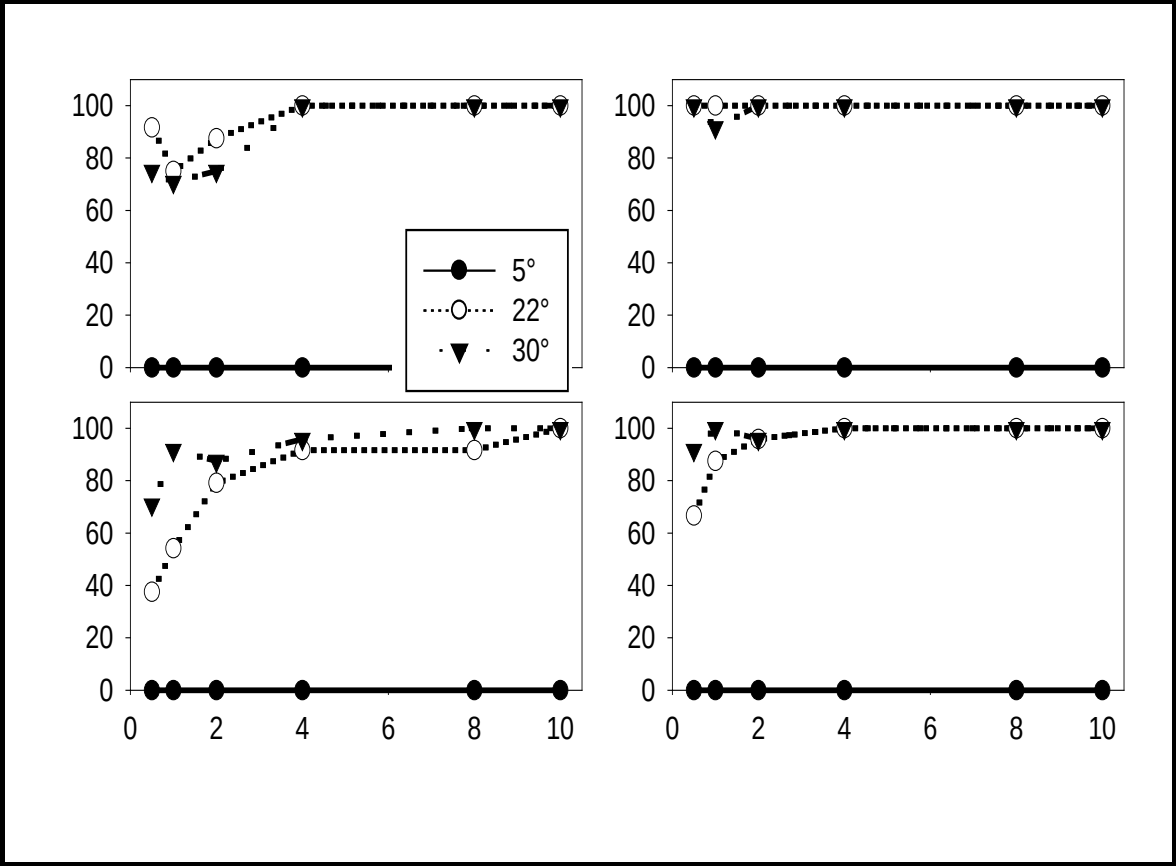



Fragment Generation, Survival and Growth

- 3 species received
  - *C. linum* (4), *C. spiralis* (4) & *C. crassa* (2)
- No significant differences in fragment generation
  - Among species: *P*=0.704
  - Among purchase types (online, local): *P*=0.654
- No effect of distance shipped/transported: *P*=0.410

Fragment Generation, Survival and Growth

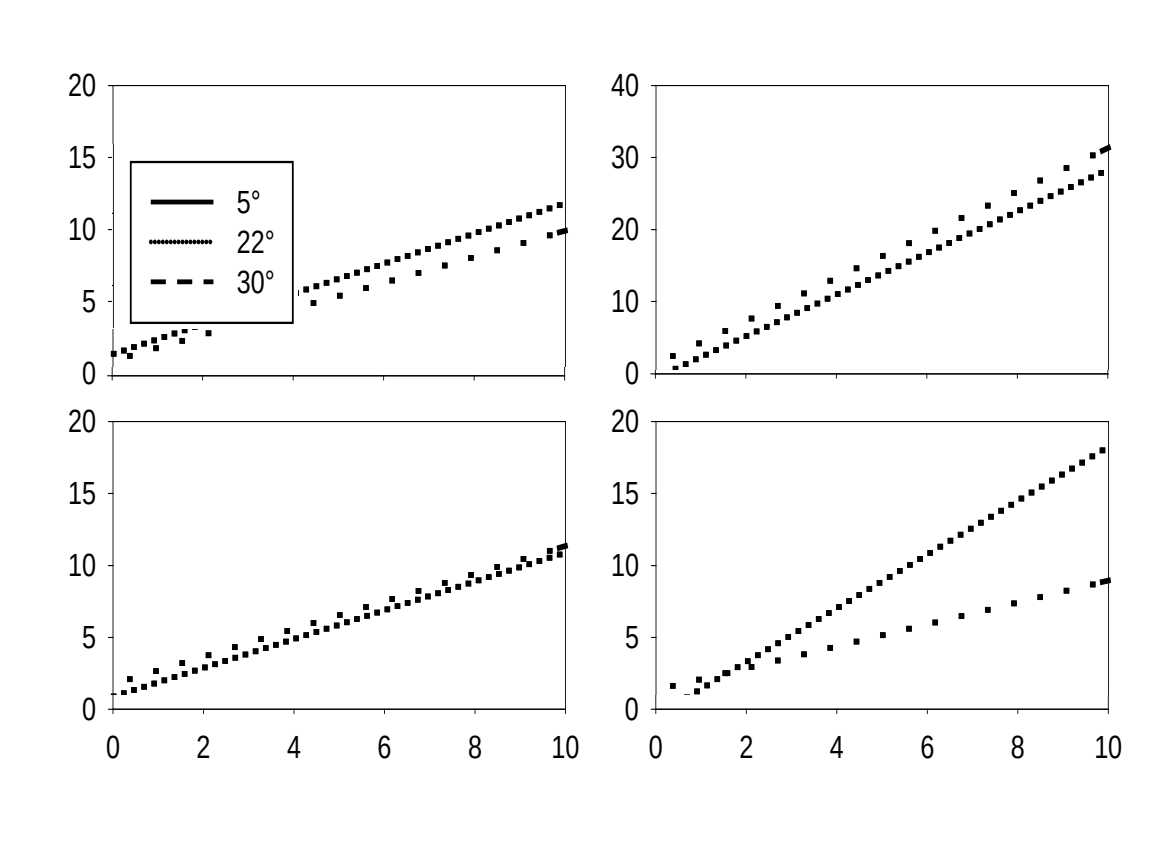
Results – Fragment Survival for *Chaetomorpha linum*



Initial size NS ($P>0.05$); Temp significant ($P<0.001$);
Interaction NS ($P>0.05$)

Fragment Generation, Survival and Growth

Results – Growth of surviving fragments



Initial size significant ($P<0.05$); Temp NS ($P>0.05$);
Interaction significant in 2 of 4

Fragment Generation

Purchase	Total no. fragments	Species	Predicted to survive at 5°	Predicted to survive at 22°	Predicted to survive at 30°
2	6266	*C. spiralis*	5% (288)	88% (5487)	58% (3643)
3	223	*C. spiralis*	0	97% (216)	98% (218)
4	28	*C. spiralis*	0	100% (28)	100% (28)
5	90	*C. crassa*	80% (72)	93% (84)	82% (74)
6	1208	*C. crassa*	0	100 (1208)	100% (1208)
7	672	*C. linum*	0	99% (667)	99% (663)
8	704	*C. linum*	0	100% (704)	100% (703)
9	1917	*C. linum*	0	98% (1880)	99% (1902)
10	857	*C. linum*	0	100% (857)	100% (857)

Fragment Generation, Survival and Growth

Answers to Research Questions

- What is the minimum viable fragment size? 0.5 mm
- Are smaller fragments less likely to survive? No
- Can fragments survive under different thermal conditions? Yes
- How many viable fragments are generated? Can be in the thousands per purchase

Hitchhikers with *Chaetomorpha*

Hitchhikers may also be introduced with *Chaetomorpha* purchases

– Includes known invasives and their congeners

Aquarist Disposal Techniques

Determine minimum exposure times for safe disposal of *Chaetomorpha* by reported methods

- Boiling
- Microwave
- Freezing
- Desiccation
- Plumbing (freshwater, light deprivation)

Does minimum duration increase with amount of algal tissue?

Aquarist Disposal Techniques

Methods

- 3 purchases
- Tested 5 techniques for fragments and for clumps
  - Boiling, microwave, freezing, desiccation, freshwater

n=10 dishes n=20 dishes

5 fragments each 1 clump each

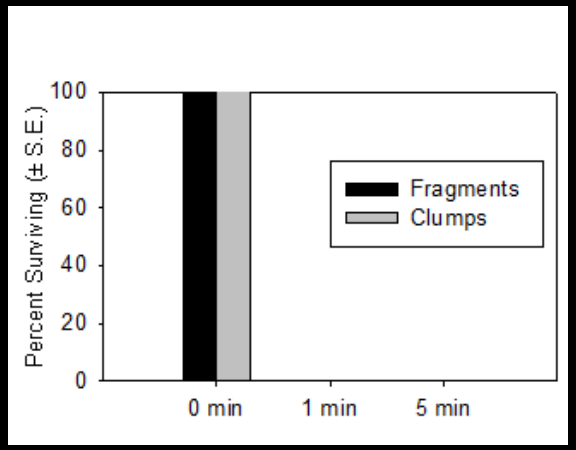
Aquarist Disposal Techniques

Methods

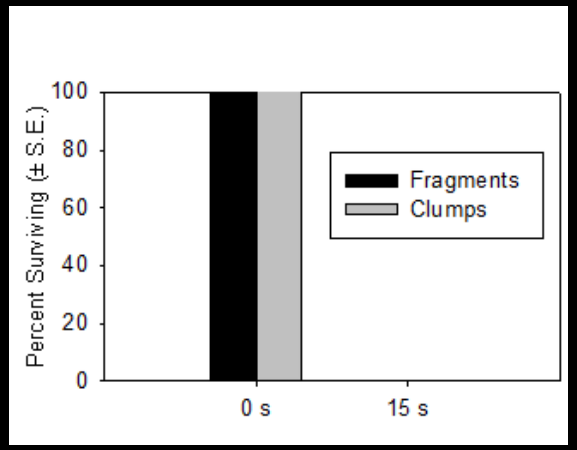
Disposal Technique	Tested Durations
Boiling	0, 1, 5 min
Microwave	0, 15 sec
Freezing	0, 12, 24, 48 hr
Desiccation (no lid)	0, 2, 4, 24 hr
Desiccation (closed lid)	0, 2, 4 hr, 3, 6 days
Freshwater (no light)	0, 3, 6 days

Aquarist Disposal Techniques

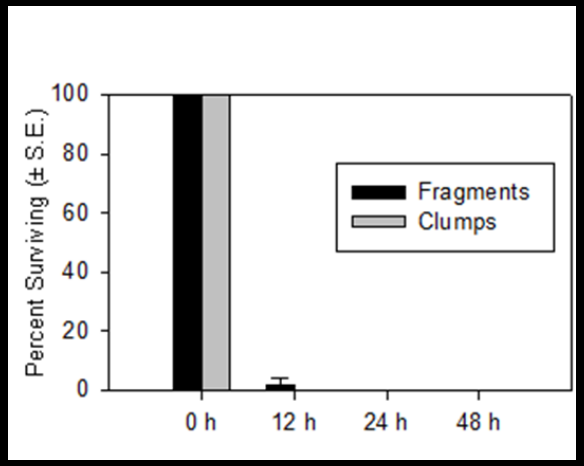
Boiling: 100% dead

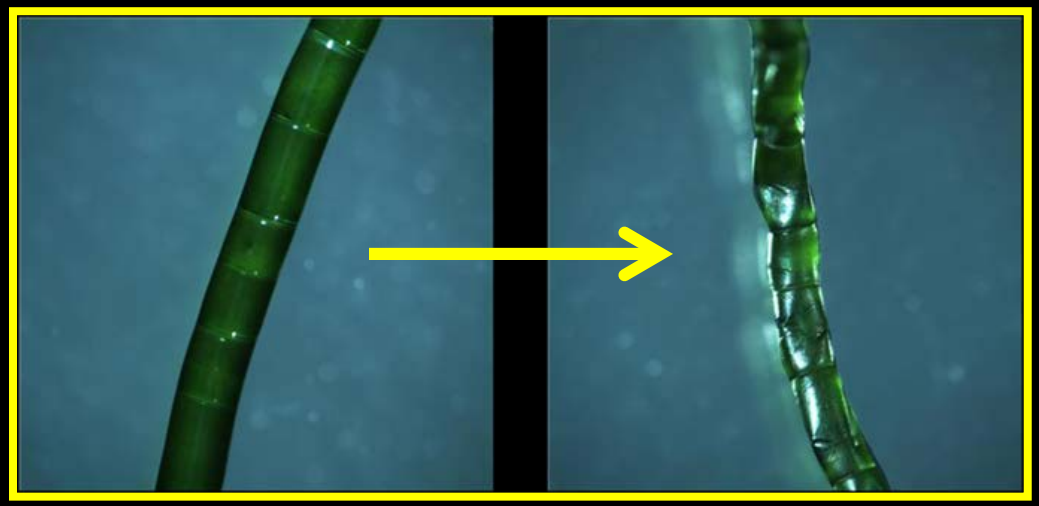


Microwave: 100% dead



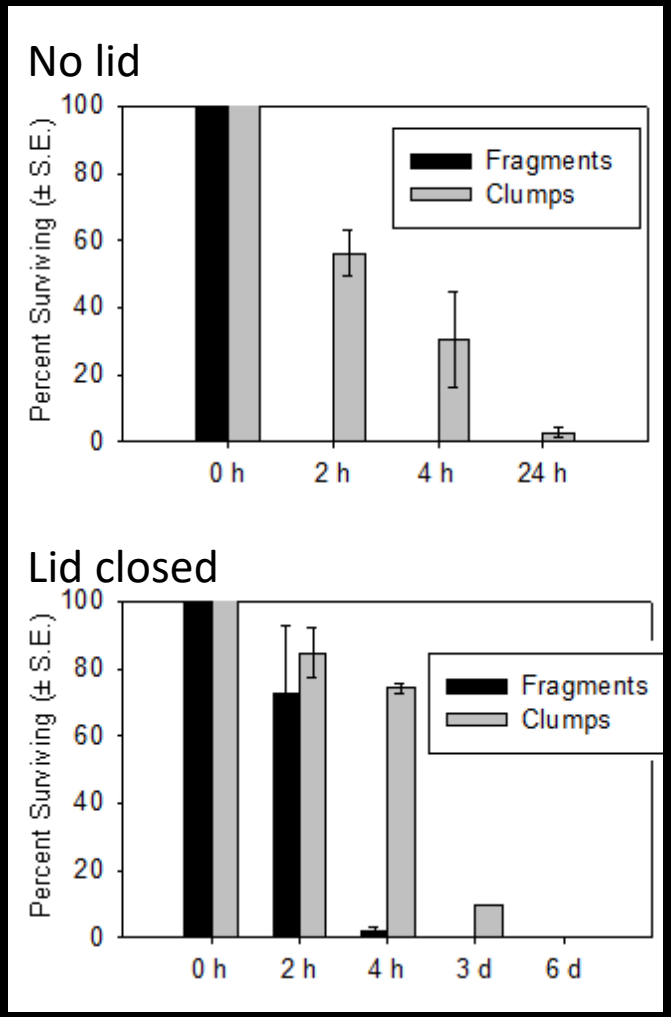
Freezing: 100% dead





Aquarist Disposal Techniques

Results – Desiccation

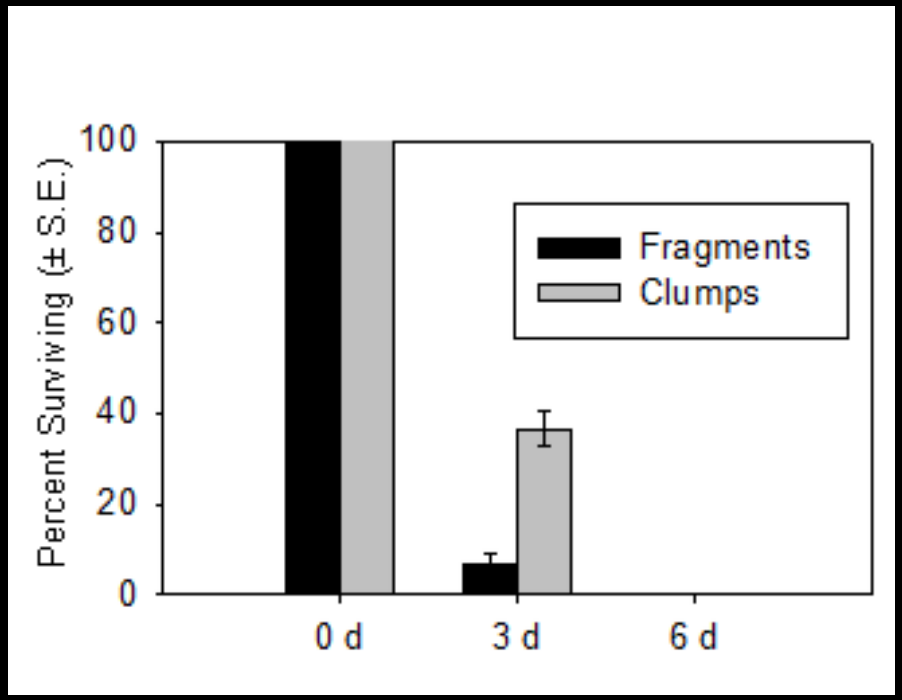


- No lid
  - Near 100% mortality at 24 hrs
- Lid closed
  - 100% mortality at 6 days

Clumps require more time for desiccation

Aquarist Disposal Techniques

Results – Freshwater (no light)



- 6 days exposure needed for 100% mortality
  - Clumps require longer than fragments

Aquarist Disposal Techniques

Disposal Recommendations

Disposal Technique	Durations	Disposal Applications
Boiling	1 min	Boiling purchase water containing algae or tank water after water change
Microwave	15 sec	Microwaving prior to disposal
Freezing	24 hr	Freezing in plastic bags prior to disposal
Desiccation (no lid)	24+ hr	Desiccation prior to disposal
Desiccation (closed lid)	6+ days	Disposal via garbage cans (destined for landfill)
Freshwater (no light)	6 days	Disposal via plumbed sinks or drains, NOT recommended via storm-water drains

Chemical Eradication Methods

Importance

- Successful eradication of an invasion requires rapid response
  - Proactively determine effective chemical treatment
  - Eliminate research time-lag to limit stronghold, spread
- Limiting detriment to nontarget species
  - Minimize quantity of chemical used

Assess effectiveness of chemical algicides for removal of potential invasions by *Chaetomorpha*

Chemical Eradication Methods

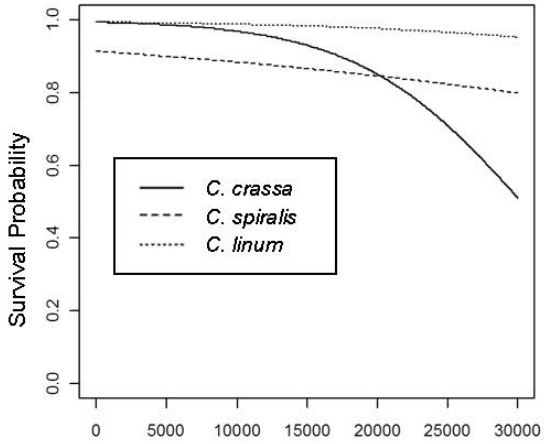
Methods

3 populations tested, n=5 (10 mm fragments)

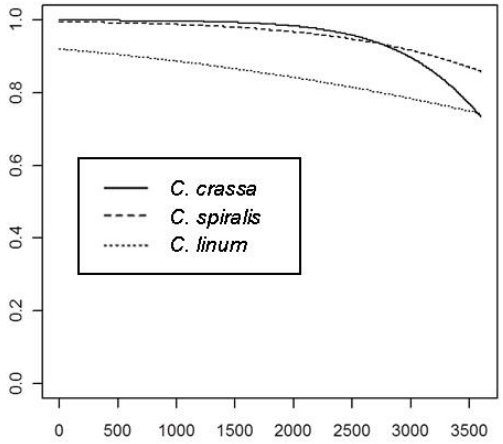
Chemical	Tested Concentrations	Exposure Durations
Chlorine bleach	0, 50, 125, 250 ppm	0, 30, 60, 90, 120 min
Rock salt	0, 10, 20, 30 g/L	0, 30, 60, 90, 120 min
Copper sulfate	0, 10, 20, 50 mg/L	0, 30, 60, 90, 120 min
Acetic acid	0, 1, 2, 4%	0, 1, 2, 3, 4 min
Sonar (A.I. fluridone)	0, 10, 20, 50 ppb	0, 2, 4, 6, 8 wks

- Used chemicals and dosages effective with *Caulerpa taxifolia*
- Exposed to chemical, rinsed, resubmerged (4 wks)
  - Survival, growth

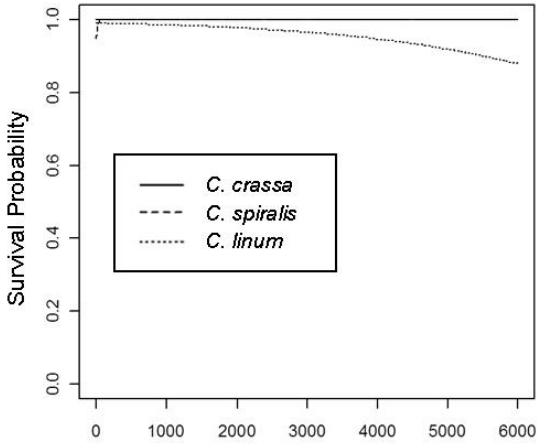
Survival



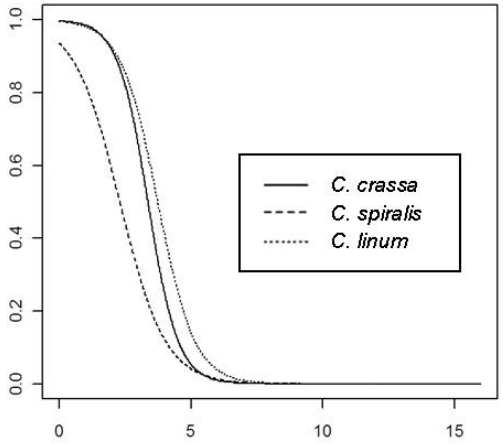
Chlorine (ppm X min)



Salt (g/L X min)



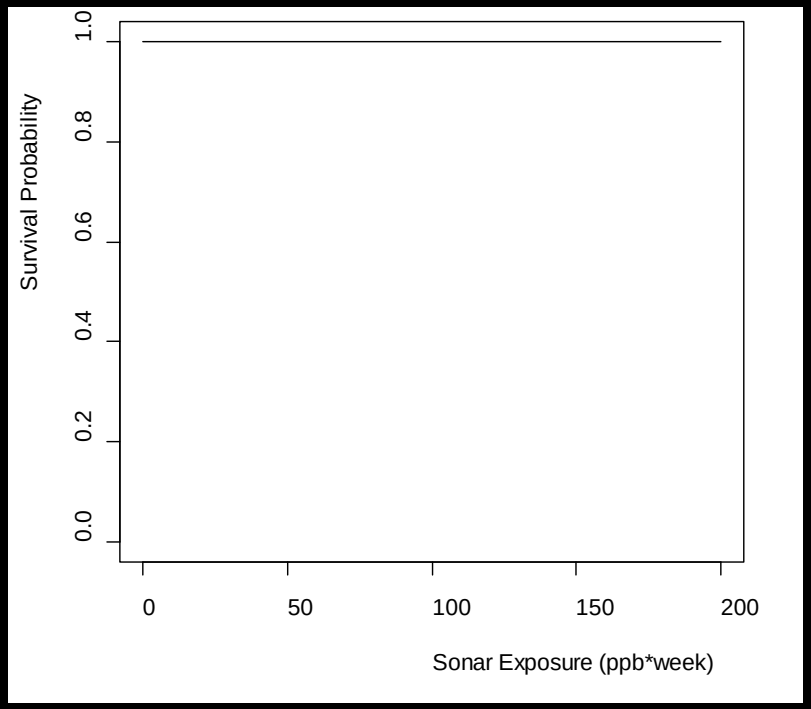
Copper (mg/L X min)



Acetic Acid (% X min)

Chemical Eradication Methods

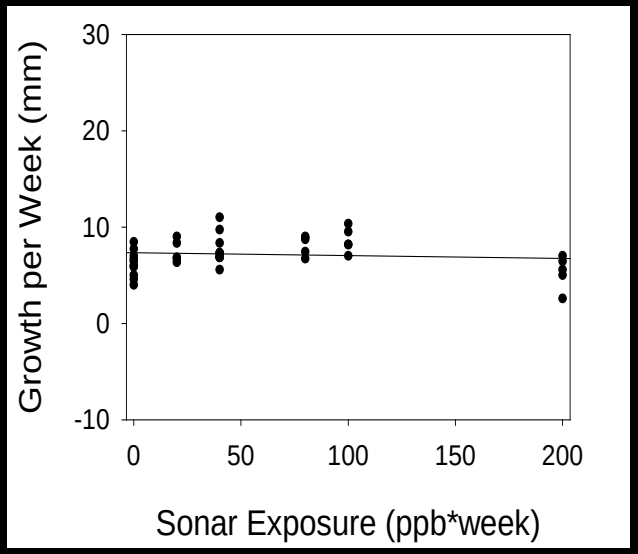
Results – Sonar



1 purchase tested, n=5 fragments

- 100% survival for all treatments
- Did not significantly limit growth

Not effective as tested



Chemical Eradication Methods

Comparison to eradication considerations for *Caulerpa taxifolia*

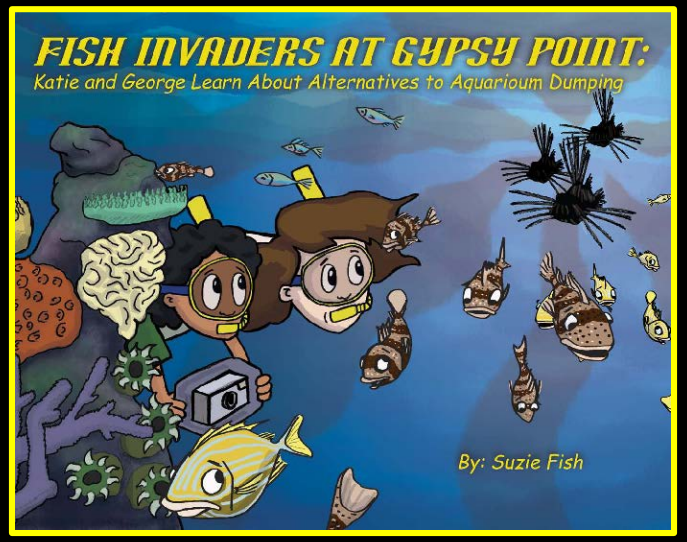
Chemical	*Caulerpa taxifolia*	*Chaetomorpha*
Chlorine bleach	125 ppm for 30-60 min 50 ppm for 90+ min	Not effective at tested concentrations (up to 250 ppm for 120 min)
Rock salt	24 g/L for 30 min 18 g/L for 60+ min	Not effective at tested concentrations (up to 30 g/L for 120 min)
Copper sulfate	20 mg/L for 30 min 5 mg/L for 60+ min	Not effective at tested concentrations (up to 50 mg/L for 120 min)
Acetic acid	1% for 60+ min	4% for 1 min 2% for 4 min
Sonar (fluridone)	50 ppb for 12 days	Not effective at tested concentrations (up to 50 ppb for 8 weeks)

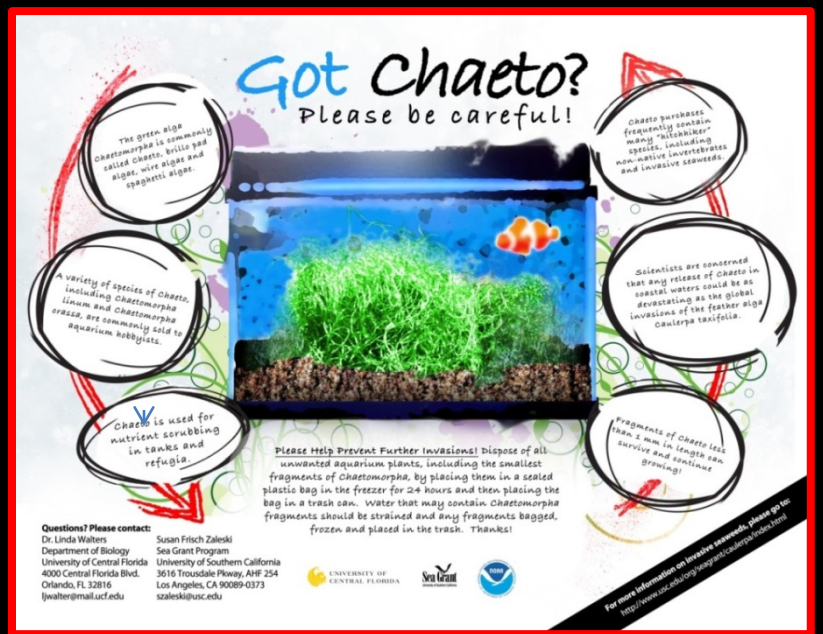
Chaetomorpha **harder to eradicate than** ***Caulerpa*****!**

Risk Mitigation Summary

Two-barrier approach

- Prepare for potential invasions
  - Rapid response enabled by prescreened chemicals for eradication and/or management of invasion
- Prevent aquarium-release introductions
  - Outreach to aquarists with science-based recommendations





Mytella charruana: St. Augustine, FL (8/14)

Ascidians (Sea Squirts) in Mosquito Lagoon