
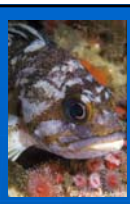


Fish Mariculture – Latest Develops in Integrated Mariculture Technology

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A Global Crisis

- Human development is changing our planet at a scale and rate that is difficult to put into words.
- We all must learn about and understand the problems & potential solutions.
- Studying the problem is not enough: WE MUST COMMUNICATE WITH EACHOTHER. (Both locally & between countries and cultures).

Are fish disappearing? Yes!

- Over 3000 species of reef fish inhabit the Coral Triangle alone.
- Over 150 million people live in the Coral Triangle region and depend on marine resources.
- Worldwide seafood stocks predicted to collapse by 2048. (29% collapsed already). (*Science*, 2006)
- In Indonesia, approximately only 6% of reefs remain pristine, in many cases the fish are faring much worse.

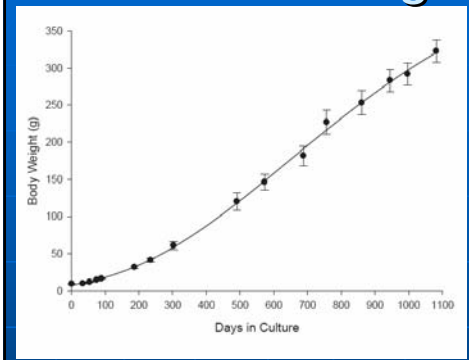
Demand for Fish Mariculture

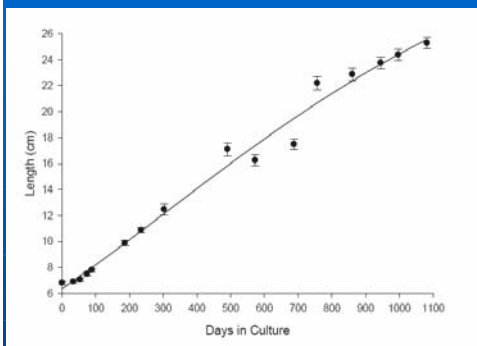
- By 2030 an additional 37 million tonnes of fish per year needed to maintain current levels of consumption.
- Fish culture is the world's fastest growing food production sector (annual growth rate of 8.8% since 1970).
- 45% of all fish consumed by humans - 48 million tonnes in all - is cultured.
- 2 billion more people in 2030 means that aquaculture production must nearly double to 85 million tonnes of fish per year to sustain current levels (no growth).

Demand not met!

- We are unable for many species to meet the current demand and keep up with growth.
- 3 major roadblocks (among many)
  - Lack of basic understanding regarding growth patterns.
  - Threats to early survival and growth
  - What do you feed them? And when? What can you do to increase growth rates?

Understanding Growth Patterns





Novel examinations of growth in culture allowed for us to develop new mathematical models that accurately predict growth for threatened rockfish species in the U.S. Critical periods were identified.

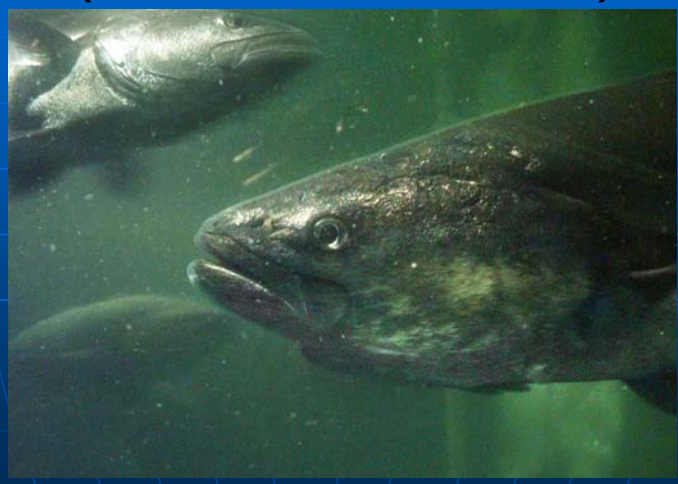
Acceleration of growth

- Growth rates of black rockfish cultured in Asia offer a promising example. Black rockfish growth has been increased 250% through simple diet adjustments.
- If culture of nearshore species in the U.S. were to equal current production of rockfish in Korea, value would increase from $16.5 million worth of a threatened wild species to $453 million in cultured rockfish (for only 1 species out of 110).

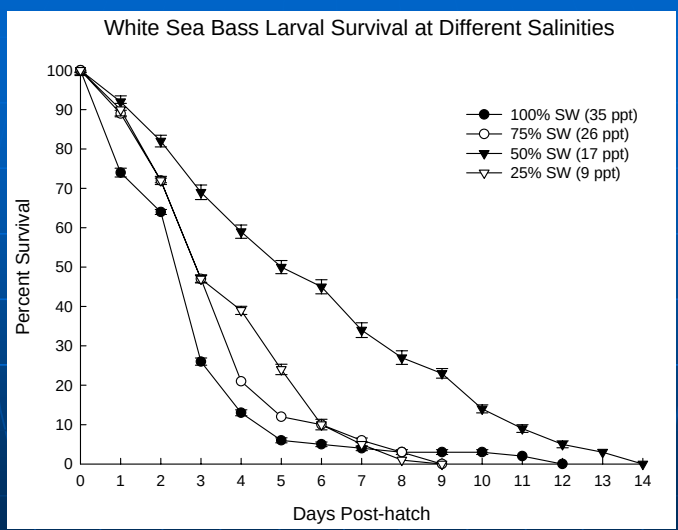
Effects of salinity on larval survival and growth

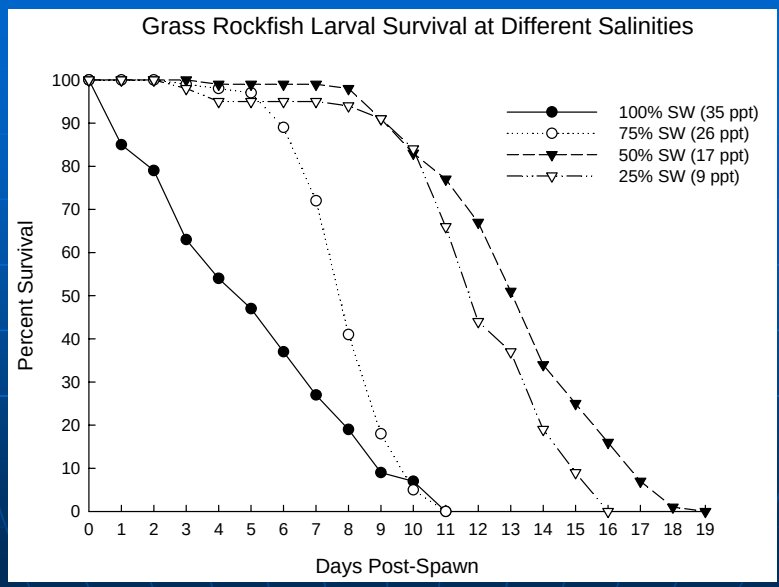
White seabass (*Atractoscion nobilis*) (left) and grass rockfish (*Sebastes rastrelliger*) (right).

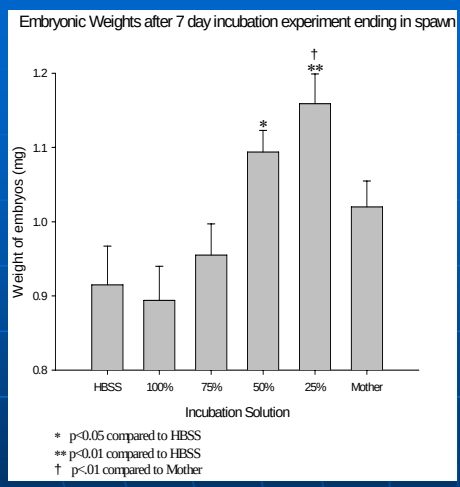
White Sea Bass (*Atractoscion nobilis*)

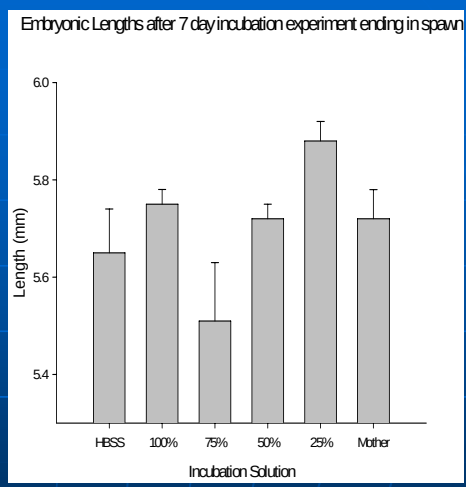


Major recreational fishery and commercial fishery in California

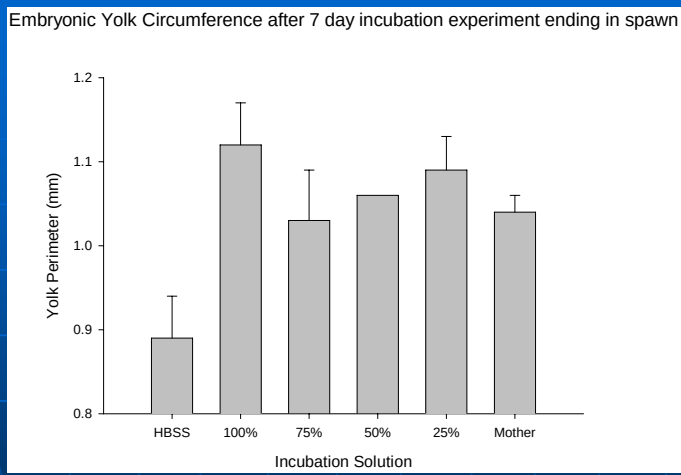








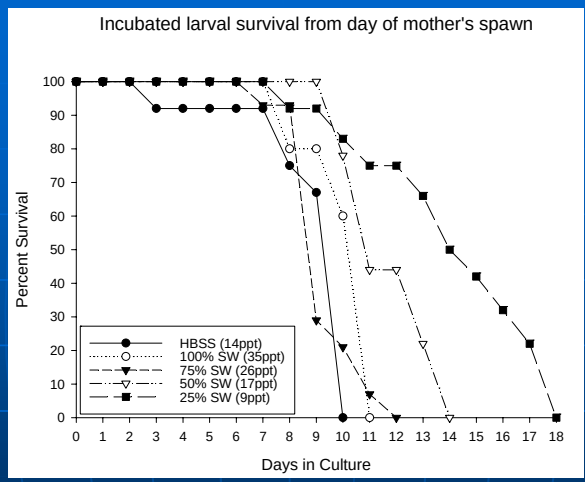
The length and weight of embryos incubated in 25% SW was significantly greater than in the other salinities and of the Embryos recovered from the mother.



There was no significant difference in yolk utilization except In those embryos incubated in ovarian fluid.

Naturally developed larvae

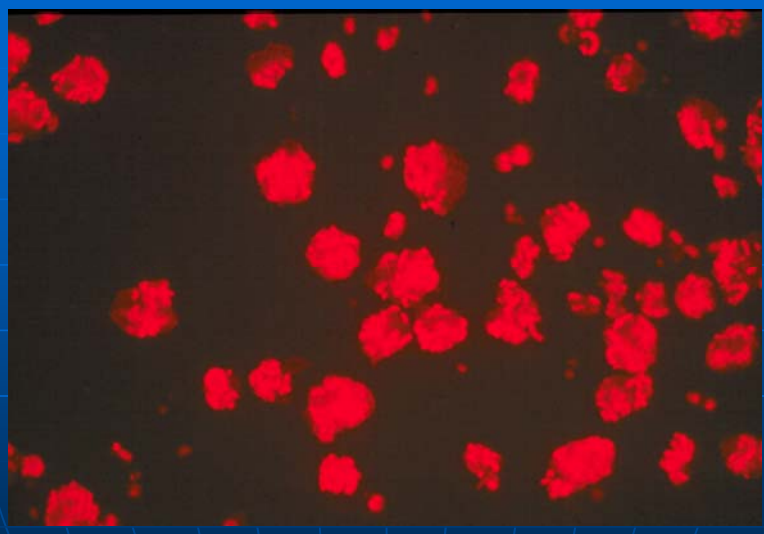
Embryo incubated in 25% SW



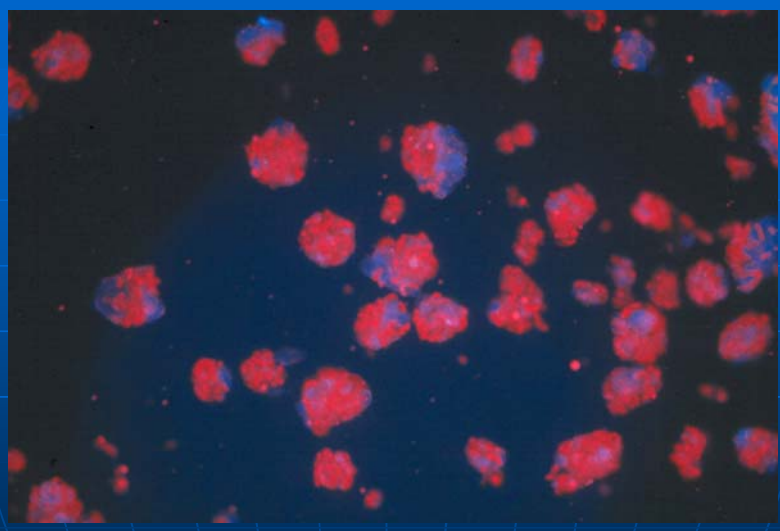
High survival rates were observed for the first 7 days or later after spawn.

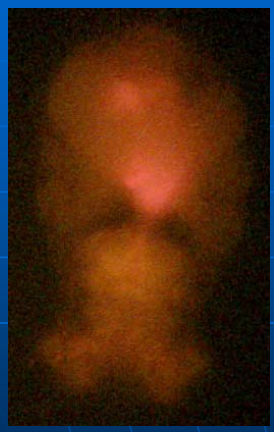
What do fish really want to eat in culture?

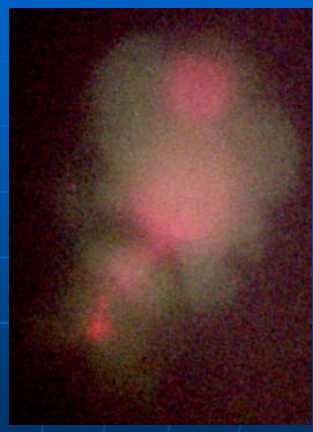
Many hours of meditation & many failures over many years.



Patented microparticles fluoresce when exposed to ultraviolet light
Due to natural pigmentation of algae used in production.

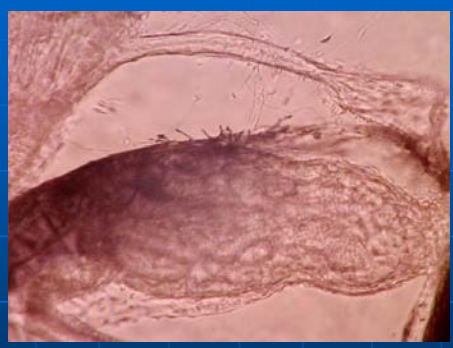




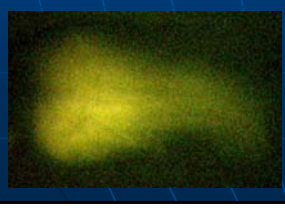
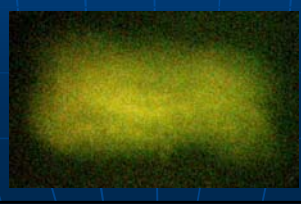
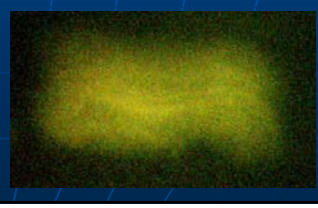


Zooplankton enriched with algal microparticles fluoresce as well.

When, and what, are fish in culture eating?

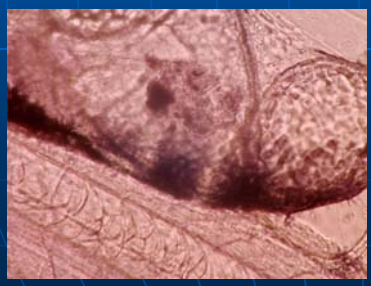


Day 1 rockfish larvae. Gut is empty as indicated by lack of characteristic fluroescence.

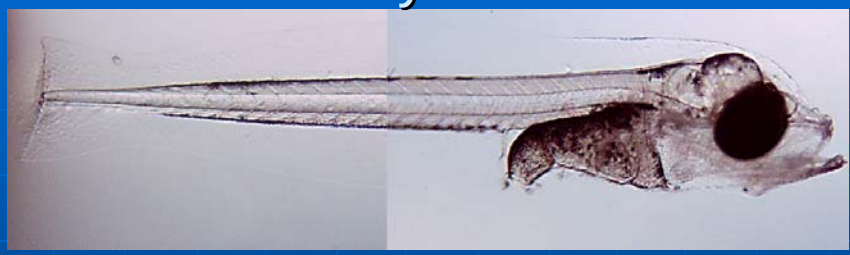
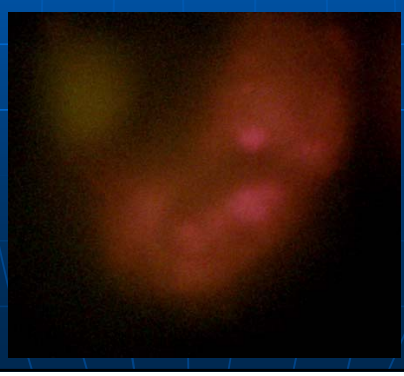




Day 2






Day 10

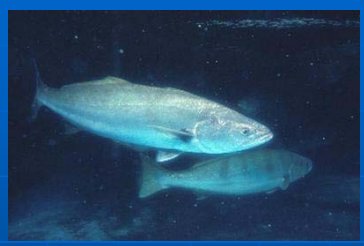
Zooplankton Cultivation

Low salinity rearing combined with accurate food consumption information in early stages can decrease mortality and labor intensive food production while increasing growth!

Examples of application of research findings

- Hubbs-SeaWorld Research Institute
  - Largest fin-fish hatchery in the United States.
  - Partnership between government, business and non-profit organizations.
  - Successful rearing of:
    - White seabass (seed prod., local grow-out, release)
    - Halibut
    - Calico bass
    - Yellowtail
    - Rockfish

White Seabass



Hatchery raised seabass are transferred to small scale floating pens for grow-out and release by non-profits. First of its kind marine fisheries enhancement success story.

Gondol Research Institute for Mariculture - Bali

- Established in 1985
- One of the largest hatcheries and research institutes in SE Asia
- Successful transfer of technology led to establishment of backyard milkfish hatcheries and created a new local industry.
- Continue to develop new technologies allowing for culture of other threatened and **valuable** marine fish species (ie. grouper).
- Example of government and international research partnerships coupling with local business.

Species in various stages of development for backyard hatchery and/or seed for grow-out

- Humpback grouper (Cromiletpes altivelis)
- Tiger grouper (Epinephelus fuscogattus)
- Marbled grouper (E. polyphekadion)
- Orange spotted grouper (E. coioides)
- Napolean wrasse (Cheilinus undulatus)
- Mangrove snapper (Lutjanus sp.)
- Leopard grouper (Pectropomus sp.)
- Yellow-fin tuna (Thunnas albacares)
- Marine ornamental fish (clownfish)

Other areas research collaborations being established

- Coral Transplantation
  - Indoors
  - Outdoors
- Sponge and Soft Coral Culture
  - Indoors
  - Outdoors
- Ornamentals
  - Shrimp
  - Finfish

Problems with transfer of technology, sustainable fish culture

- Research and development needs to continue to increase capacity.
  - Successful rearing is not enough. We must find ways to increase survival and growth rates in culture.
- Relationships must be maintained between business, government and researchers to ensure needs are met and technology is not abandoned for new species or the market flooded.
  - In the case of milkfish and grouper in Bali, market fluxes lead to switching between species and in many cases cause collapse.
- Effective management of projects and collaborations can ensure returns on business investments and ensure SUSTAINABILITY.

Conclusions

- It is imperative we increase our production of cultured fish species.
- Collaboration between all sectors is essential for progress to be made.
- This gathering is an important step towards the furthering of sustainable mariculture development.
- However, the critical step is not the meeting, rather the utilization of all the resources gathered to ensure existing projects are supported and establish new partnerships.