Marine Stock Enhancement in the USA: Status, Trends and Needs

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Historical Perspective on Stock Enhancement in the US

- 1871 was a key year in United States
  - 1st salmon hatchery in the US, in Maine
  - Congress funded shore-based marine finfish hatcheries
    - Cod, haddock, pollock, flounder were produced
    - Eggs and yolk-sac fry were stocked in an effort to replenish diminished fish stocks

Historical Perspective

- 1938: US Congress passed the Mitchell act, amended in 1946, to mitigate, in perpetuity, for habitat and salmon runs lost to federal water projects within the Columbia River basin (mainly hydro- electric dams)
  - Supports 25 major salmon hatcheries
  - > 70 million smolts annually
  - 50 - 70% of all adults in coastal fisheries

US Closed Its Marine Hatcheries

- Emphasis for a century was on magnitude of hatchery production
- After 70 years of stocking, no signs of success
- Still stocking only newly hatched fry when Woods Hole (1949) and Gloucester (1953) hatcheries closed

Anadromous Species Stocking Programs Expanded

- US Congress passed the Anadromous Fish Act in 1965
  - Mostly focused on increasing sports fishing opportunity
- Much Federal, State, Industry & NGO support of US Pacific salmon fisheries
  - US$ 270 million commercial fishery
  - And large sport fisheries

Current US Public & Private Support for Stocking Pacific Salmon

- Alaska's Private hatcheries ~ $25 M
- Mitchell Act ~ $13 M
- Bonneville Power Company ~ $12 M
- Salmon Recovery Program ~ $8 M
- Salmon Hatchery Reform ~ $5 M
- Pacific NW Indian Tribes
- US-Canada Pacific Salmon treaty
- Dingle Johnson / Wallop Breaux sport fish restoration tax
- USFWS
- NGOs & Industry

Renewed Interest in Marine Species After Advances in Culture and Tags

- Texas - red drum, seatrout, (tarpon)
- California - white seabass, CA halibut
- Connecticut – scallops, turbot
- Florida – red drum, snook, red snapper, scallops, sturgeon
- Hawaii – mullet, moi, red snapper
- Maryland – blue crab
- Mississippi – snapper, spotted seatrout
- New Hampshire – winter flounder
- North Carolina – summer flounder
- South Carolina – red drum, cobia
- Virginia – blue crab
- Washington – lingcod

Annual Funding for Stocking Programs in the US

- Anadromous species
  - US$ > 105 million
- Marine and catadromous species
  - US$ ~ 12 million

Marine S/E - Now at intermediate stage of development

Predictions:

Marine Hatchery Releases Increase Fish Abundance

- **Cultured Marine Fish Survive and Grow in the Wild** ✓
- **Hatchery Releases Increase Fishery Production** ?
- **Cultured Fish Do Not Displace Wild Individuals** ?

Status: many Critical Uncertainties About Stocking Remain Unevaluated

- Actual impact on total net production
- Effects on wild stocks
- Effects on the ecosystem
- Release strategies: effectiveness & efficiency
- Population and community dynamics
- Unregulated fishing-effort dynamics
- Cost effectiveness
- Sustainable replenishment *versus* dependency on stocking
- Are yields achieved greater than yields from the alternatives: regulations & habitat management

Trends in Fisheries Enhancement in the USA

- Public and scientific debate
  - We've debated for decades the ethical use of fish culture in fisheries management
  - Now the discussion has moved to the broader societal forum – the environmental community
  - Fishery management is undergoing dramatic evolution as fish population dynamics becomes better understood

Fishery Management Objectives are Mainly Determined by Public Demand

- Criteria for use of cultured species has changed in the US in response to evolving public fishery policy – precautionary principal
- "Modern fishery management" would have natural systems with native biota & optimal biodiversity; political climate among policy makers has moved towards the greener side
- End result will be a sound public policy that captures the social & economic benefits of renewable common property fishery resources

Trends: Learning From Our Mistakes – Much Greater Emphasis on Research

- New technologies: coded wire tags, passive integrated transponders, elastomer tags, chemical, temp. & genetic tags, hydro-acoustics, aquaculture advances
- Testing enhancement impact and effectiveness with release experiments
- Increasing focus on study of interactions between hatchery and wild stocks
- Genetic stock ID studies

Much Greater Emphasis on Research (continued)

- Strong movement towards active adaptive management (Hilborn & Walters)
- Serious new focus on advancing the science underlying stocking effects
- Dramatic increase in scientific publications and symposia on stock enhancement within the past decade

Marine Fisheries Enhancement is Now Evolving as a Science

Key Peer-Reviewed Publication Volumes & Reviews

- Lockwood, 1991
  "ICES Marine Science Symposium 192"
- Danielssen, Howell & Moksness, 1994
  "Aquaculture & Fisheries Management 25 (Suppl 1)"
- Schramm & Piper, 1995
  "AFS Symposium 15" Uses & Effects of Cultured Fishes...
- Munroe & Bell, 1997
  "Reviews in Fisheries Science 5(2)"
- Coleman, Travis & Thistle, 1998
  "Bulletin of Marine Science 62(2)" Mote Symp. Fishery Ecology
- Howell, Moksness & Svasand, 1999
  "Stock Enhancement & Sea Ranching, Blackwell Science"

Prioritizing Global Research Issues

Symposia and other Stock Enhancement Resources

- Norway -- 1st International Symposium in
  Stock Enhancement & Sea Ranching, Bergen, 1997
- Japan -- 2nd Inter. Symp. in S/E & S/R, Kobe City, 2002
- Japan Sea Farming Association -- (see overview by Honma, 1994)
- European Aquaculture Society
  Fisheries & Aquaculture Interactions Symposia (1993; 2000)
- World Aquaculture Society
  International Working Group on Stock Enhancement (formed in Torremolinos, 1993) – plan annual symposia at WAS conferences
- Norway, Institute of Marine Research
  Stock Enhancement & Sea Ranching Homepage http://www.efan.no/was
- US - Japan Cooperative Program in Natural Resources (UJNR) Aquaculture Panel - annual symposia

A Responsible Approach to Marine Stock Enhancement *

(WAS Working Group Position Paper - Published in 1995)

- Develop Species Management Plan:
  - 1. Prioritize Species for Enhancement
  - 2. Identify Harvest & Genetic Objectives
- Develop Sound Enhancement Strategy:
  - 3. Define Quantitative Measures of Success
  - 4. Use Genetic Resource Management to Prevent Inbreeding
  - 5. Use Disease and Health Management
  - 6. Consider Ecological, Biological & Life-History Patterns
  - 7. Identify Hatchery Fish & Assess Stocking Impact
  - 8. Use Experiments to Identify Optimum Release Protocols
  - 9. Identify Economic & Policy Guidelines
  - 10 Use Adaptive Management

(* Blankenship & Leber, 1995)

Now We Must Address and Solve the Needs in Fisheries Enhancement

- Top priority: more rapid development of a science of fisheries enhancement
  - Develop predictable, controlled results
  - Field evaluations of genetic effects
  - Cost-effective stocking strategies
  - Understand and control interactions of hatchery and wild stocks
    - Competitive interactions
    - Predation and cannibalism

Current "Question of the Day" Regards Density-Dependent Effects

Developing Theory in the Emerging Science of Stock Enhancement

- Foraging arena theory (Walters & Juanes, __ & Korman, __ & Kitchell, '93,'99,'01, CJFAS, RFB&F)
  - Fish habitat availability is not what it seems
  - Fish abundance strongly controlled by food availability, predation and refuge
  - Hypothesizes that unless spawning stocks are severely over fished, juvenile abundance is not recruitment limited
  - Competition over food is important even at low densities
  - Survival is density dependent at low densities
  - Increasing juvenile density has high likelihood of increasing mortality - as juveniles search for food

Willie asked the right question...

(Walters and Juanes, 1993, CJFAS)

- **Why don't the fish eat them all, dad?**

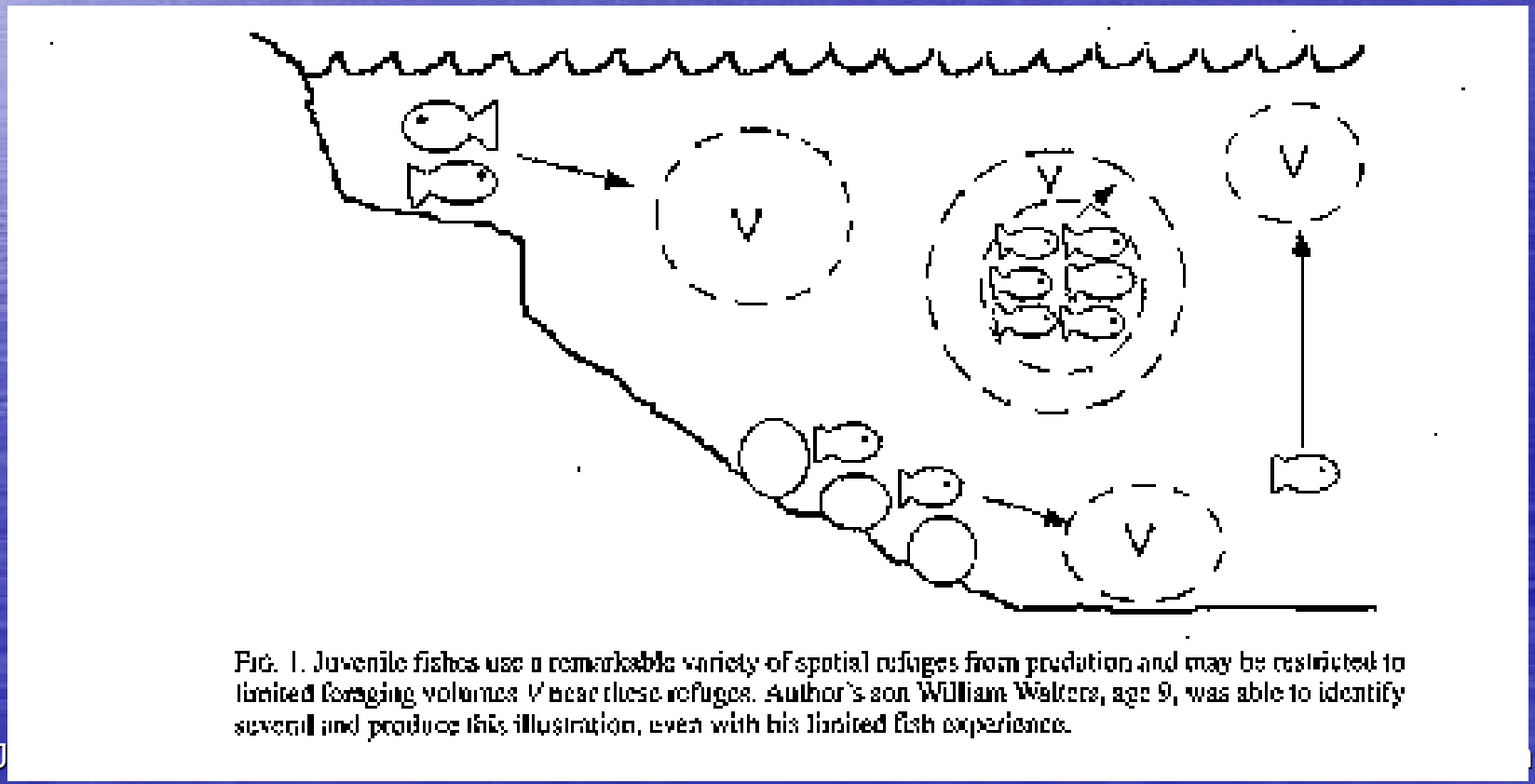
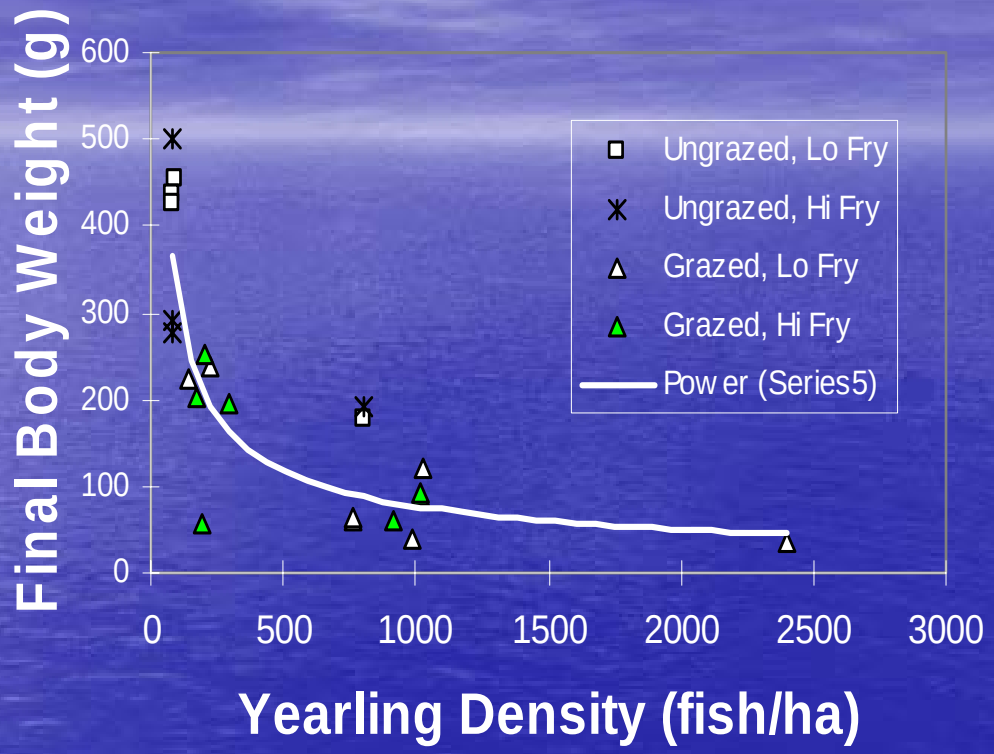


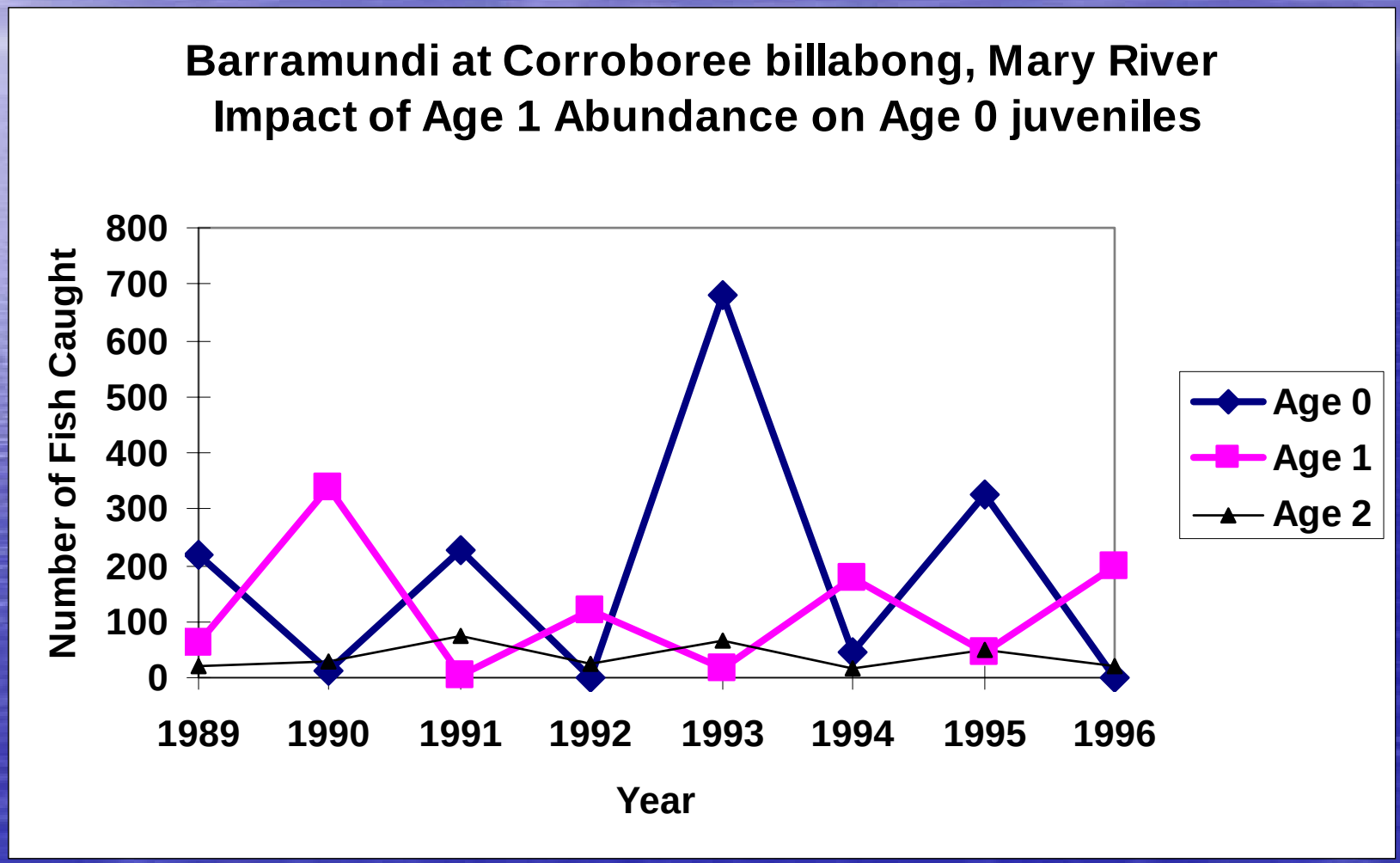
FIG. 1. Juvenile fishes use a remarkable variety of spatial refuges from predation and may be restricted to limited foraging volumes V near these refuges. Author's son William Walters, age 9, was able to identify several and produce this illustration, even with his limited fish experience.

Strong effects at low densities:



Growth and/or foraging time responses imply predation risk proportional to density, resulting in Beverton-Holt recruitment pattern.

Survival vs density tradeoffs imply strict limits on total abundance



US Needs: A Stocking Code of Ethics
(and Walters suggests a model)

- Marine enhancement should not be used as a substitute for effective regulations
- It can be used, temporarily, to accelerate rebuilding wild stocks suffering from over fishing or habitat damage, provided these problems are effectively addressed
- Marine enhancement can be used to create fisheries where habitat constraints prevent wild recruitment – if no harm to wild stocks

US Stocking Code of Ethics (Continued)

- Monitoring of Effectiveness shall include:
  - Assessment of survival of enhanced fish
    - -- i.e. the net contribution to fishery harvests
  - Assessment of impact on survival and net fishery contribution of any wild stock impacted
    - -- i.e. by competition or predation due to stocked fish
  - Assessment of changes in fishing mortality rates, on both wild & stocked fish
    - -- Caused by unregulated responses of fishing effort to the presence of enhanced fish

US Stocking Code of Ethics
(the essence is know the results)

- Every marine enhancement program should be treated as an adaptive-management experiment
- *Adaptive-management* monitoring shall be treated as a long-term cost component of enhancement investment -- to be capable of detecting responses, wild-stock impacts, and performance of enhanced fish populations over multiple fish generations

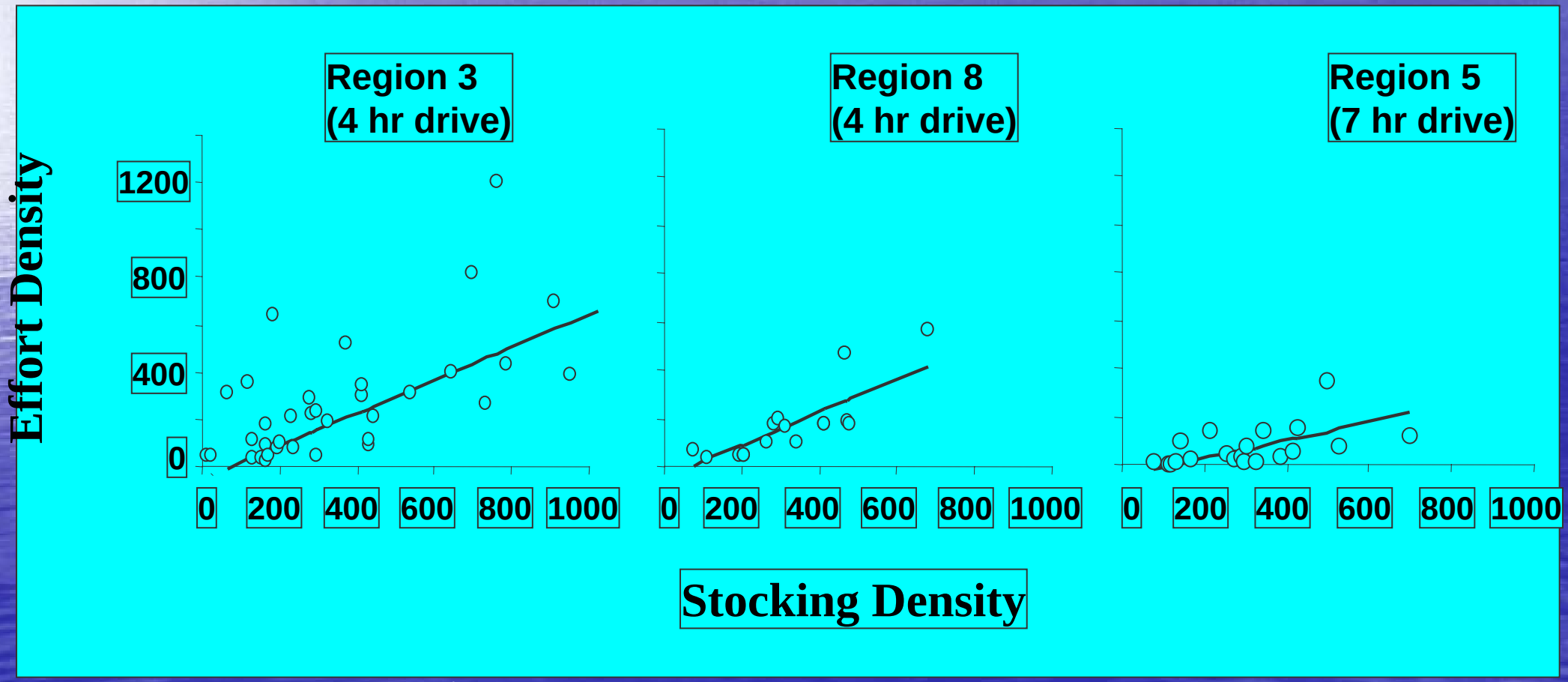
Balancing Society's Priorities

- Managing food production
  - Is the polar opposite of managing biodiversity
- Managing biodiversity
  - In a changing ecosystem, what is the target? Stopping or reversing succession?
- Managing sport-fishing opportunity
  - Lies in the middle of the production-biodiversity gradient
  - Must balance fishing effort, habitat restoration & stocking strategies

For sport fisheries, enhancement doesn't necessarily put more fish in the boat

- CPUE is ~ fish abundance / fishing effort
  - But, increase fish abundance and you bring out the boats (i.e., increase fishing effort)
- In the US, we are just learning we can't increase CPUE as a goal of enhancement without managing fishing effort
- Thus, for the USA, the target of enhancement is to increase fishing opportunity and total catch, not CPUE

Higher abundance attracts higher effort



Coupling Stock Enhancement With Habitat Restoration

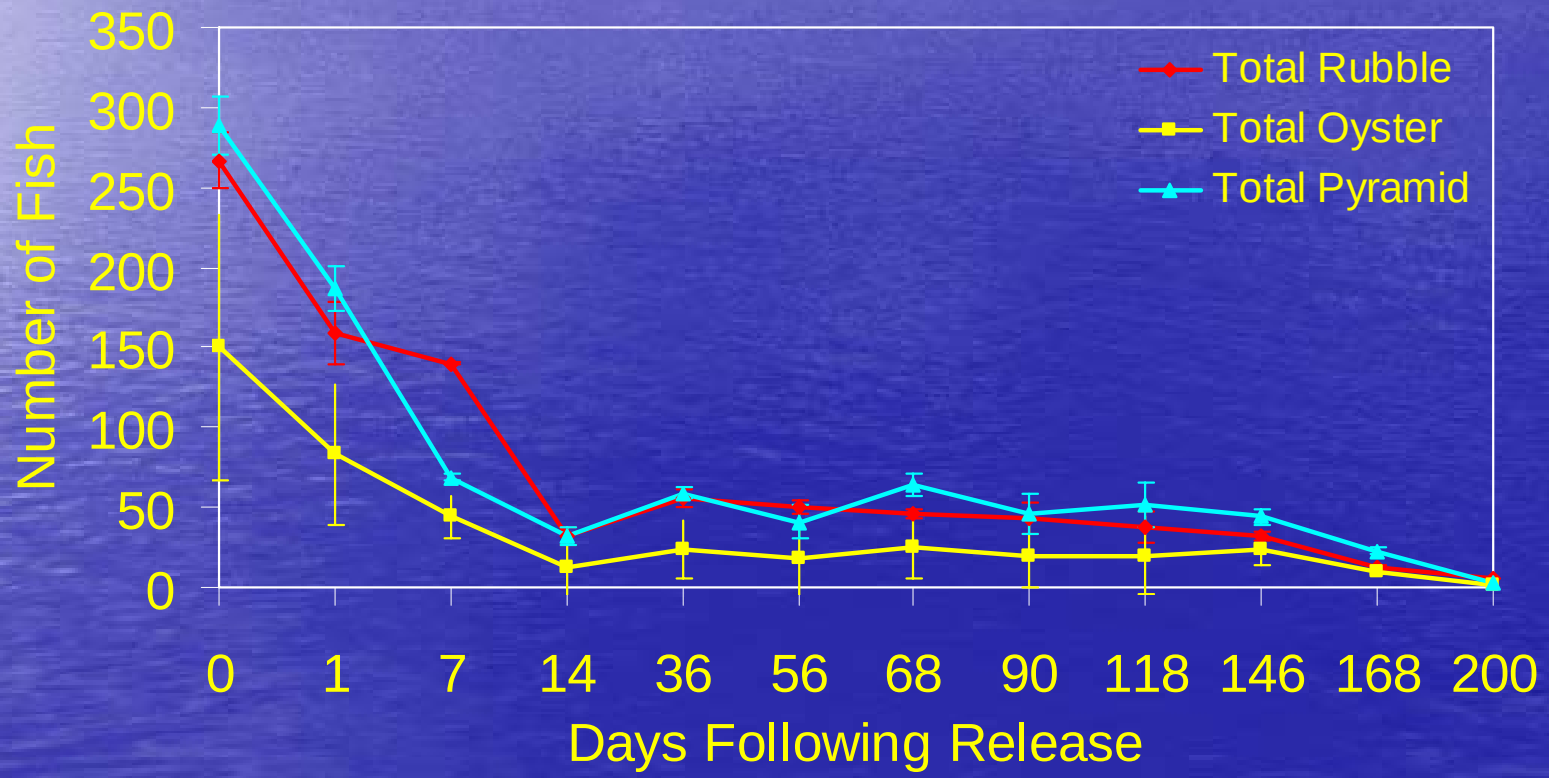
- The one factor that fisheries managers have the least control over is habitat
  - Stocking effectiveness is critically dependent upon habitat availability & quality
  - Some of the most important uncertainties about stocking impact can be addressed by research that combines habitat manipulations with density manipulations

Gulf of Mexico Stock Enhancement Program Provides an Example

(University of Southern Mississippi, Oceanic Institute, and Mote Marine Lab)

Science Consortium for Ocean Replenishment

Densities of Stocked Red Snapper Clearly Responding Differently after 14 Days



CONCLUSIONS

- In the US, we cannot afford to miss the opportunity this moment in time affords us.
- For we are at a turning point in the history of fisheries management, where we must decide either to walk away from spending more on ambiguous results, or make the shift clearly needed to "active adaptive management", which will give us the science and information we need to use stock enhancement wisely.
- Our fisheries community must rise to the challenge before us – to develop a reliable, effective, environmentally responsible stock enhancement and sea ranching technology.