

***Mariculture Research for Fisheries
Replenishment and Food Production:
Key Drivers for Offshore Aquaculture***

Paula C. Sylvia

Don Kent, Mark Drawbridge

Hubbs-SeaWorld Research Institute

WAS Las Vegas

February 16, 2006



Background - Fisheries Perspective

- **Majority of wild fisheries are depleted**
- **Demand for seafood is increasing and aquaculture will need to fill the deficit**
- **Need for expanded mariculture is well recognized by FAO, NOAA and the U.S. Commission Report on Ocean Policy**
- **There are serious limitations to mariculture development in the U.S.-regulatory, juvenile production, etc**



Number of Saltwater Anglers

in Thousands of Individuals (2001)

386 (4%)

70 (<1%)

370 (4%)

161 (2%)

385 (4%)

348 (4%)

932 (10%)

860 (9.5%)

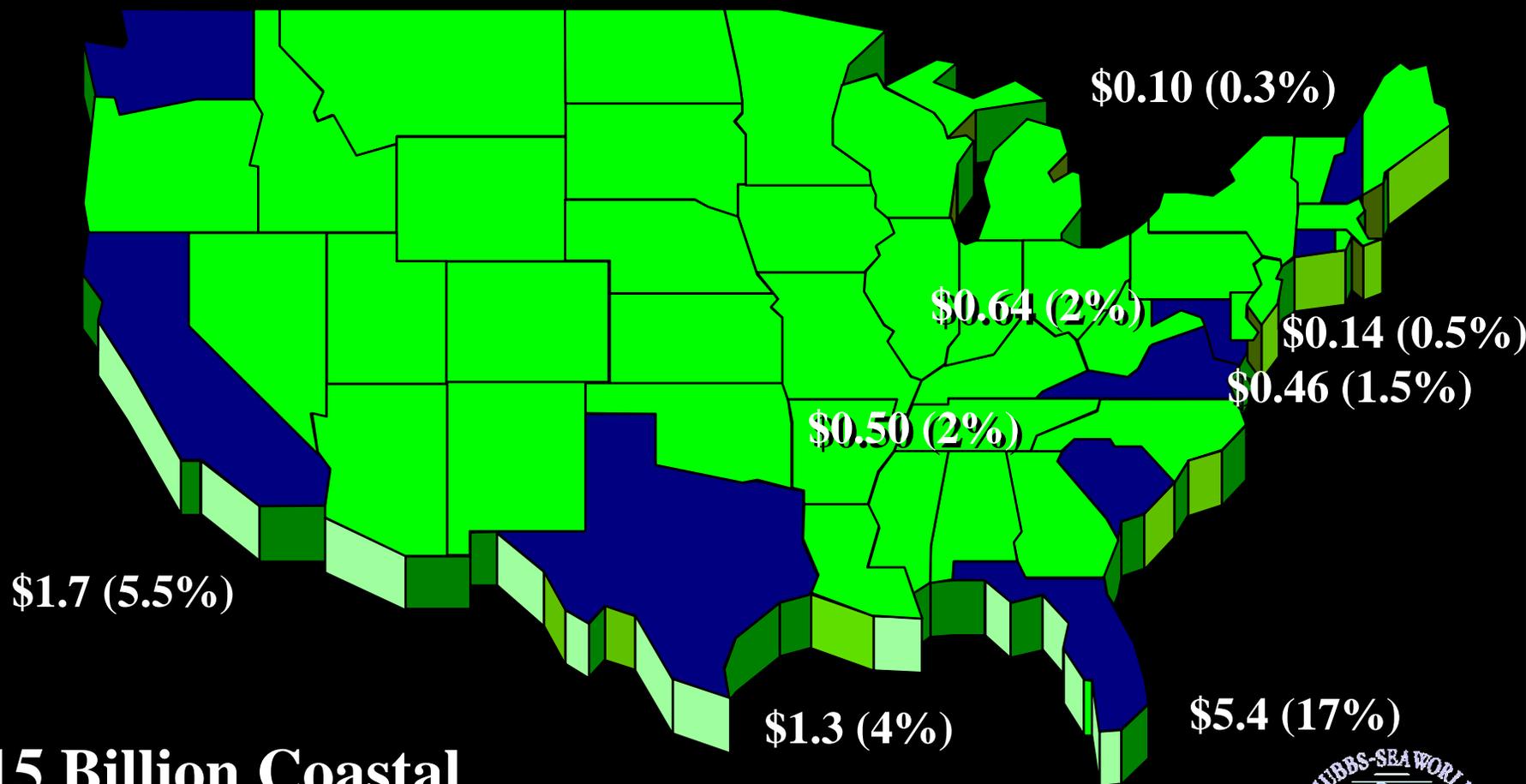
2,437 (27%)



Source: ASA, 2001

Economic Output for Saltwater Angling in Billions of Dollars (2001)

\$0.60 (2%)



\$15 Billion Coastal
\$31 Billion Nationwide



Source: ASA, 2001

Aquaculture Development Needs

- **Maintenance of wild stocks through replenishment with cultured juveniles**
- **Reliable large-scale production of juveniles for food production**
- **Streamlined permitting process**
- **Continued development of closed cycle technology**
- **Expansion of production into the off-shore environment**



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 m³
each**



Hubbs-SeaWorld Research Institute Mariculture Experience

- **White seabass enhancement program**
- **White seabass commercialization study**
- **Rockfish and other groundfish enhancement**
- **Other species**
 - **Striped bass**
 - **California Halibut**
 - **Yellowtail**
 - **Abalone**
 - **Tuna**



White Seabass (*Atractoscion nobilis*)



White seabass have been evaluated as a primary candidate for stock enhancement since 1983. Captive broodstock held under controlled conditions provide eggs year-round. The species is also being evaluated for commercial culture. H-SWRI released 1 millionth fish in October, 2004!



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 are currently being 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.



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.



Abalone (Haliotis spp.)



Eight species of abalone are found off the coast of California. Because of their depleted status, commercial and recreational harvest of all abalone has been prohibited south of San Francisco since 1997. The white abalone, *Haliotis sorenseni*, was listed as endangered in 2001. Hatchery-based enhancement is being considered among the restoration tools for several of these species.



Striped Bass (Morone saxatilis)



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



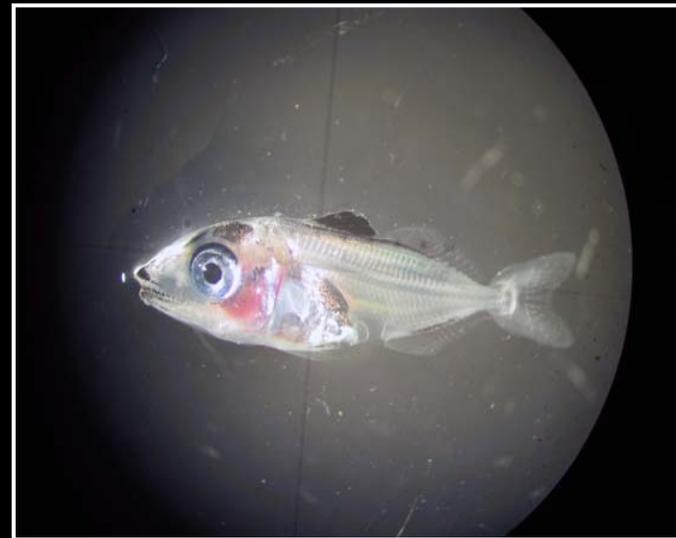
California Yellowtail (*Seriola lalandi*)



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.



Tuna (Thunnus spp.)



Three of the most commercially valuable species of tuna are found off the coast of California-bluefin, bigeye and yellowfin. They are seasonally abundant species that command top dollar in Japanese sushi markets. These species are being considered for farming for food production in California and elsewhere.



Rockfish Status

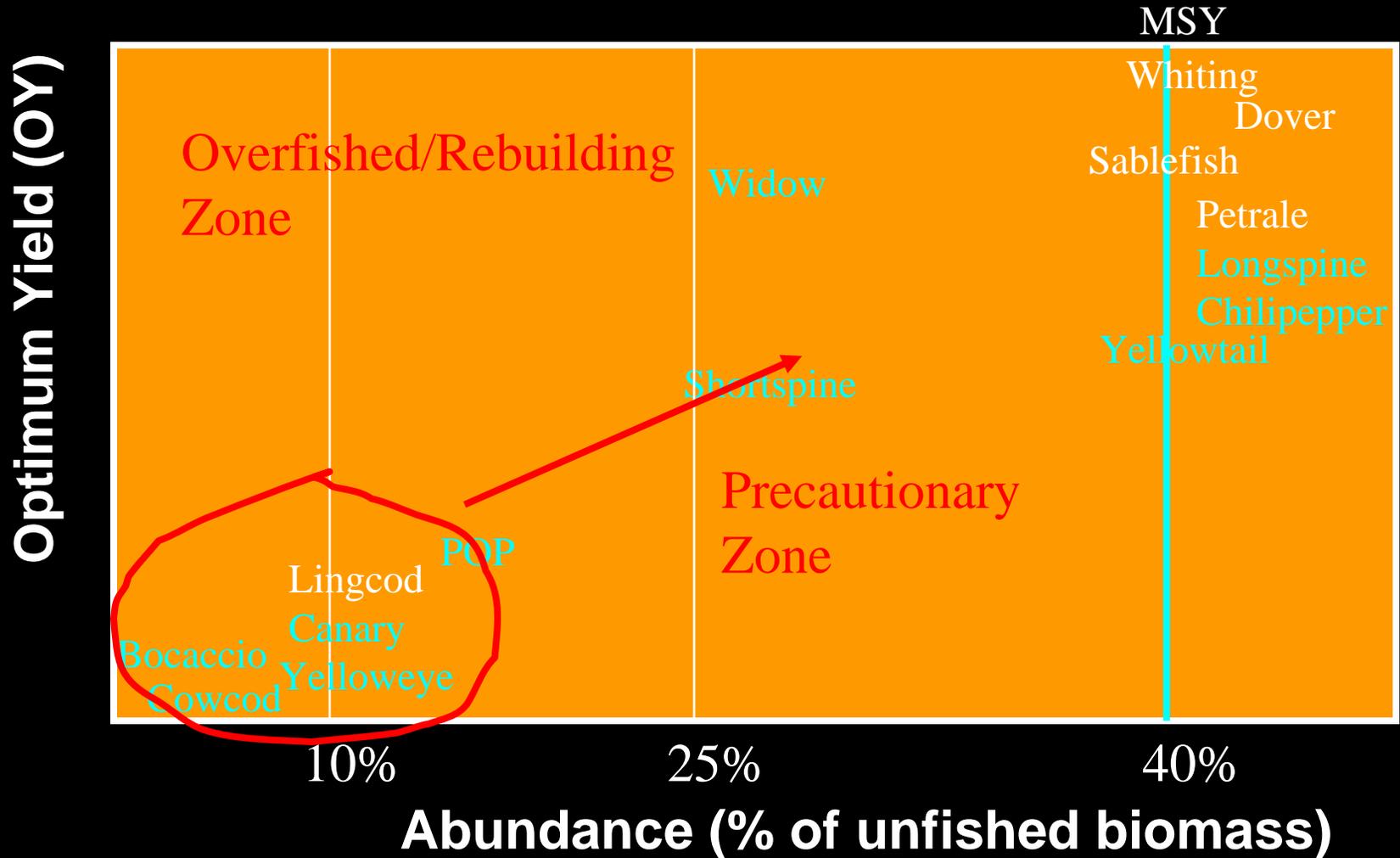


Recreational landings of bocaccio in CA (1980-2000)

- Rockfish are fished commercially and recreationally but stocks have been declining for years.
- Several species have been petitioned for inclusion on the endangered species list and are considered “overfished” by the NMFS.
- **NOAA Fisheries Research Plan for West Coast Groundfish – “evaluate artificial propagation methods to accelerate recovery, supplement depleted stocks, and increase production of valuable fishery products.” (NMFS, 2002)**



Why Rockfish?



*Sebastes in purple

From: Pacific Fishery Management Council Newsletter, November 1999.

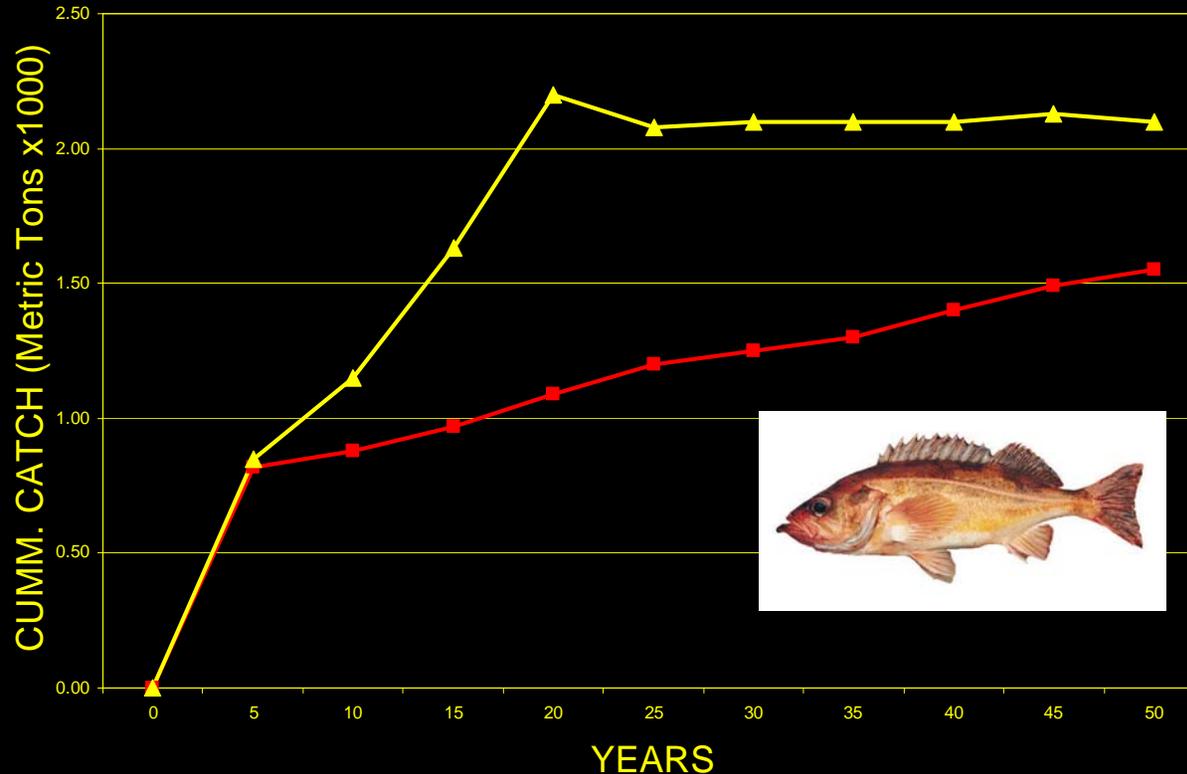


***Rebuilding on their own:
How long does it take to get
to MSY?***

- **Bocaccio - PFMC1999 - 32 years**
- **Cowcod - PFMC2001 - 95 years**
- **Canary rockfish - PFMC2001 - 57 years**
- **Yelloweye rockfish -PFMC2003 - 95 years**



Can Rockfish Hatcheries Speed the recovery of depleted rockfish Stocks?



Fifty years of simulated annual catches using two management strategies for Pacific ocean perch. Both assume catch set at $F=0.06$ for fifty years.. The red line assumes no releases. The yellow line assumes stocking 5 million juveniles a year for the first 12 years only.

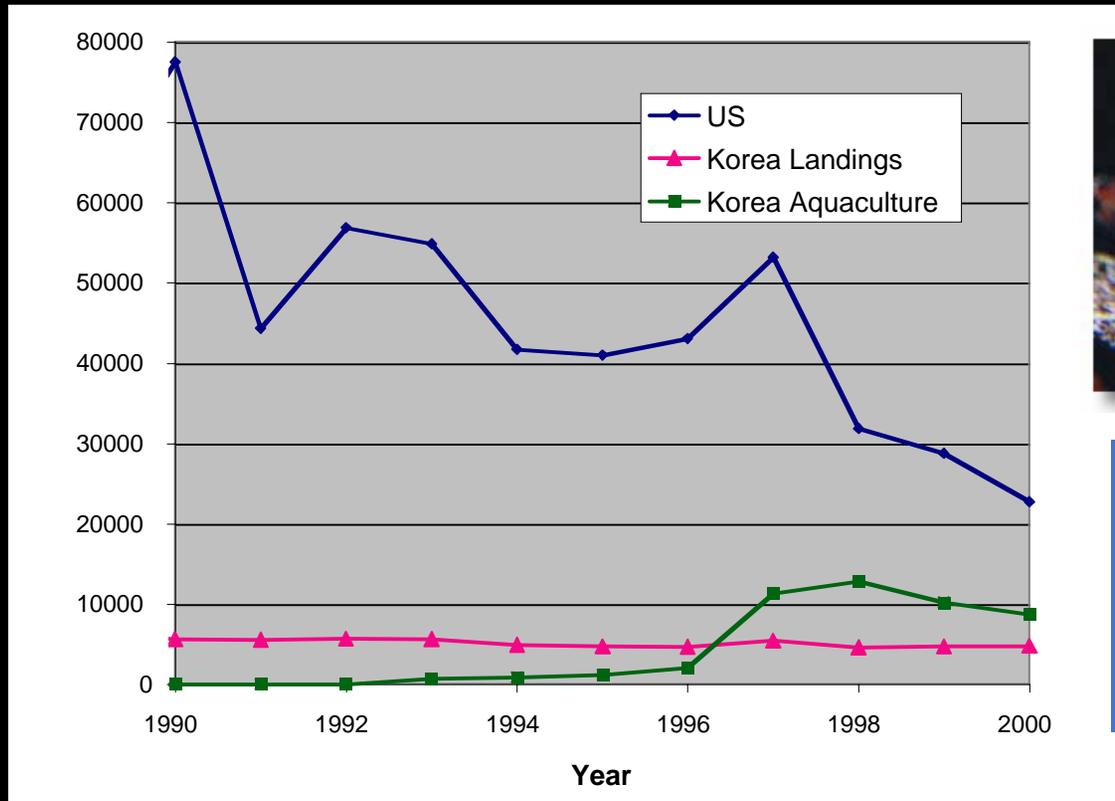


Adapted from Polovina 1991.

Note: Newer models are now under development



Korean Experience



- **Production of Pacific rockfish (*Sebastes* sp) in Korea and the United States for the period 1990 to 2000. Korean aquaculture now produces approximately twice as much as the capture sector.**



Fisheries Replenishment Progress in Southern California:

- **White seabass**
- **California sheephead**
- **11 species of rockfish/groundfish
broodstock under culture-some reproducing**
 - **Cowcod, Bocaccio, Vermillion, Starry, Black and Yellow, Gopher, Brown, Grass, Kelp, Tree, Cabezon, Lingcod**



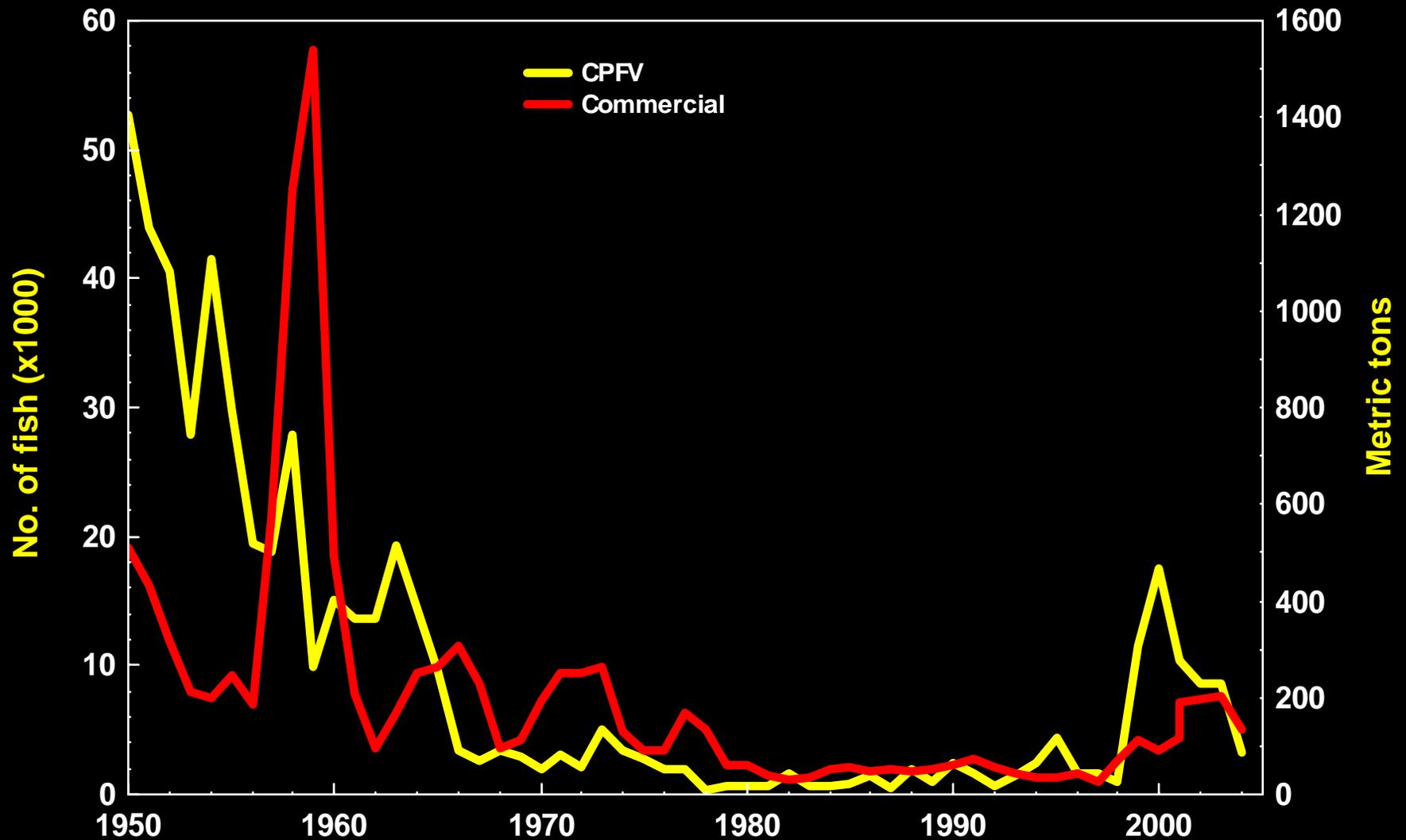
Ocean Resources Enhancement and Hatchery Program



- **Hubbs-SeaWorld Research Institute**
- **California Department of Fish & Game**
- **United Anglers of SoCal**
- **Sportfishing Association of California**
- **Many volunteers**

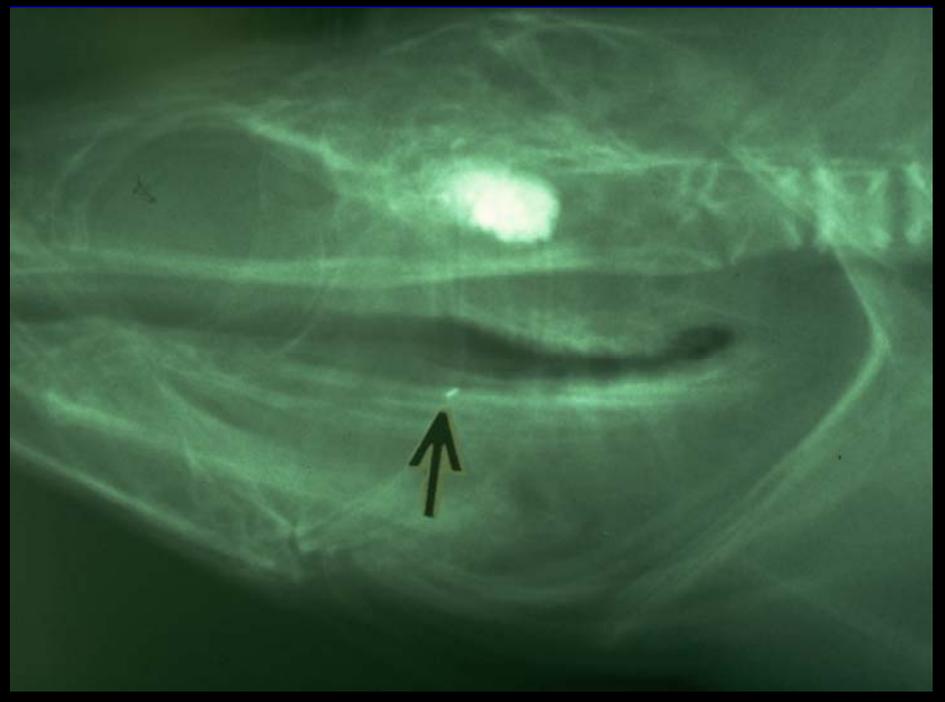
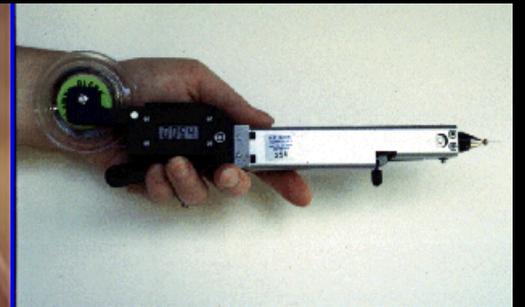


White Seabass Landings 1950-2004





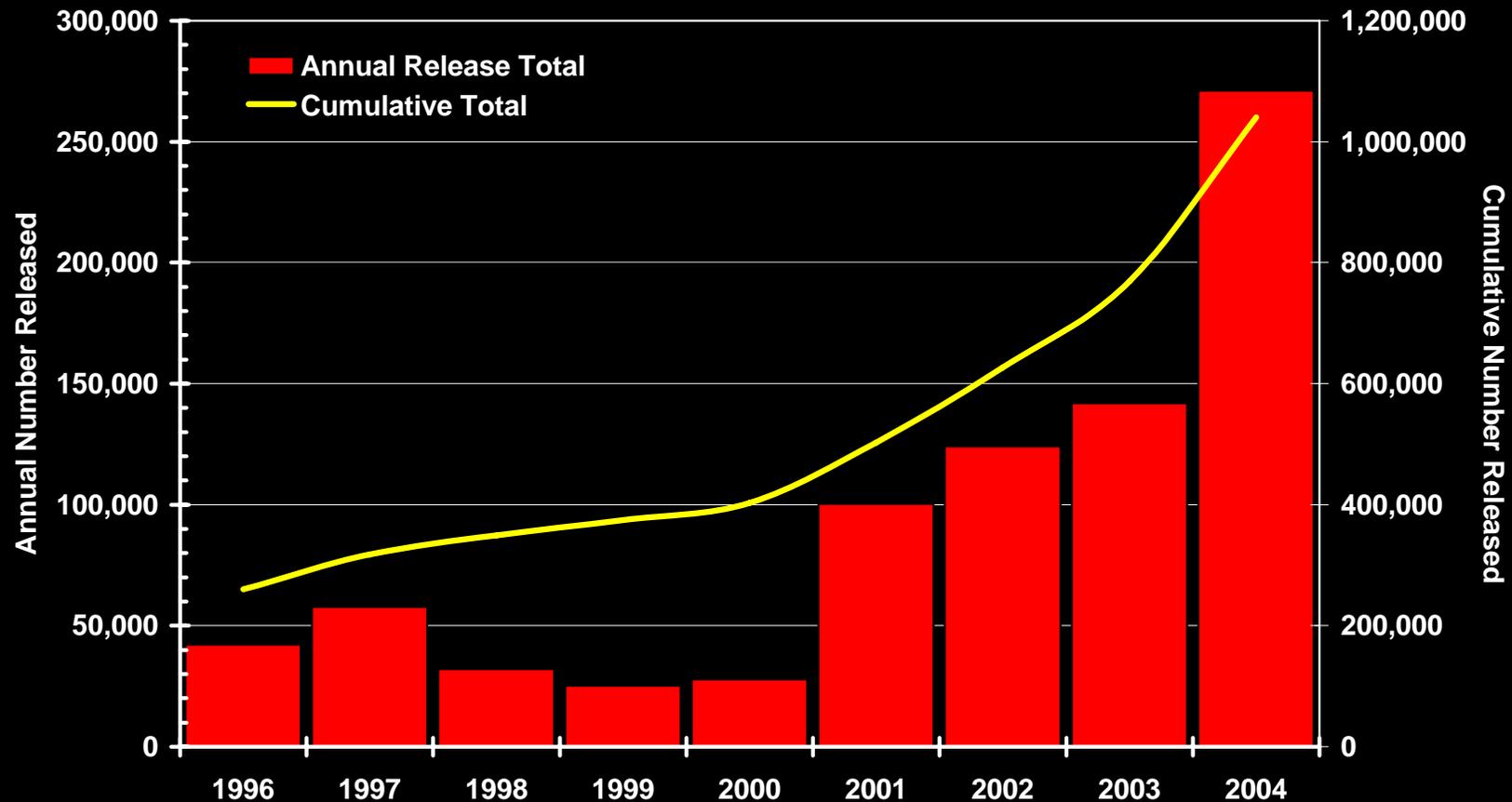
***Leon Raymond Hubbard, Jr.
Marine Fish Hatchery
Dedicated October 13, 1995***



Location of White Seabass Hatchery and Satellite Growout Facilities



History of WSB Releases From Carlsbad Hatchery



October 16th, 2004
1,000,000!



Post-Release Assessment

- **Inshore gill netting**
 - **Seasonal (April – October)**
 - **Targets sub-legal fish (1 –5 yrs)**
- **Sport/Recreational catch**
 - **Reliant on public cooperation/involvement**
 - **Contests, promotions**
- **Commercial catch**
- **Acoustic tracking**



Summary of Release – Recapture Results

- **More than one million tagged seabass released since 1986**
- **More than 1,000 tagged fish recovered; several > 10yr old**
- **Hatchery fish represent approximately 6% of the fishery-independent catches of subadults**
- **Survival of hatchery fish is dependent on fish size, season and habitat. Pre-release acclimation and conditioning are being evaluated**



Rockfish/Groundfish Replenishment

- **Successful broodstock collection of sensitive, deep water species using decompression chamber**



Rockfish/Groundfish Replenishment

- Over 100 broodstock of 11 different species-some reproduced this year-continued work with NOAA, NMFS, WA.



Food Production Accomplishments- Culture Technologies:



- Closed the life cycle on several new species –CA Yellowtail, CA halibut, CA sheephead
- Closing the gap on larger scale, reliable juvenile fish production for many species



Food Production Accomplishments- Culture Technologies:

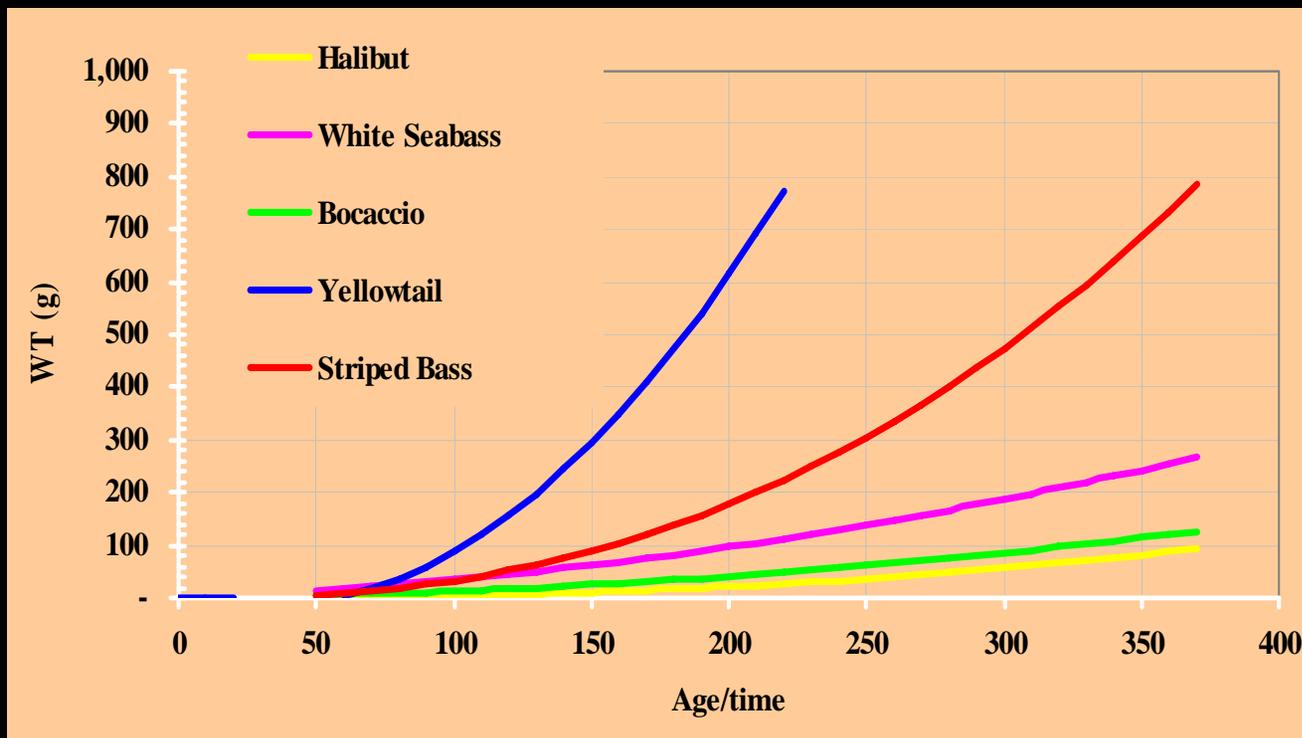


- Only CA Yellowtail hatchery in the Northern hemisphere
- All technology used is modular and transferable to platform, other offshore bases



Food Production Accomplishments- Culture Technologies:

- Validating growth performance and economic models



Food Production Accomplishments- Culture Technologies:

- *Market testing*
 - Demand from restaurants, hotels, and wholesale market is high for all species
 - Price projections improved over originals



**Striped bass – from
\$6 to 7.50/kg**

**CA YT – from \$12 to
\$13.50-\$15/kg**



What's Next ?-Answer Research Questions that Currently Limit Offshore Aquaculture Development

- **Standardize permitting process for cages in the EEZ**
- **Facilitate research to answer outstanding environmental questions**
- **Continued 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...**



What Next-2?



- Identifying, securing permits for offshore operation-
- **The Grace Mariculture Project is just about to enter the environmental review phase-NEPA**
- **Significant resources and infrastructure already expended and in place to support the program once permits are acquired.**
 - Species culture, systems testing, environmental monitoring, etc.



Permits Required:

- **Lead Agency-Army Corps of Engineers**
 - **United States Coast Guard: navigational concerns**
 - **National Marine Fisheries Service: Essential Fish Habitat/Protected Species Interactions, Possible Exempted Fishing Permit**
- **Environmental Protection Agency**
 - **NPDES Permit, Air Quality**
- **CA Dept. of Fish and Game**
 - **Aquaculture Permit**
 - **Wild broodstock collection**
- **Minerals Management Service**
 - **sub-lease approval (i.e., acknowledge “no change to Platform’s DPP”)**
- **County Air Pollution Control District**
 - **Air Quality Concerns, Aquaculture has separate SIC code**



Summary Points

- **Marine aquaculture is being developed globally, and the US will buy its products**
- **We need to advance our nation's culture capacity to meet our demanding standards for conservation of the environment**
- **Much progress has been made toward large scale juvenile species production**
- **However, limitations still exist toward achieving economies of scale-facilities, sites, etc**
- **CA experience-in late 2006, we'll have juveniles ready to stock...but with no place to go!**



Thank You!

