



Science Consortium for Ocean Replenishment



SCORE

SCIENCE CONSORTIUM FOR OCEAN REPLENISHMENT

Technical and Planning Meeting

NOAA-NWFSC Manchester Research Station

Manchester, Washington
September 11-12, 2008



Science Consortium for Ocean Replenishment

SCORE Update

Current Status:

- ☀ 4 principal partners encompassing Atlantic, Gulf and Pacific coasts including **Mote Marine Lab, NOAA-Fisheries Manchester Lab, University of New Hampshire, University of Southern Mississippi**
- ☀ and several agency collaborators including **NOAA-NMFS, Florida FWC, Mississippi DMR, Washington DFW, NorthWest Indian Fishery Commission**
- ☀ Working now to raise funding needed to incorporate a 5th partner – **Hubbs-SeaWorld Research Institute**



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SCORE Update

Significant Outputs:

- ✱ **Educational web site**
- ✱ **22 peer-reviewed scientific publications on SCORE supported research**
- ✱ **Leadership in planning, conducting and publishing both the 2nd and 3rd International Symposia on Stock Enhancement and Sea Ranching**
- ✱ **Co-leadership and guidance in agency stock enhancement programs in 3 states**
- ✱ **Development and demonstration of improvements in stock enhancement technology and tests of key assumptions about enhancement performance**



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SCORE Consortium

- [Mote Marine Laboratory](#)
- [NMFS NW Fisheries Science Center](#)
- [University of New Hampshire](#)
- [University of Southern Mississippi](#)

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Probing the Potential of Marine Stock Enhancement

The Science Consortium for Ocean Replenishment (SCORE) is developing responsible, effective, and scientifically-based marine stock enhancement & restocking technologies. The consortium is a multi-state US initiative to help boost recovery of depleted fisheries.

What is stock enhancement?

The fish and invertebrates that support coastal fisheries are among our Nation's most important natural resources. Sustaining these is much more challenging today than in the past. [Stock enhancement](#) entails releasing hatchery-reared juveniles into the wild to augment the natural supply of juveniles and help optimize fishery harvests.

But the effectiveness of stocking is not well understood and techniques for ensuring success have not been developed. To realize the potential of stock enhancement to rapidly replenish fish stocks, better science is needed about stocking juveniles into the sea.

SCORE is conducting the research needed to make stocking effective. The goal is to develop stocking into an economical, environmentally friendly fishery management strategy to be used, when appropriate, along with fishing regulations and habitat protection.

Managing Stocking Effect on Fisheries



Hatchery snook in Gulf Coast fishery [>>More](#)

Hatchery Reform

Scientific Review Group in action... [>>More](#)

Offshore Aquaculture Act [>>More](#)

Stock Enhancement Symposia

[>>More](#)

See Our Latest Publications [>>More](#)

Sample of Publications

http://www.stockenhancement.org/science/publications.html

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Google

Acclimation effects on survival



NEW

Fairchild, E.A., N. Rennels and W.H. Howell. 2008. Predators are attracted to acclimation cages used for winter flounder stock enhancement. *Reviews in Fisheries Science* 16:262-168. >>read now...



Brennan, N. P., M. C. Darcy and K. M. Leber. 2006. Predator-free enclosures improve post-release survival of stocked common snook. *Journal of Experimental Marine Biology and Ecology*. 335(2): 302-311. >>read now...

Behavior of hatchery fish



Lee, J.S.F. and B. Berejikian. In Press. Stability in behavioural syndromes but plasticity in individual behavior: consequences for rockfish stock enhancement. *Environmental Biology of Fishes*.



Fairchild, E. A. and W. H. Howell. 2004. Factors affecting the post-release survival of cultured juvenile *Pseudopleuronectes americanus*. *Journal of Fish Biology* 65 (Supplement A):69-87. >>read now...

Ecology and life-history



Fairchild, E.A. and W.H. Howell. 2000. Predator-prey size relationship between *Pseudopleuronectes americanus* and *Carcinus maenas*. *Journal of Sea Research* 44: 81-90.

Release-transport stress effects



Sulikowski, J. A., E. A. Fairchild, N. Rennels, W. H. Howell, P. CW. Tsang. 2006. The Effects of Transport Density on Cortisol Levels in Juvenile Winter Flounder, *Pseudopleuronectes americanus* *Journal of the World Aquaculture Society* 37 (1):107-112 >>read now...



Sulikowski, J. A., E. A. Fairchild, N. Rennels, W. H. Howell and P. CW. Tsang. 2005. The effects of tagging and transport on stress in juvenile winter flounder, *Pseudopleuronectes americanus*: implications for successful stock enhancement. *Journal World Aquaculture Society* 36: 148-156. >>read now...



Scientific Consortium for Ocean Replenishment

3rd International Symposium on Stock Enhancement & Sea Ranching

SCORE scientists comprised half of the Steering Committee for this Conference

Reviews in Fisheries Science
Volume 16 (Issue 1, 2, 3)
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**A New Era For Restocking, Stock Enhancement and Sea Ranching
of Coastal Fishery Resources**

**JOHANN D. BELL, KENNETH M. LEBER, H. LEE BLANKENSHIP, NEIL
R. LONERAGAN, REIJI MASUDA & GERALDINE VANDERHAESEN**



*A Responsible Approach to Marine Stock Enhancement **

Stay Within Context of Fisheries Management Plan:

1. Prioritize Species for Enhancement
2. Make a Stocking Plan that Fits with & Helps Achieve the Goals of the Fishery Management Plan, and Identify the Expectations

Develop Sound Enhancement Strategy:

3. Define Quantitative Measures of Success
4. Use Genetic Resource Mgmt. to Prevent Deleterious Effects
5. Use Disease and Health Management
6. Consider Ecological, Biological, & Life-History Patterns
7. Identify Hatchery Fish & Assess Stocking Effects
8. Use an Empirical Process to Define Optimal Release Strategies
9. Identify Economic & Policy Guidelines
10. Use Adaptive Management

(* Blankenship & Leber, 1995)

PDF is online at StockEnhancement.org/science/publications.html



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**SCIENCE CONSORTIUM FOR
OCEAN REPLENISHMENT**

**Progress Updates:
Washington, New Hampshire,
Florida, & Mississippi**

Florida SCORE Updates

Science Consortium for Ocean Replenishment



Ken Leber
Kai Lorenzen
Kevan Main
Nathan Brennan
Carole Neidig



Mote
Scientific
Foundation

Florida Fish & Wildlife's new statewide *Science Consortium for Ocean Replenishment* replenishment initiative



FLORIDA'S SALTWATER HATCHERY & HABITAT INITIATIVE

*A Partnership to Ensure More Recreational Fishing Opportunities in Florida,
Today and Tomorrow Through Sound Management Practices.*

Welcome



WILDLIFE FOUNDATION OF FLORIDA
ESTABLISHED | 1994

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Florida's Marine Fisheries Enhancement Initiative

Science Consortium for Ocean Replenishment

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Florida Marine Fisheries Enhancement Initiative

Strengthening the Future for Sportfishing Along Florida's Vast Coastal Waterways.

A Brief Description

The Florida Marine Fisheries Enhancement Initiative is a multi-year, multi-partner program vital to sustaining our saltwater sportfish populations and the natural habitats of our precious marine life.

Our first saltwater hatchery helped keep the red drum population healthy and available in the Tampa Bay area. New technology and scientific insight have enabled the construction of even more effective marine enhancement centers that can provide a variety of game fish, at different stages of development.

THE BIG THREE



Red Drum



Snook



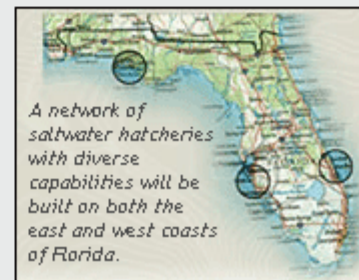
Spotted Sea Trout

To help bolster Florida's sportfish populations that will otherwise be reduced by current demand, fishery scientists and managers advise creating a series of strategically networked hatcheries and grow-out facilities on both the Atlantic and Gulf coasts. This network, combined with parallel habitat restoration, will be most the efficient model for sustaining healthy sportfish populations.

Florida is the most popular sportfishing destination in the country and that popularity contributes almost \$8 billion to Florida's economy annually. Maintaining healthy fish populations and habitats is critical to the continuation of that success. That is why we urge everyone who lives, works or plays in our beautiful state to help us make this initiative a reality and **Support Florida Sportfish**.

A Team Effort

Construction of these innovative marine propagation and ecosystem restoration facilities will only be possible through teamwork. In addition to the partners already involved in the initiative, the team must include support from government, non-profit, academic and private fisheries research institutions-and from concerned citizens and other stakeholders. We also want to work with interested communities to design a localized program that can involve all interested residents. Your contributions are vital. Donations can be in the form of time, money, or property.



A network of saltwater hatcheries with diverse capabilities will be built on both the east and west coasts of Florida.

[Http://www.fmfei.org](http://www.fmfei.org)

Enhancing Saltwater Sport Fisheries

Example – Florida: “Snook Fishing Capital of the World”

Snook contribute to Florida’s \$5.1 billion saltwater recreational fishing industry



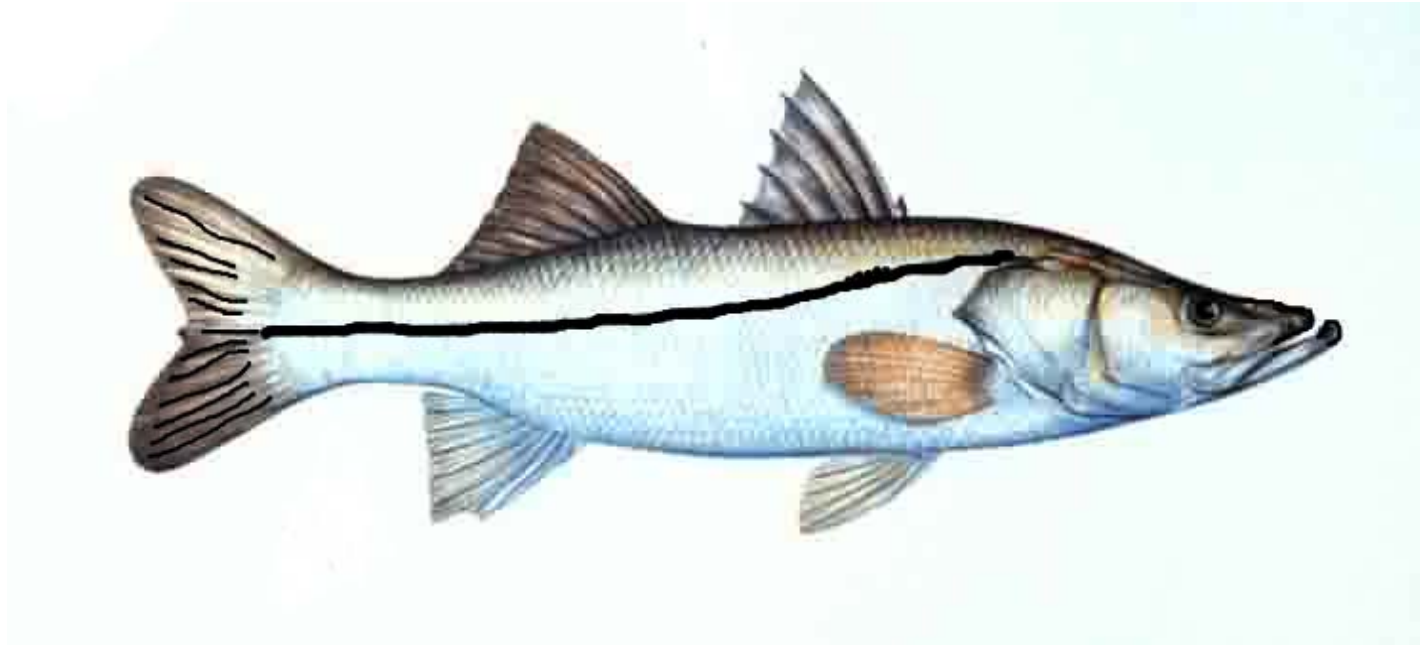
Snook are Threatened by:
Rapid Population Growth
Cold Winter Freezes
Red Tides





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Snook Enhancement and Fishery Management Workshop II



**Florida Fish & Wildlife St Petersburg
15 May 2008**



Kai Lorenzen & Ken Leber





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Goal and objectives

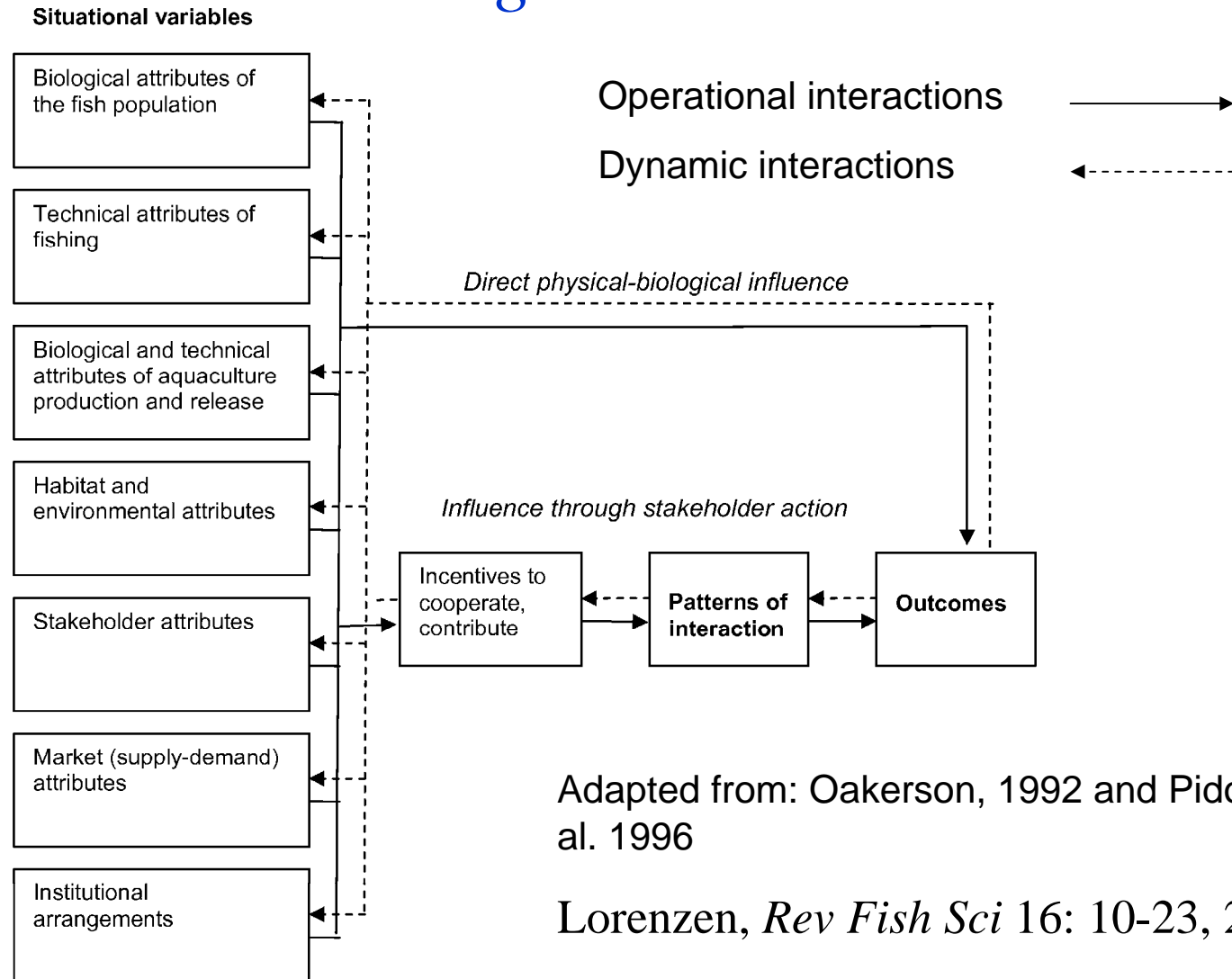
Goal:

To explore the potential role of enhancement in the management of the snook fishery

Objectives:

1. To review the results from workshop I
2. To discuss a planning process for the further development of snook fisheries enhancement initiatives

How physical/biological processes and human dimensions interact: *Institutional Analysis and Design* framework



Adapted from: Oakerson, 1992 and Pido et al. 1996

Lorenzen, *Rev Fish Sci* 16: 10-23, 2008



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Biological attributes of the fish population

- Estuarine carnivore
- Juveniles particularly dependent on freshwater (!) and estuarine habitats
- Large/adult fish can live in degraded coastal habitat
- Protandric hermaphrodite
- Separate Atlantic and Gulf of Mexico stocks with different biological parameters.
- Current SSB about 20% of unexploited SSB

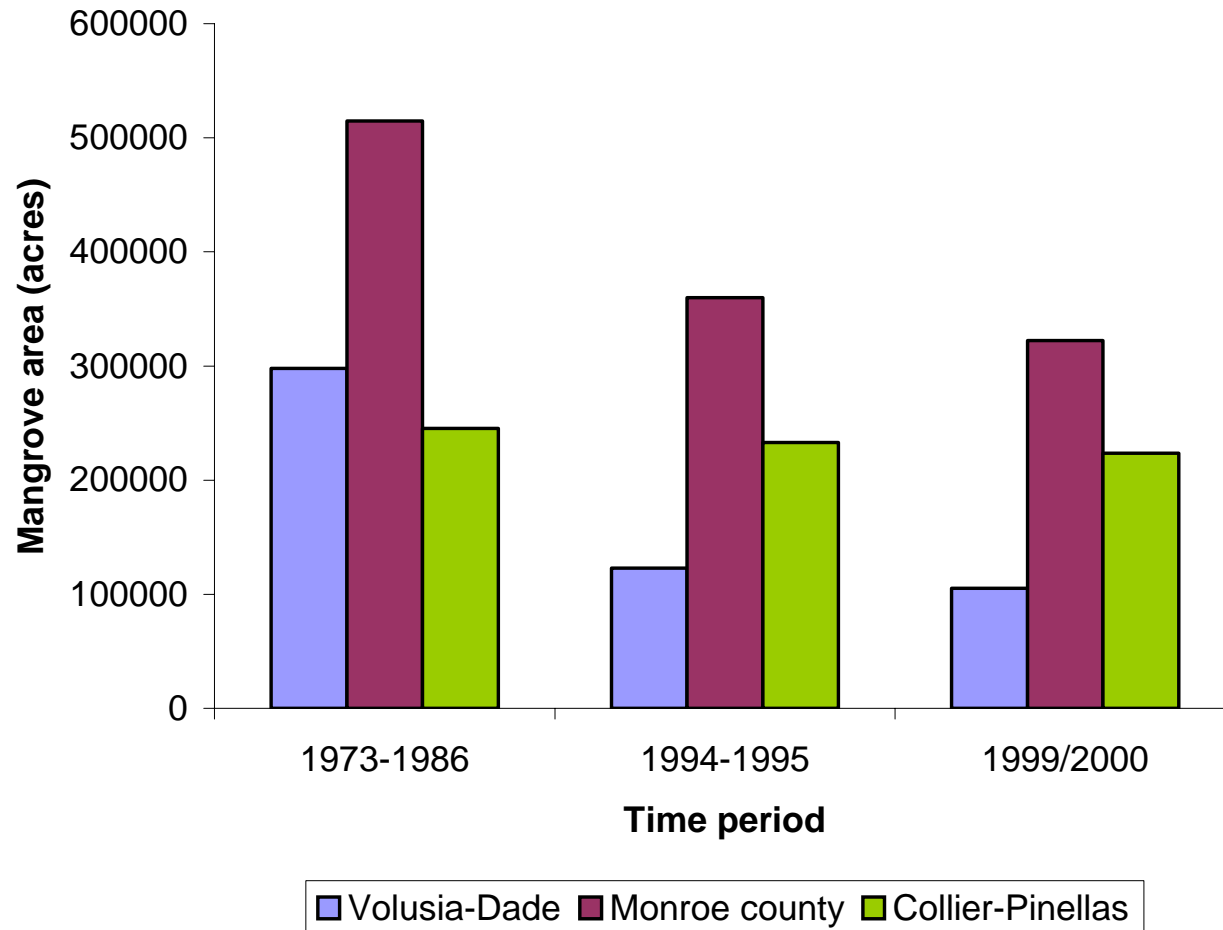
Stock status (Bob Muller, Ron Taylor)

Method	Coast	$F_{40\%}$	F_{2004}	sSPR	tSPR
ICA	Atlantic	0.16	0.24	27%	25%
	Gulf	0.22	0.36	27%	32%
ASAP	Atlantic	0.17	0.24	25%	26%
	Gulf	0.27	0.48	22%	26%

Table 4.3.5. Comparison on management benchmarks including $F_{40\%}$, F_{2004} on age-7 fish, static spawning potential ratio (sSPR) and transitional spawning potential ratio (tSPR) from ICA and ASAP.



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Estimated acreage of mangroves from composite images by coast from three time periods: 1973-1986, 1994-1995, and 1999-2000.



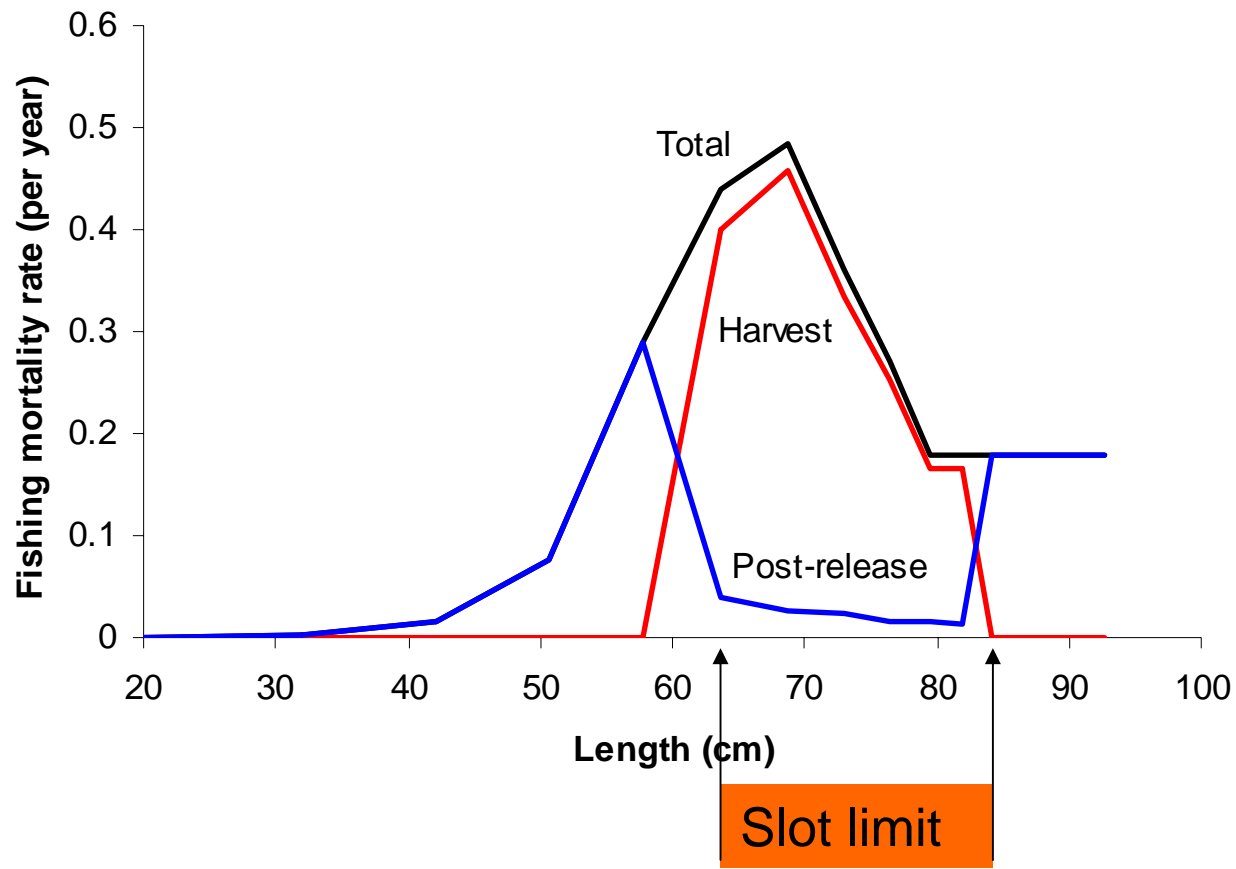
Technical attributes of fishing

- Rod and line fishing
- Catch-and-release dominant
- Release mortality accounts for 35% of total fishing mortality
- Slot limit 26'-34'
- Fishing only partially selective: technical interaction with red drum fishery



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Fishing mortality pattern in Gulf snook: Harvest and catch-and-release mortality



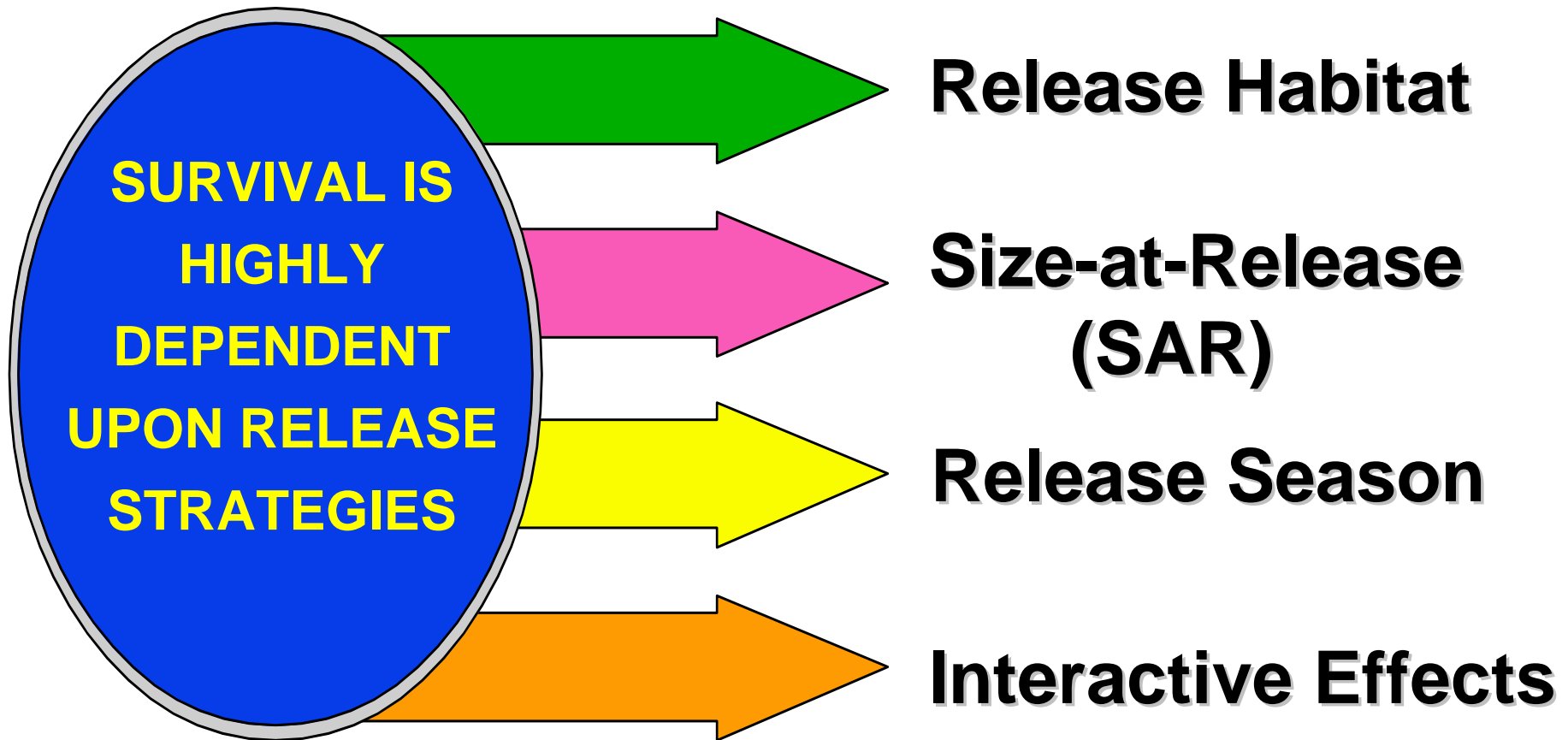


Biological and technical attributes of aquaculture and release

- Pilot-scale, specialist enhancement hatchery at Mote
- Spawning stock consists of wild fish
- Produces 4-27 cm juveniles
- No specific measures to promote 'life skills'
- Acclimation in cages for 3 days before release
- Average release: 6000 juveniles per year



Rationale for Pilot Studies to Optimize Release Protocol (Ken Leber)





Center for Ocean Reproduction

Release Microhabitat has a Large Effect on Snook Survival; for example:

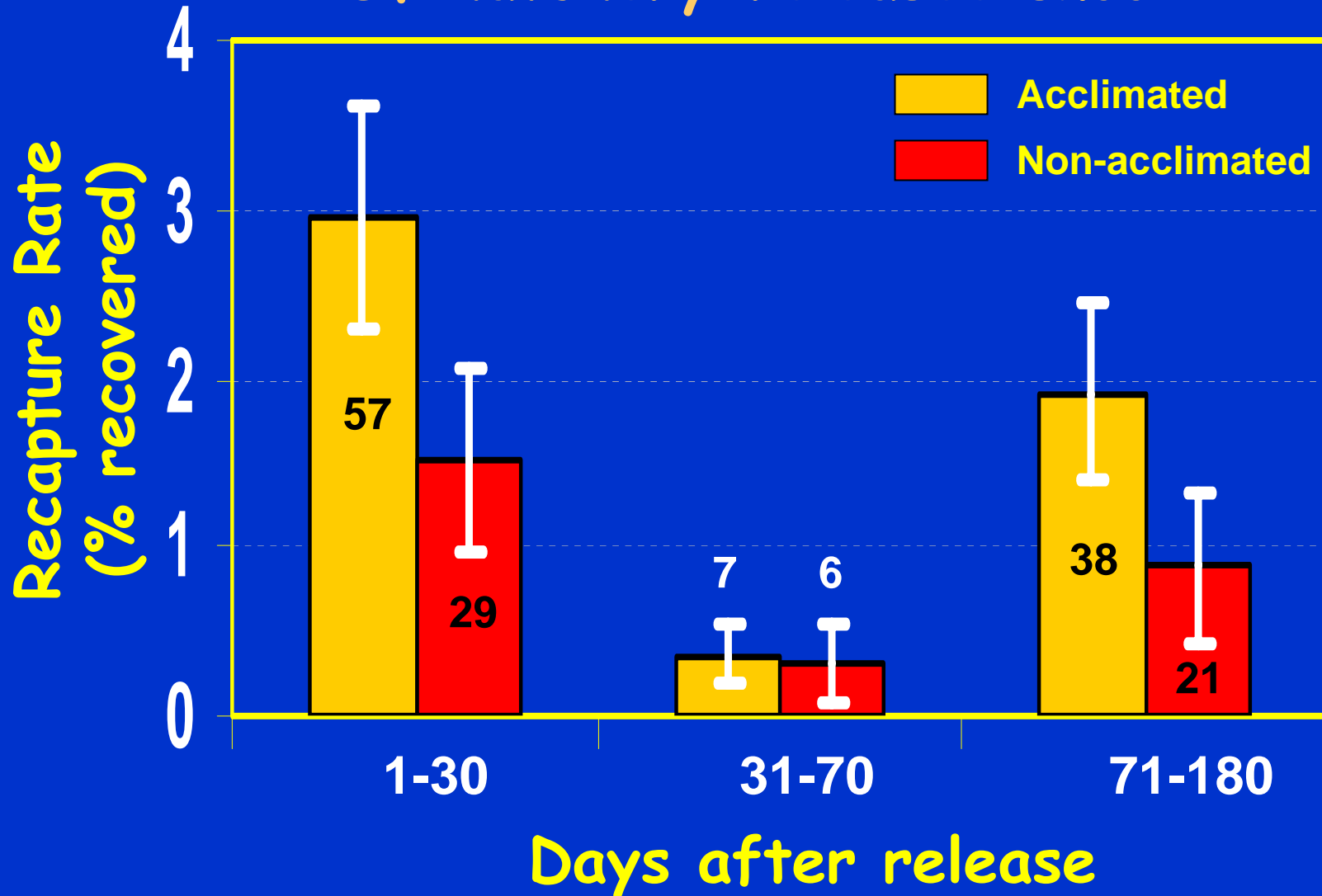
(>12 MONTHS AT SEA)



Brennan & Leber, *in Review*



Acclimation effect on recapture rate Of hatchery-released snook



Brennan, Darcy & Leber, *JEMBE* 335(2): 305-311, 2008



Habitat and environmental attributes

- Mangrove swamps, salt marshes, beaches, intercoastal passes, and offshore reefs, *freshwater (!)*
- Juvenile habitat strongly affected by coastal development, modification of freshwater outflow
- Episodic mass-mortalities from red tides or cold events



Stakeholder attributes

Primary stakeholders

- Anglers from boats and from shore
- Guides, bait shops etc.
- Hatchery operator (Mote)

Secondary stakeholders

- FWC (incl FWRI): fisheries management & research
- DEP: regulation of coastal development
- CCA
- Florida Sportsman Magazine & other media
- Conservation NGOs
- Snook Foundation



Market (supply-demand) attributes

- Sport fishing demand high and rising
- 1.5 million fishing trips (5% of total) target snook
- Value of trips: about \$ 255 million
- Willingness to pay for an additional fish per trip: \$ 10-20
- Cost of hatchery snook: about \$ 15 per 20 cm juvenile (?)



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Institutional arrangements

Operational rules

Fishery: bag limits, closed season, slot limits

Aquaculture and release: FL Genetic Policy

How operational rules are made

FWC, with research support from FWRI and Mote and in consultation with Snook Workgroup

History of Florida's snook regulations

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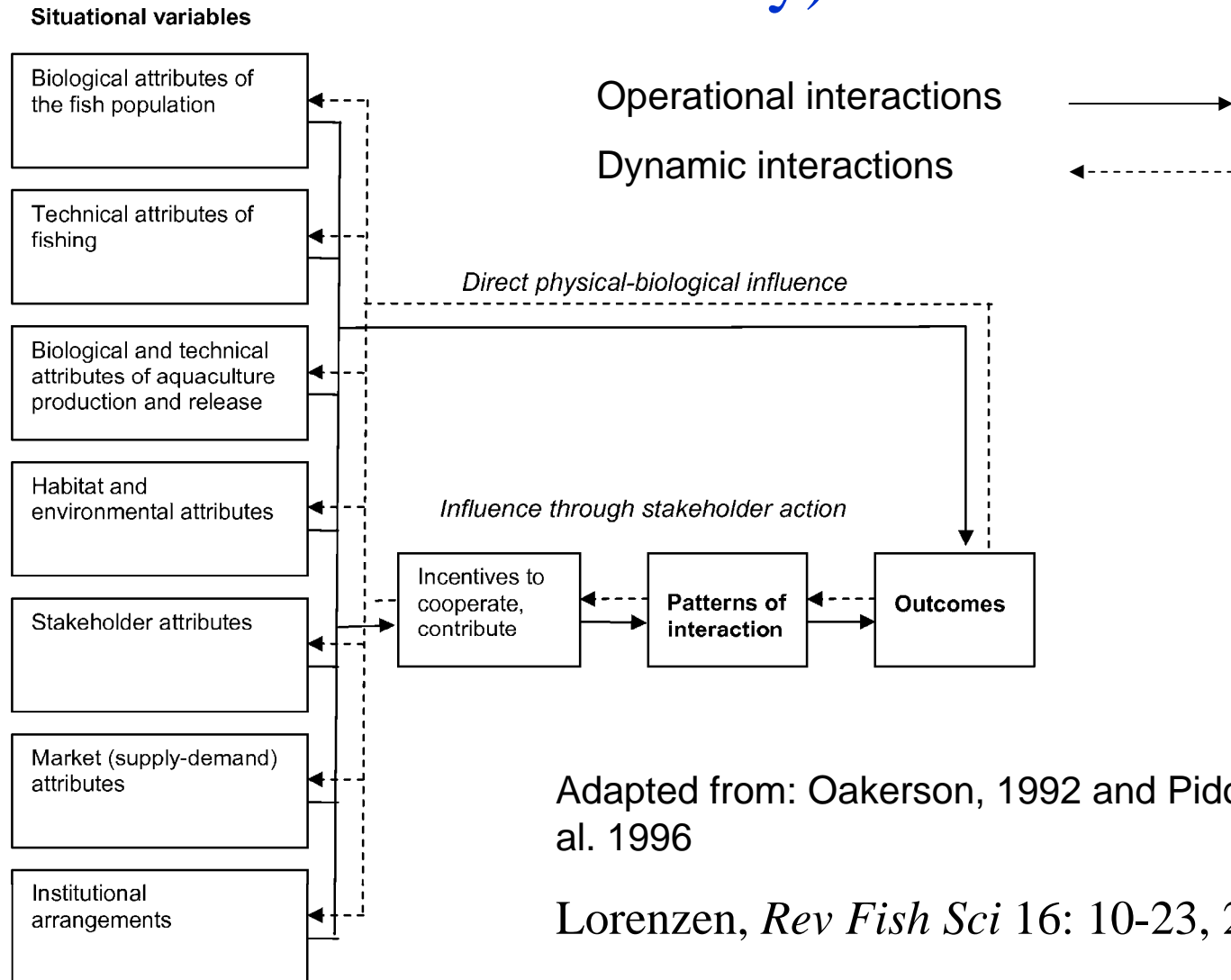
- 1947- Snook haul seines made illegal in Lee County.
- 1951 - Snook haul seines made illegal in Collier County.
- 1953 - Minimum size set at 18" FL.
- 1957 - Snook made illegal to buy or sell; Bag limit set at four snook > 18" FL.
- 1981 - Bag limit reduced to two snook/ day. No snook < 26" FL may be taken in June or July during 1982-1986.
- 1982 - June and July of 1982 closed to snook possession.
 - Snook designated 'species of special concern.'
- 1983 - January and February 1983-1986 closed to snook possession.
 - June and July 1983-1986 closed to snook possession.
 - Marine Fisheries Commission established.
- 1985 - January, February, June, and July closed permanently.
 - August 1985-1986 closed.
 - Minimum size increased to 24" TL.
 - Only one snook may be >34"TL
- 1987 - All species of *Centropomus* covered by the regulations.
 - August is closed permanently.
 - Use of treble hooks prohibited with natural baits.
- 1989- A \$2.00 snook stamp required of boaters to retain legal snook.
- 1994 - Winter closed during 15 December -January 31.
 - SPR goal set at 40%.
- 1997 - Population separated into Atlantic and Gulf stocks.
- 1999 - Harvest slot set at 26" to 34 inches" TL.
- 2001 - Snook removed from list of 'species of special concern'
- 2002 - Gulf: closed during May; daily bag reduced to one snook.
- 2007 -Atlantic: bag reduced to 1 fish, slot set at 28-32"TL
Gulf: slot set 28-33" TL, closed Dec and Feb



Current outcomes

- High recreational fishing pressure
- Catch per trip about 1 fish
- Stock at about 15-20% of unexploited spawner biomass, or 26-32% SPR
- High economic value, about \$ 255 million
- Stock enhancement on pilot scale only
- Habitat remains limited, degraded

How will outcomes change when situational variables are modified (inadvertently or intentionally)?



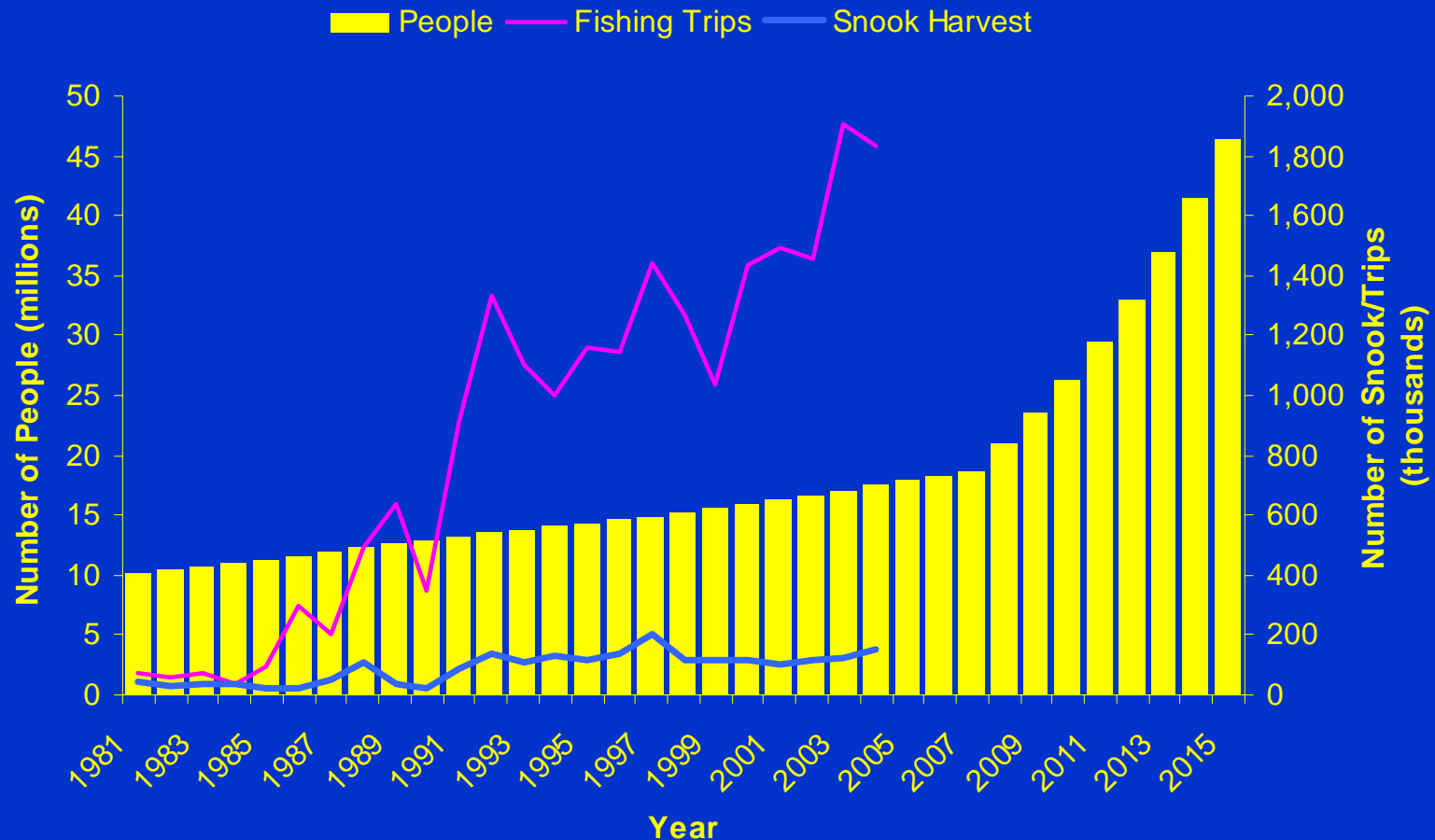
Adapted from: Oakerson, 1992 and Pido et al. 1996

Lorenzen, *Rev Fish Sci* 16: 10-23, 2008



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Future of Florida's Snook Fishery





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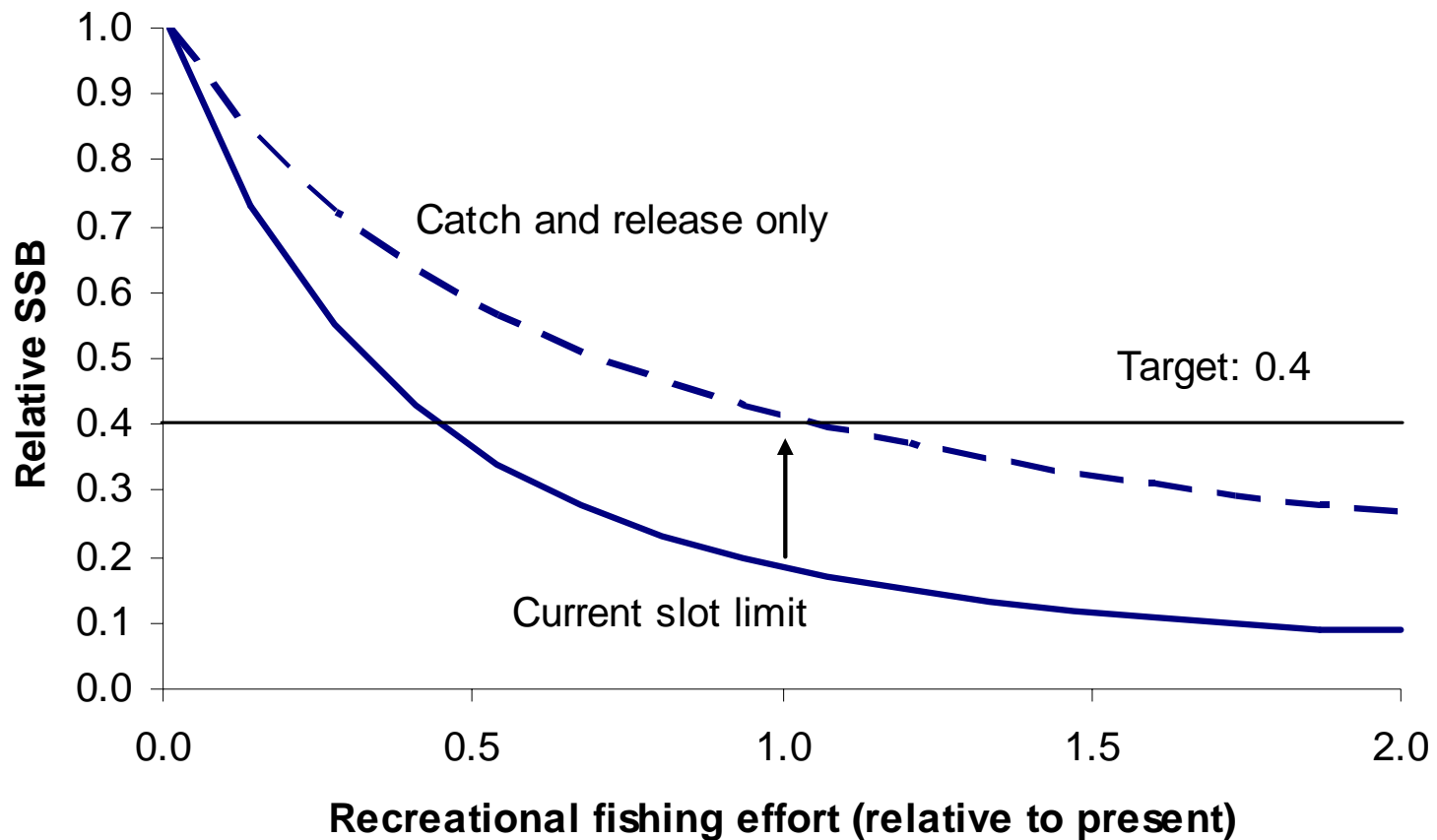
Management options

- Fishing regulations: increasingly restrictive harvest, catch and release only, access restrictions
- Stock enhancement
- Habitat restoration



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Effect of allowing catch-and-release angling only on relative SSB at different levels of effort





Snook stock enhancement: management options to increase spawner biomass to 1200 t

Management option	Spawner biomass (t)			
	Wild	Naturally recruited hatchery type	Stocked hatchery type	Total
Target reference point (0.4 unexploited spawner biomass)	1200			1200
Current fishing regime	550			550
Catch and release only	1250			1250
Stocking of 1 Million recruits (20 cm), current fishing regime	200	400	600	1200
Stocking of 1.2 Million sterile recruits (20 cm), current fishing regime	550		650	550 650 (1200)
Habitat enhancement: 100% increase in juvenile carrying capacity, current fishing regime	1200			1200



Different ‘models’ of hatchery enhancement

- Releasing reproductively competent fish into self-recruiting wild population
- Releasing sterile fish into self-recruiting wild population
- Releasing hatchery fish in areas where habitat is too degraded to support self-recruiting wild population
- ...?



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Habitat restoration

- What would be effective?



Some VERY rough economics

- Doubling of SSB would double catch per trip from 1 to 2 fish
- Anglers willing to pay \$ 10-20 for an additional fish per trip
- With 1.5 million trips, that's \$ 15-30 million
- Cost of producing 1 million hatchery snook: \$ 15 million



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The human dimension

- Enhancement expands the technical toolbox of fisheries management – but how will stakeholders respond?
- Will anglers fish more for snook as the stock becomes more abundant, or they hear about the enhancement?
- Would stakeholders be more willing to accept certain restrictions if ‘compensated’ by enhancement?
- Could enhancement facilitate creative thinking and fundamental change in fisheries management?

1) Fishery management goals

- What are the goals and objectives of snook fishery management?
- What are good reference points/indicators of success?

2) Integrative management

- Should we aim to integrate harvest management, habitat restoration, and hatchery enhancement in assessment and management, or focus on one or two aspects?
- How can we foster integration (if we want it)?

3) Key research questions

- What are the key research questions we need to address with respect to integrated snook management?
- How?



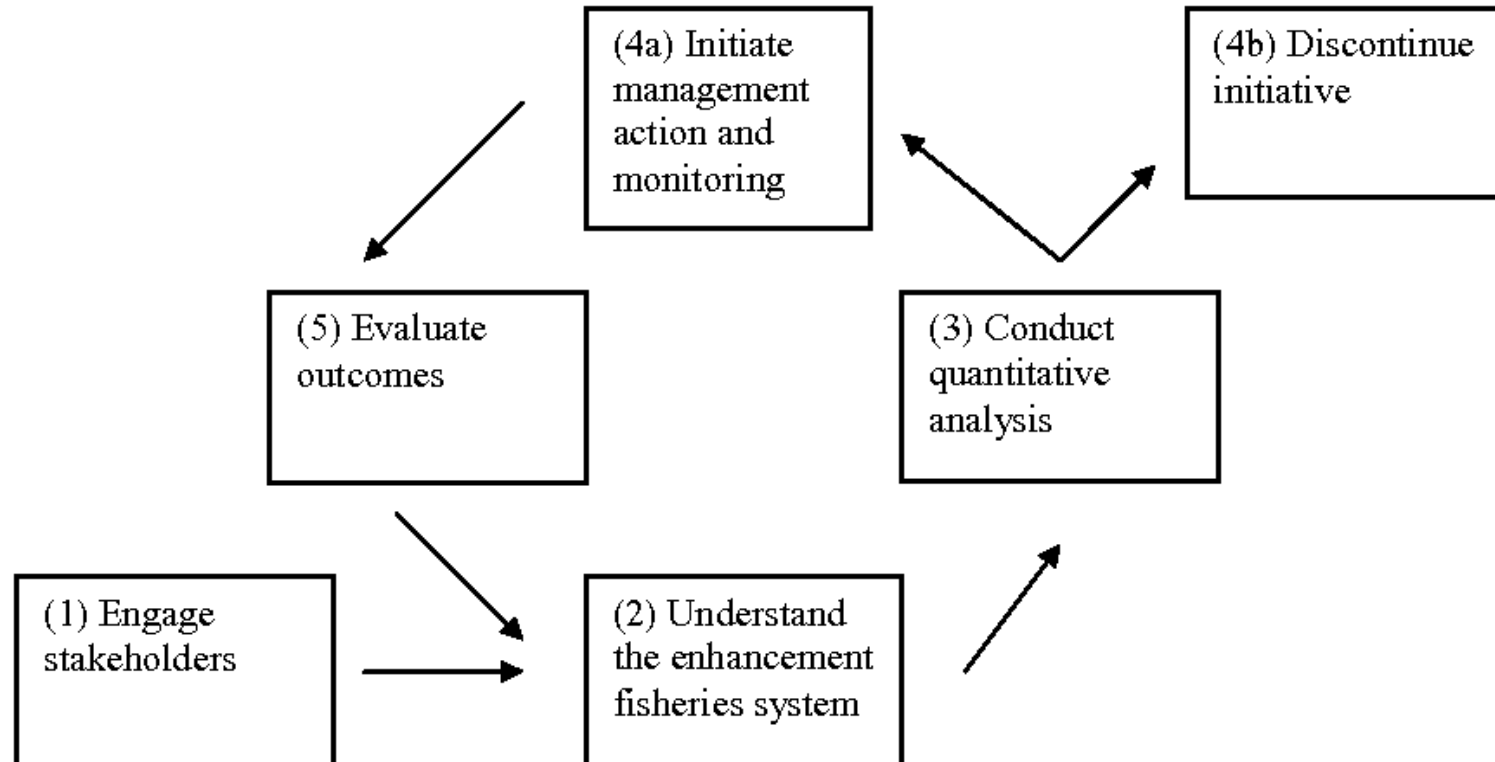
Research and data needs (FWC Perspective)

- **Expand age and length sampling from anglers as part of MRFSS sampling.**
- **Determine the impact of red tides on snook stocks.**
- **Determine how adult snook use rivers and offshore reefs.**





Integrated process for bringing stock and habitat enhancement into the fisheries management arena?



4) Planning process

- Should we open a broader, structured dialogue and planning process for snook management?
- Who should be involved?
- Should this be separate from ongoing processes (e.g. the Snook Workgroup), or be integrated into one of them?
- When should it start and what should be the timeframe?
- Who should lead or ‘anchor’ the process?



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Strategic Technical Issues

- Cannibalism – reduction of & auto-graders
- Genetic integrity of hatchery-wild genotype fish
- Define success story
- Identifying mark for selective fisheries on marine hatchery fish
- Critical uncertainties about stocking effectiveness
- Modeling stock enhancement potential
- Cost effectiveness
- Funding “full-scale” stock enhancement
- CCA involvement / endorsement
- Chemicals / Inads



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Next Steps in Florida

- Seeking matching funds from Florida Sea Grant, FWC and Foundations
- Complete development of mass culture technology for common snook needed for large scale test of concept
- Publish all of completed SCORE projects
- Assist FWC in the expansion of sportfish enhancement in Florida
- Further development of snook fisheries in inland ponds
- Expand awareness of SCORE goals and accomplishments