Offshore Non-Salmon Aquaculture: Tuna Culture as a Demonstration of Commercial Scale Production

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H-SWRI Existing Facilities

H-SWRI Mission Bay Laboratory
San Diego, CA
System Capacity = 300-750 gpm

Leon Raymond Hubbard Jr. Marine Fish Hatchery
Carlsbad, CA
System Capacity = 1200 gpm

Catalina Island Cage Facility
Catalina Island, CA
System Capacity = 4 cages of 555 m^3 each

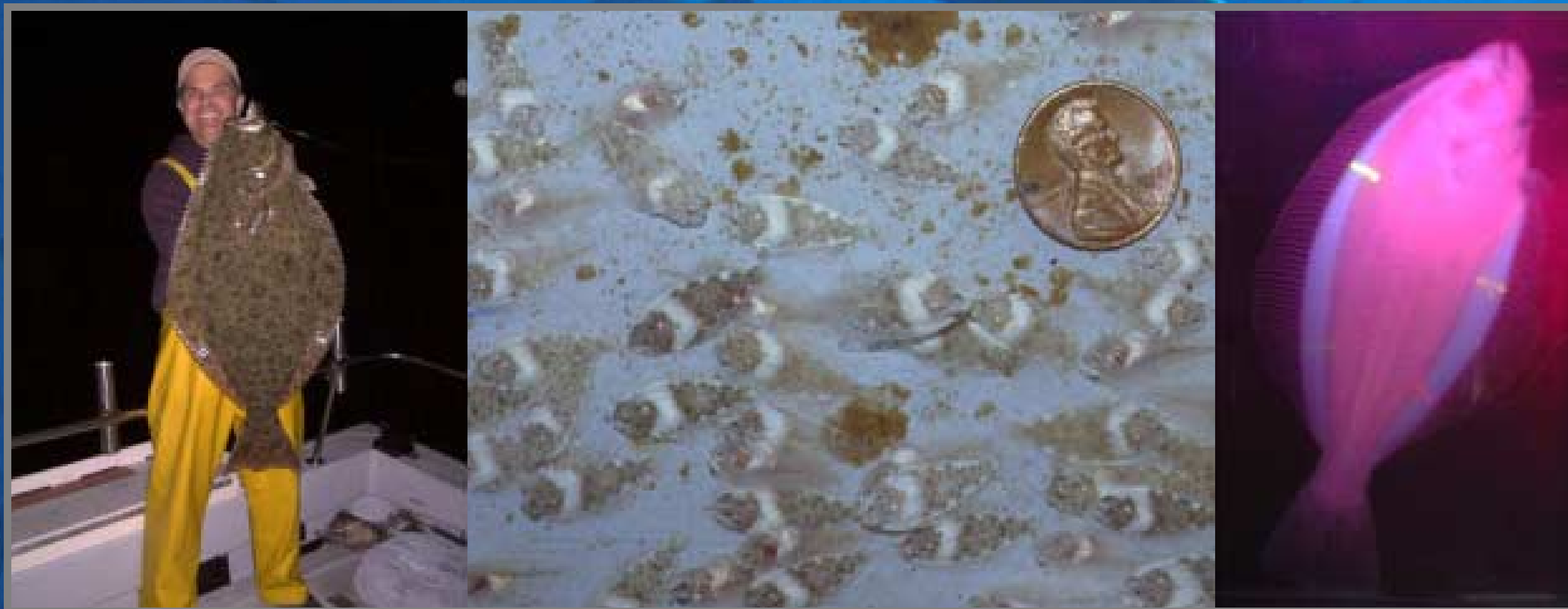
White Seabass Enhancement

Striped Bass (Morone saxatilis)

Their freshwater counterparts, hybrid striped bass, represents a 9-million pound aquaculture industry in the United States. Striped bass are being released for enhancement in central California, and are considered an excellent candidate for open ocean cages.

California Halibut (Paralichthys californicus)



California halibut have been evaluated as a secondary candidate for stock enhancement at a modest scale since 1983. Captive broodstock held under ambient conditions provide eggs during the spring and summer. The species is also being evaluated for commercial culture.

California Yellowtail (Seriola lalandi)

A transitory, seasonally abundant species in southern California, yellowtail are one of Japan's primary culture species, highly prized for sushi and traditional cooking. Because of its transitory nature and general abundance, it is being considered for farming but not enhancement in California.

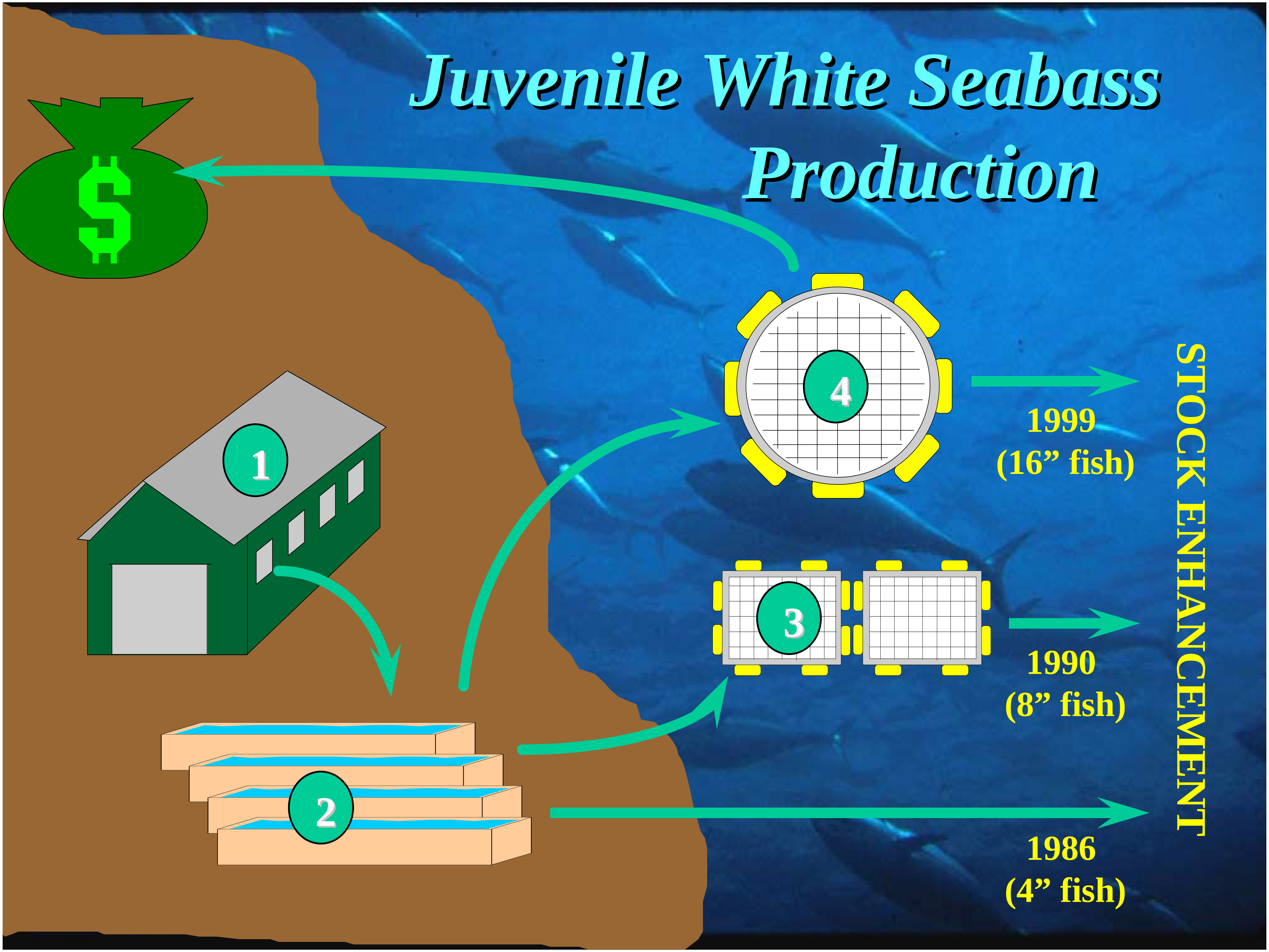
California Sheephead (Semicossyphus pulcher)

In recent years, trap-fishing for a high value live-fish fishery has left the California sheephead heavily exploited. It is listed as one of 19 high priority species for management plan development under California's Marine Life Management Act (MLMA).

Bocaccio (Sebastes paucispinis)

One of California's most valuable groundfishes, bocaccio have been heavily exploited. They were recently considered for listing as a threatened species under the ESA. Because juvenile growth rates are reported to be relatively fast, this is considered a good candidate for further culture research

Commercialization Study
(1998-99)
White Seabass
Funded by the
National Marine Fisheries Service
Saltonstall-Kennedy Program


Juvenile White Seabass
Production
$
1
2
3
4
1999
(16" fish)
1990
(8" fish)
1986
(4" fish)
STOCK ENHANCEMENT

Commercialization Study Goals

- **Evaluate the technical and economic feasibility of culturing and marketing white seabass**
- **Test the application of off-shore, semi-exposed net cages**

Catalina Cage System

Economic Model - Scaling Criteria

Description		Value	Units	Data Source
Annual Production		230,000	kg per yr	assumed
Number of Crops		12	per year	assumed
Cage Number		2	per crop	assumed
		24	per year	assumed
Cage Volume		700	cubic m	observed
Harvest Density		12.26	kg per cubic m	observed
Harvest Weight		0.80	kg per fish	observed
Growout Survival		96.8%		observed
Food Conversion Coeff		2.0	kg feed per kg fish	observed
Whole Fish Value	$	6.00	per kg	observed
Food Cost	$	1.21	per kg	observed
Cage Volume		781	cubic m	calculated
Stocking Number		24,883	fish per crop	calculated
Harvest Number		24,095	fish per crop	calculated
		298,594	fish total	calculated
Harvest Biomass		19,167	kg per crop	calculated

Conclusions

- **Cage culture of white seabass is biologically and technically feasible**
- **A larger scale demonstration project is required to:**
  - **better address permitting constraints, logistical considerations, legal issues, and environmental concerns**
  - **validate the economic model developed in this study**

National Mandate

- **National Oceanic and Atmospheric Administration states the need to expand U.S. aquaculture production from 0.5 to over 2 million tons per year by 2025**
- **Value of this production will be over $5 billion annually**

Where Will This High-Volume Aquaculture be Done in the U.S.?

Away from the coastal zone where . . .

- **Land values make aquaculture economically impractical**
- **Water quality is often poor**
- **Aquaculture would compete with uses that are more profitable (i.e. commercial and recreational development)**
- **Permitting processes are exhaustive and designed to limit growth**

Primary Commercial Species Using "Offshore" Cage Technology:

- **Tuna species (Bluefin, Bigeye, Yellowfin)**
- ***Seriola* species (Yellowtail, Kingfish)**
- **Cobia**
- **Pacific threadfin (Moi)**
- **Bass, Bream, Groupers, Barramundi, snappers, drum, etc.**

Market Characteristics

- **Tuna sp.-**
  - **~25,000 MT of farmed production in 2003**
  - **$20-$50/kg, depending on species, size and fat content**
  - **Primarily farmed for sushi and sashimi**
  - **33%+ of tuna on the Japanese sushi market is farmed**
  - **0% of tuna is farmed in U.S. waters**
- ***Seriola lalandi-***
  - **~150,000 MT of farmed production in 2003**
  - **$9-$15/kg, depending on size and fat content**
  - **100% of farmed *S. lalandi* targets the sushi/sashimi market**
  - **0% is farmed in U.S. waters**
- **Cobia-**
  - **~???? MT of farmed production in 2003**
  - **$8.80/kg, gilled and gutted**
  - **Sushi, sashimi and fillet markets targeted**
  - **?% grown in U.S. waters**

Market Characteristics 2:

- **Tuna sp., *Seriola* sp. and Cobia are native to U.S. waters**
- **Estimated U.S. fresh market:**
  - **Tuna: ~45,000 MT (sushi,sashimi,fillet)**
  - ***Seriola*: ~2500 MT (sushi,sashimi,fillet)**
  - **Cobia: ~????**
- **Many U.S. groups already working with these species (sites in Florida, California, Puerto Rico, Bahamas, Hawaii, etc.)**
- **Expansion to offshore for grow-out is next step**

Countries Farming Tuna

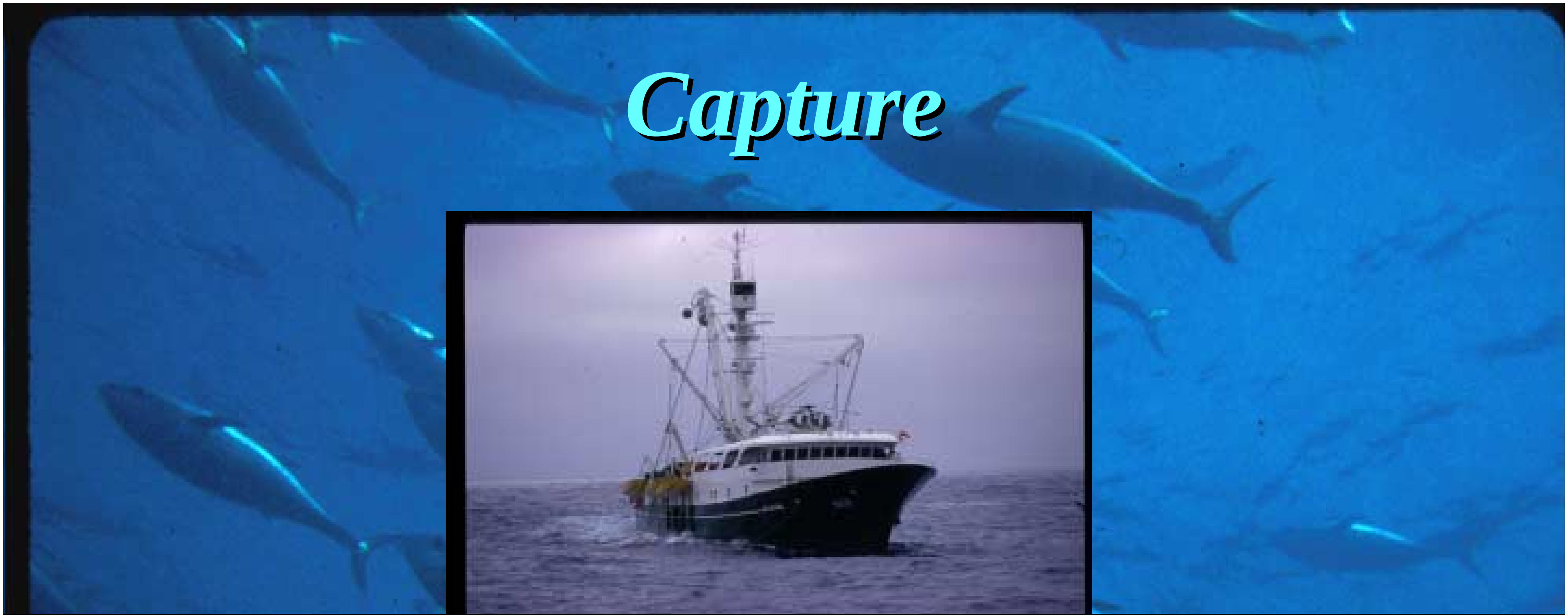
Tuna Culture Currently:

- **Involves capture of wild juveniles- using purse seine vessels**
- **Hold tuna in sea cages for a period of time, “fattening” the fish**
- **Harvest fish according to Japanese market demand**

Production Cycle

- **Capture-tow-grow-out-harvest**
- **Typical cycle: 3-9 months**
- **Farm size: 100-1000 MT**
- **Typical weight gain: 30-90%**
- **Potential revenues: $1-30 million per cycle**

Capture



Towing

1-2 knots towing speed
60 - >500 miles
5 – 30 days tow time

Grow-Out/Feeding

Frozen Sardines/Trash Fish
Semi-Moist Pellet
Commercial pellets trials on-going

One Feeding's Worth of Sardines (20 Tonnes)

Feeding


Harvest-Seine

Harvest

Harvest-Coring and Bleeding

Harvest-Chilling Fish

Chilled to –2° C Before Shipping to Japan

Market-Japan

Flesh Quality

Fat Content

Color

Average-$20-50/kg

$173,500.00
For One Fish!!!!!

Tuna Farming Concerns and Future Prospective:

Tuna farming is a new industry that needs to mature to the next level

Tuna industry research currently focusing on developing:

- **artificial feeds**
- **hatchery technology**

U.S. Potential:

- **Many offshore projects already exist-Hawaii, NH, GOM, Puerto Rico, Bahamas**
- **Other projects in permitting phases for expansion offshore-Hawaii, California**
- **Expansion is hampered by lack of an efficient permitting process and mass production hatchery technologies for marine finfish in the U.S.**

Hatchery Technologies Elsewhere:

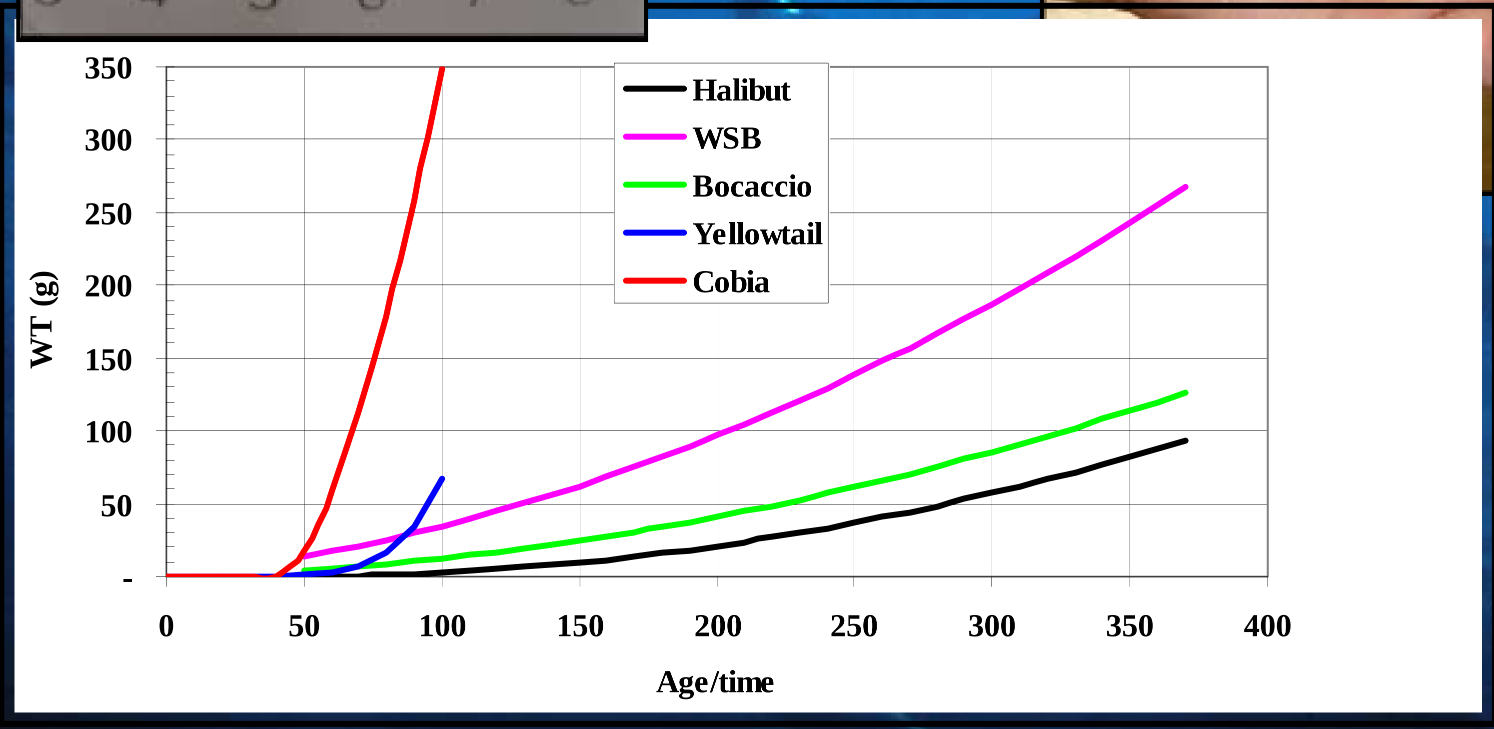
33 DPH Yellowfin tuna-Panama

44 DPH *S. lalandi*-HSWRI, CA

Cobia fingerlings-U. Miami

- **Tuna hatcheries exist in Japan and Panama and are being developed in Australia and the Mediterranean**
- ***Seriola*** **hatcheries exist in Japan and Australia and are being developed in Hawaii and California**
- **Cobia hatcheries exist in Taiwan and Florida**

HSWRI Experience-
California Yellowtail (Seriola lalandi)



University of Miami, RSMAS Experience

Comparative Growth During Early Developmental Stages
45 DPH (Days Post Hatch) – 6 weeks

Cobia
5.5 g; 11.5 cm (4.5 in)

Snapper
0.2 g; 2.0 cm (1.0 in)

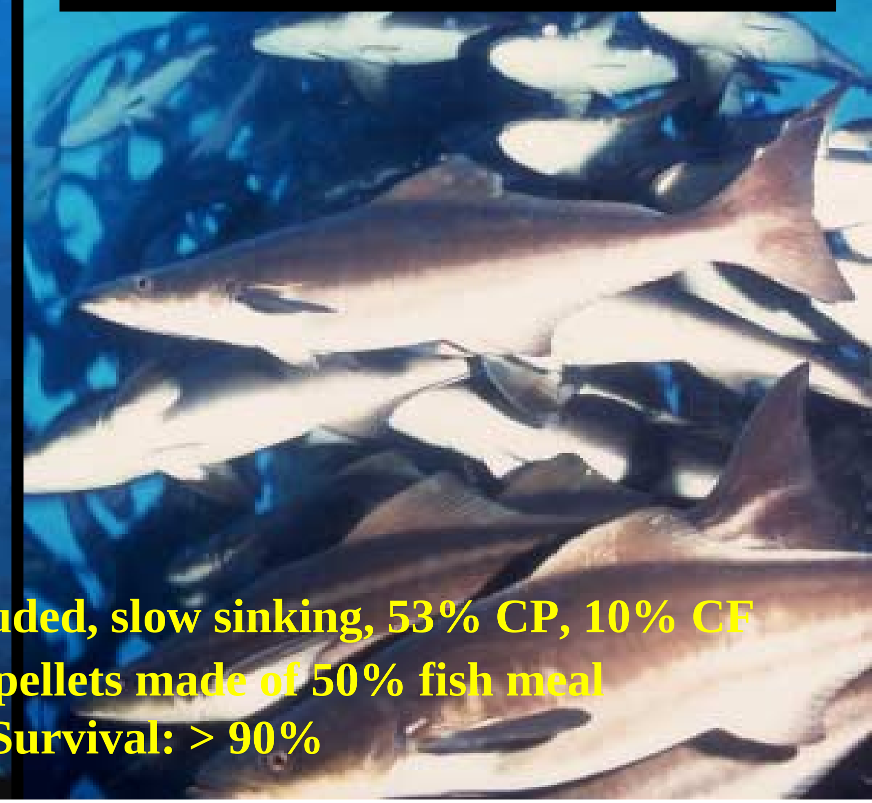
STOCKING DENSITIES

20,000 fingerlings stocked/3,000 m^3 cage (2,700 m^3) = 7 fingerlings/ m^3

20,000 fingerlings @ 90% survival = 18,000 harvest/market size fish (6 kg)

18,000 fish @ 6 kg/ea = 108.000 kg (108 Ton) / 2,700 m^3 = 40 kg/ m^3

GROWOUT



Pellets: AquaExcel 5310 (Burris): Extruded, slow sinking, 53% CP, 10% CF

Estimated FCR = 1.0 on pellets made of 50% fish meal

Estimated Survival: > 90%

12-month-old, 9 kg (20 lb) cobia cultured offshore

Length x Weight Relationship
Exponent Wild = 3.08; Cultured = 3.43

12-month-old average was 6 kg (12.4 lb)

Observations Relative to Specific Criteria

(Based on Hawaii Administrative Rules, Title 11, Department of Health, Chapter 24,Water Quality Standards)

Total # of observations – 373

Parameter	Geometric mean not to exceed the given value	Not to exceed more than 10% of the time	**Observations** Maximum value observed and Number of Occurrences ( )
Total Nitrogen µg N/L	150	250	>150 to 250 (2)
Ammonia Nitrogen µg NH_4/L	3.5	8.5	> 8.5 to 69 (9) >3.5 < 8.5 (32)
Nitrate + Nitrite N µg (NO_3+NO_2)/L	5.0	14.0	always < 5
Total Phosphorus µg P/L	20.0	40.0	>20 <31 (1) > 40 (0)

pH 8.2+/-0.05; Temperature ± 0.5°C from ambient; Salinity 35+/-0.5; D.O. >80%

Conclusions from Water Sampling

- No samples had values in excess of allowable values under the NPDES permit
- NH4+ is the only nutrient that is ever above background
- NH4+ is only above background very near the cage for a few hours about two hours after feeding

SEA GRANT HAWAII


Systems Used:
Tuna sp., *Seriola* sp.
Bass, Bream, Cobia,
Moi, other

Offshore Gravity Cage Types

Gravity Cage Construction

H-SWRI Experience

This cage was moored 25 miles off the Virginia coast-1996.

It withstood 2 Hurricanes.

A NOAA buoy < 1 mile away recorded 45 ft seas and winds > 90 mph.

No damage to fish stock.
Minimal damage to stanchions.

What's Next???

- Standardized permitting process for cages in the EEZ
- Facilitate research to answer outstanding environmental questions
- Need to focus on development of reliable mass-production technologies for fingerlings of candidate species to support expansion in U.S.
- Use of existing offshore structures as operational bases for offshore aquaculture operations…

Oil Production Platforms are IDEAL for Offshore Fish Production

- **Excellent water quality would promote fish health**
- **Good assimilative capacity for organic wastes**
- **No impact on public access to near-shore waters**
- **Significant infrastructure support**

Mariculture Supported by Offshore Platforms is not New Elsewhere . . .

- Gulf of Mexico
- Caspian Sea
- Japan


OIL PRODUCTION PLATFORMS
OFFSHORE CALIFORNIA
Santa Barbara
Santa Barbara Channel
Santa Monica Bay
Los Angeles
San Pedro Bay

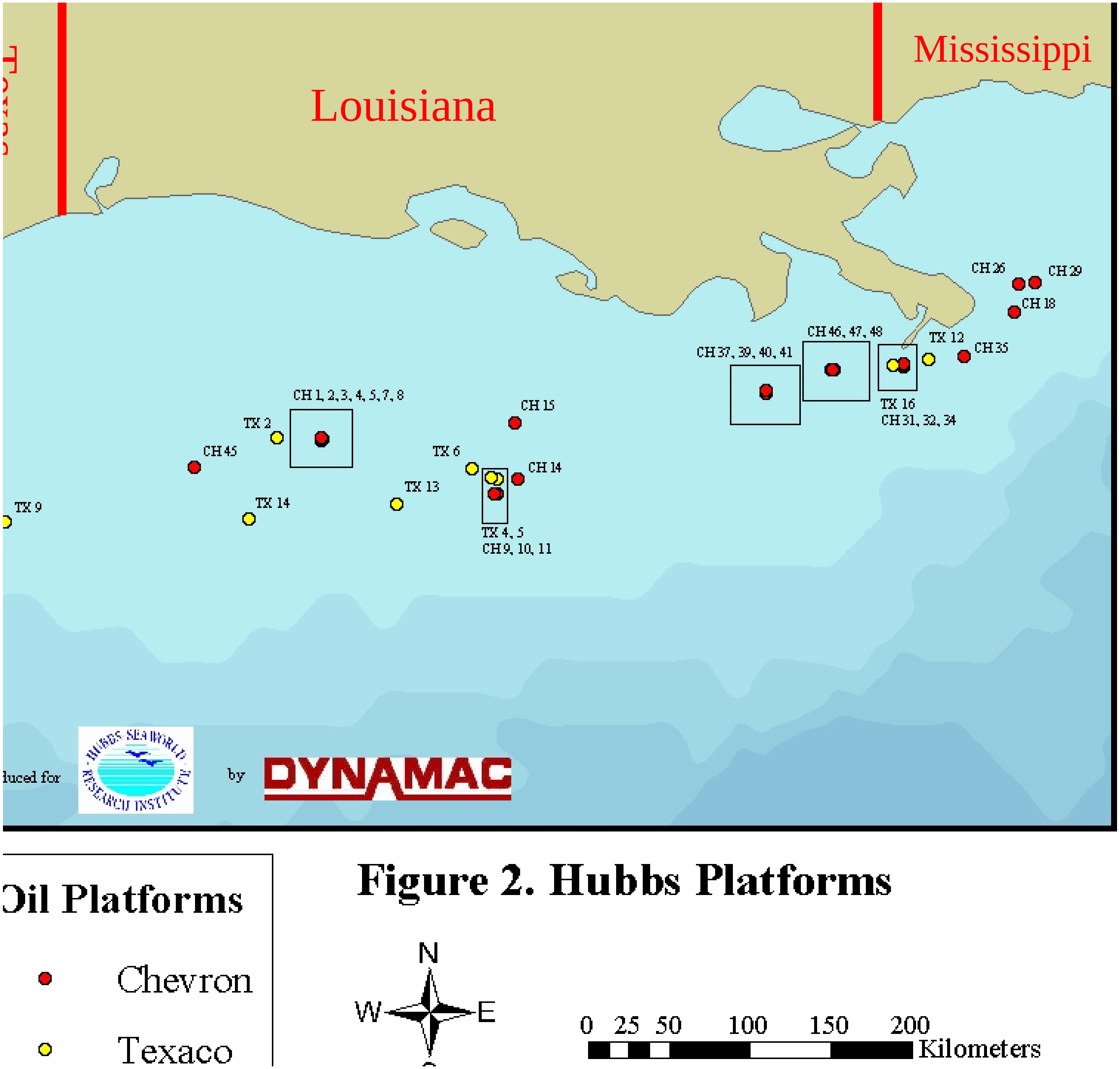


Figure 2. Hubbs Platforms

CODE	LATITUDE	LONGITUDE
CH 1	28.414496	-92.633
CH 2	28.414500	-92.632
CH 3	28.415204	-92.632
CH 4	28.418468	-92.628
CH 5	28.418941	-92.628
CH 7	28.427502	-92.630
CH 8	28.427505	-92.630
CH 9	28.115678	-91.657
CH 10	28.117147	-91.669
CH 11	28.118085	-91.669
CH 14	28.202480	-91.537
CH 15	28.515034	-91.556
CH 18	29.126464	-88.779
CH 26	29.287181	-88.759
CH 29	29.292398	-88.669
CH 31	28.822233	-89.394
CH 32	28.830833	-89.406
CH 34	28.843894	-89.396
CH 35	28.884871	-89.063
CH 37	28.674646	-90.158
CH 39	28.674918	-90.157
CH 40	28.674924	-90.158
CH 41	28.696654	-90.157
CH 45	28.269858	-93.343
CH 46	28.804811	-89.801
CH 47	28.808877	-89.787
CH 48	28.809573	-89.788
TX 2	28.428907	-92.878
TX 4	28.200863	-91.656
TX 5	28.206843	-91.685
TX 6	28.257411	-91.793
TX 9	27.964052	-94.388
TX 12	28.866098	-89.260
TX 13	28.057275	-92.215
TX 14	27.981372	-93.034

Summary

- The offshore cage technology is well established
- More species with economic potential need to have their culture cycle “closed”
- Cage sites need to be identified and the permit process standardized
- Research infrastructure to resolve culture limitations has to be established


Thank You !!
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SEA GRANT
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