Aquaculture of the giant opihi *Cellana talcosa* (ko`ele). Development of an artificial diet.

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Introduction and Background

"'Opihi overharvesting means slim pickings"

Honolulu Advertiser, Wed, June 1, 2005

•Scientists fear that the largest and most prized species of the hardy 'opihi a uniquely Hawaiian delicacy may be essentially extinct on O'ahu, and the population of other limpets statewide is also on the decline.

•"Pupu" in Hawaiian means "snail" and in modern times it is used to mean hors d'oeuvres. Opihi were the most favored pupu traditionally.

Opihi

- High value potential aquacultured product in Hawaii, $150/gallon with shell on. A century ago, 'opihi pickers were selling 140,000 pounds of the limpets annually. In recent years the number has been less than 10 percent of that, around 13,000 pounds.
- They dubbed ‘opihi “the fish of death” because so many people were swept away while prying it off the rocks. www.nature.org

Three main species of opihi in Hawaii

- *Cellana sandwicensis* - opihi alinalina – yellow foot – most common – preferred
- *Cellana exarata* - opihi makaiauli – black foot
  - *not preferred*
- *Cellana talcosa* - opihi ko`ele – giant

opihi – grows fast –lives in calm,

deep water – we targeted this

http://www2.hawaii.edu/~cbird/Opihi/frames.htm

Other views

Cellana exarata
(opihi makaiauli)

Cellana sandwicensis
(opihi alinalina)

Cellana talcosa
(opihi koʻele)

Outline of this talk

- To talk story about optimization of capture and holding strategies. Problem: 75% mortality in early days of holding and transferring. Starvation after a few days.
- To talk story about natural feeds and holding on biofilm. Benthic diatoms
- To describe early feed preference studies. Fish/soy and biofilm
- To talk story about a feed that may be capable of supporting long term growth and survival. We now have an artificial feed for the opihi. Diets containing commercial porphyra

Survival after capture, a new problem

(we attribute mortality to damage during capture)

Trial	individuals (started)	Mortalities after 4 days	% survival
First collection	38	21	48
Second collection	45	12	73
Third collection	29	5	83
Fourth collection	12	2	83

- We are getting better at collecting by being careful

Survival during research

(Problematic when removing from one tank wall to another tank)

	Individuals start	individuals after moving	% survival
1st group	17	9	53
2nd group	33	0	100
3rd group	24	0	100
4th group	10	0	100

- Problem scraping off tanks walls
- Put plastic liner and easy to remove

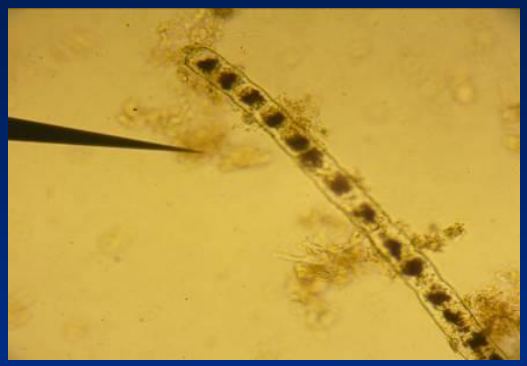
Biofilm. What is it?

- Stomach content of opihi. Unidentifyable particles as well as *Bacillaria, Fragilaria, Melosira*, *Navicula. Rhabdonema.* What they normally eat.
- Biofilm on tanks. From sand filtered seawater or salt spray. In the sun. Looks like a mat of benthic diatoms (brown film on tank plastic). In the microscope these included *Niztchia, Rhizosolenoa, Melosira, Cosinodiscus, and Navicula.* Also bacteria, macroalgae, and unidentifyable particles.

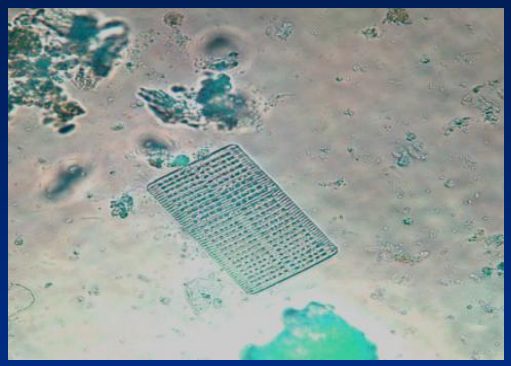
Stomach contents, a more complete list

Species seen often	Moderately abundant	Observed
Bacillaria paxillifer	*Amphora sp*	*Asterionella* sp.
Fragilaria sp.	*Climacosphenia sp*	*Cymbella* sp.
Melosira sp	*Grammatophora sp*	*Diplonesis* spp.
Navicula sp	*Licmophora sp*	*Mastogloia* sp.
Rhabdonema sp.	*Nitzchia* sp	*Opephora* sp
	Pleurosigma sp.	*Surirella sp*
	Tabellaria sp	*Thalassionella sp*
	Trigonium sp.	

Some stomach contents

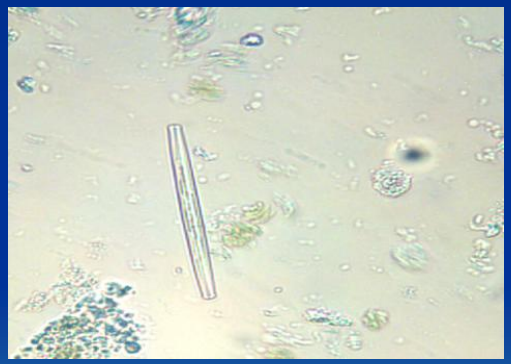


Melosira

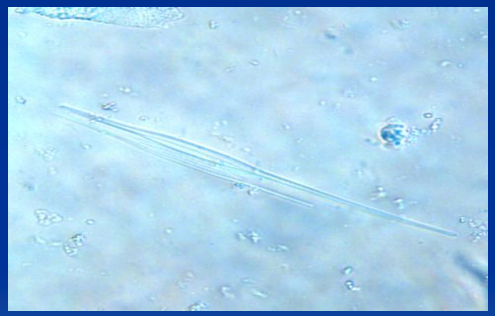


Rhabdonema

Navicula



Fragilaria



Niztchia

Lab grown biofilm seems to be similar to natural food.

Feeding on biofilm

- Opihi eat biofilm
- They do not eat every day
- The eating rate of 0.47% may be a natural feeding rate (slow growth)
- When in doubt we can hold opihi on biofilm.

	% drymatter/bodyweight/day							
1	0.7	0.59	1.3	0	0	1.2	0.25	0
2	0.93	0.60	0	0	0.84	0	0.30	0
3	0.12	0.42	0.42	0.74	0.78	0	0.87	0.75
4	0	1.12	0.55	0	0	0.56	0.50	0.37
5	0.12	0.56	0.84	1.06	0.52	1.11	0.33	.037
avg	0.37	0.66	0.62	0.36	0.43	0.57	0.45	0.30
	0.47±0.13							

For aquaculture

- Need an artificial feed.
- Need to hold animals for long periods of time, to breed them, and rear the larvae.
- Phase 1. What do they like to eat?
- Phase 2. Design a nutritious feed, spawing, larval rearing etc.

Feeding preferences

dry feeds

diet	%dry matter/bodyweight/ day
6% fishmeal+6%squidmeal	0.17
12% fishmeal	0.08
12% squidmeal	0.09
mussel homogenate	0.02
squid homogenate	0.02

Diet	%dry matter/bodyweight/ day
6% fishmeal+6%squidmeal	0.02
12% fishmeal	0.03
12% squidmeal	0.03

1. Have to feed animals before they die.
2. First test shows preference for marine meals
3. Second test cannot be compared to first. Shows no preference among marine meals. N=3

Feeding preferences
(gelatin feed: easier to make for us)

% dry matter/bodyweight/day			
Fish/soy	Soy/corn	Fish/soy/betaine	Soy/corn/betaine
0.16±0.06	0.10±0.03	0.03±0.05	0.01±0.01

N=3 (three animals/diet)
T=5 (5 days/diet)

Conclusions. Within limits of experimental uncertainty

1. The fish soy diet seems to be eaten in largest amount.
2. The fish soy diet eaten often, 53% of the nights.
3. Betaine not an attractant

Feeding preferences
(agar feeds, also easy to make)

% dry matter/bodyweight/day			
Fish/soy	Fish/soy/biofilm	Fish/soy/GABA	Fish/soy/DMPT
0.07±0.12	0.17±0.19	0.08±0.11	0.04±0.07

N=3 in most cases
Time = 5 days

Conclusions

1. The diet with biofilm was eaten in largest amount and often (43% of nights)
1. Gamma amino butryic acid and dimethyl propiothetin are not attractants. Spirulina too (data not shown).

Focus in

- Fish/soy and biofilm seem preferred.
- Focus in on this. Are we right or wrong?

Focusing in

Is high fishmeal diet without biofilm also liked? Not especially.

	% dry matter/bodyweight/day
High fishmeal no biofilm	0.012±0.01

N=5; Time=4 days

Is high fishmeal diet and biofilm liked? Yes. Or biofilm with more fishmeal liked more? No.

	% dry matter/bodyweight/day
Fishmeal and biofilm	0.08±0.03
High fishmeal and biofilm	0.07±0.01

N=6; Time = 6 days

Conclusions

1. Removal of biofilm decreases feeding
2. Adding additional fishmeal does not help.
3. Hence, biofilm is the key.

Biofilm is the key to feed acceptance

- But biofilm is a randomly recruited assemblage of wild benthic diatoms. It might be unreliable.
- Biofilm would have to be grown.
- Vernon Sato suggested a trip to Don Quixote to find a commercial substitute.

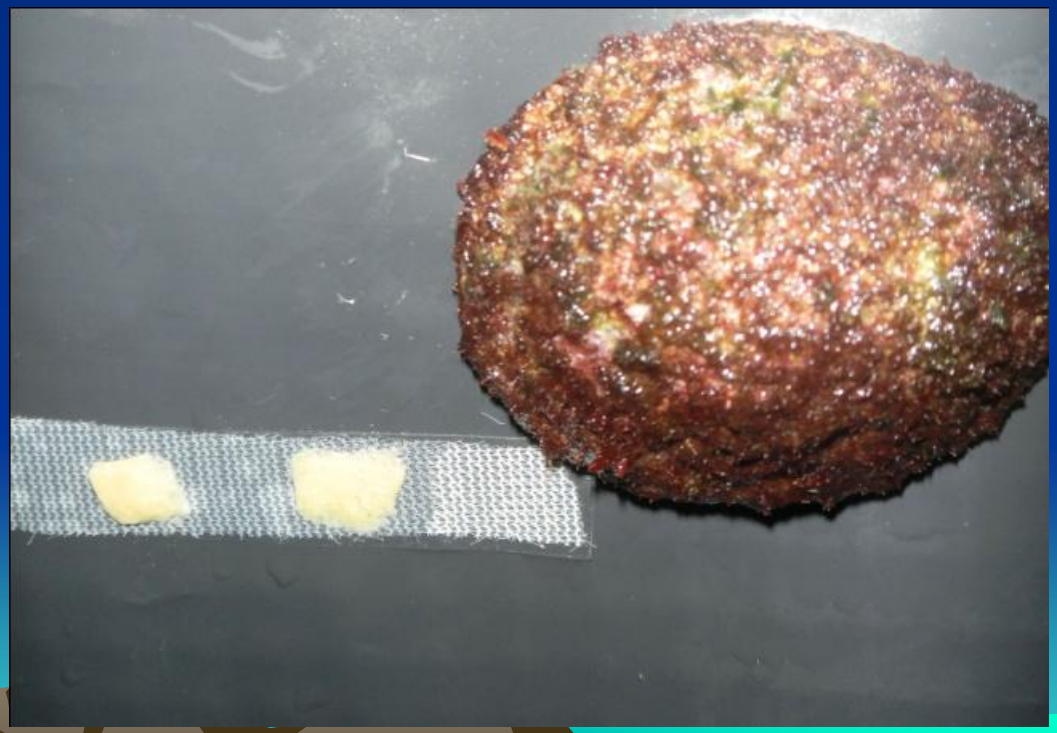
0.16	0	
0	0.12	
0.1	0	0
0	0.22	0
0.18	0	0.2
0	0.2	0.18
0	0	0
0.12	0.1	0
0.1	0.15	0
0.21	0	0.17
0	0.16	0
0	0.32	0.12
0.16	0	0
0	0.12	0.11
0.074	0	0.15
	0.21	0
	0.13	0
	0.12	0.18
	0	0
	0.11	0.13
	0	0.12
	0.18	0
	0.08	0.23
	0	0
	0.23	0.18
	0.08	0
	0.15	0.2
	0.17	0.08
	0.11	0
	0	0.2
	0.3	0.12
	0.12	0
	0.22	0.12
	0.23	0.1
	0	0
	0.1	died
	0.22	
0.074	0.113	0.076

Sustained feeding on feed with *Porphyra* %DM/BW/day

1. One giant opihi lived 15 days and ate 0.074%/day.
2. Another giant opihi lived 45 days and ate 0.11%/day.
3. A blackfoot lived 32 days, ate 0.076%
4. We believe we are on the cusp of keeping opihi forever.
5. Diet is fish meal, soy meal, Nori, algenate, vitamins, cholesterol, agar

Choice experiments

- Preference to feed on food attached to the vertical side of the aquarium
- Feed pressed to net attached by double sided tape to plastic in aquarium.



Summary

- We believe that we have figured out how to capture and hold opihi. Plastic lined tanks are the key.

- We believe that we have determined that a key to feed palatability is biofilm, an aggregate of benthic diatoms and we can replace grown biofilm with a commercial *Porphyra* preparation.

- Instead of struggling to keep opihi alive with our artificial diets we can hold opihi and study them for an extended time. This is a big deal for us.

Future work

•We need more animals to do nutritional experiments.
•We must get ripe opihi to spawn. Either wild caught or preferably aquacultured. Several spawning methods will be applied to trigger spawning of specimens such as vigorous aeration, thermal shock, hydrogen peroxide…
•Larval rearing, settlement and metamorphosis. Substratum preference, diatoms species as biofilm, chemical cues GABA…
• Growout and closing the life cycle.

•The future of opihi is hopeful.

Thank you very much for your attention!!!

MAHALO!

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- The authors thank Chris Bird for initiating animal collection
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