



~ Adaptive Management is a Fundamental but Often Lacking Enhancement Policy ~

Taking inventory in fisheries enhancements

Ken Leber

www.bio.fsu.edu/mote/international_symposia.php

www.SeaRanching.org

New Technologies Spawn New Technologies

- Rapid expansion of marine aquaculture since the 1980s enabled corresponding expansion of aquaculture-based fisheries enhancements
- But in many enhancement efforts, improvements in enhancement policy have not kept pace with improvements in enhancement science
- In particular, why is active adaptive management so rarely incorporated as a fundamental part of enhancement operational policy?

Release Variables: Critical Uncertainties

Some of the Most Basic Choices Managers of Hatchery Releases Must Make

- Tag type, tag placement, tagged proportion
- Acclimation at release site
- Size-at-release (SAR)
- Season and tidal timing
- Effects of interactions
- Release habitat & microhabitat
- Release magnitude

Optimize Release Strategies

To Maximize Survival

- After stocking, take inventory so that stocked hatchery fish can approach survival levels of wild fish; and stocking efficiency is maximized

Blind Management

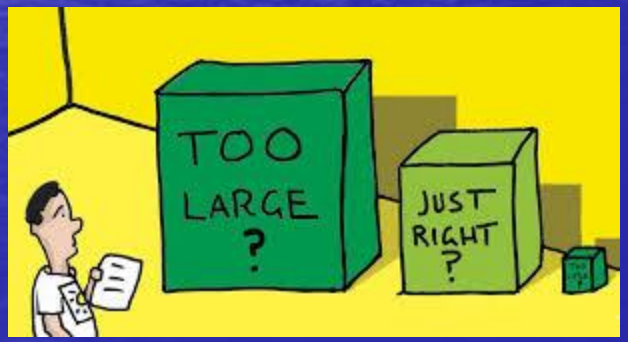
???

Grow Harvest Stock Repeat

You'd include adaptive management cost in your budget if you owned a business

Was stocking here successful???

It's a safe bet that successful entrepreneurs take inventory and do marketing research



What size should we stock???

Was stocking this much a failure???

Ann. Rev. Ecol. Syst. 1978. 9:157–88

ECOLOGICAL OPTIMIZATION AND ADAPTIVE MANAGEMENT

Carl J. Walters
Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C., Canada V6T 1W5

Ray Hilborn
Canadian Department of Fisheries & Environment, and Institute of Animal Resource Ecology, University of British Columbia, Vancouver, B.C., Canada V6T 1W5

INTRODUCTION

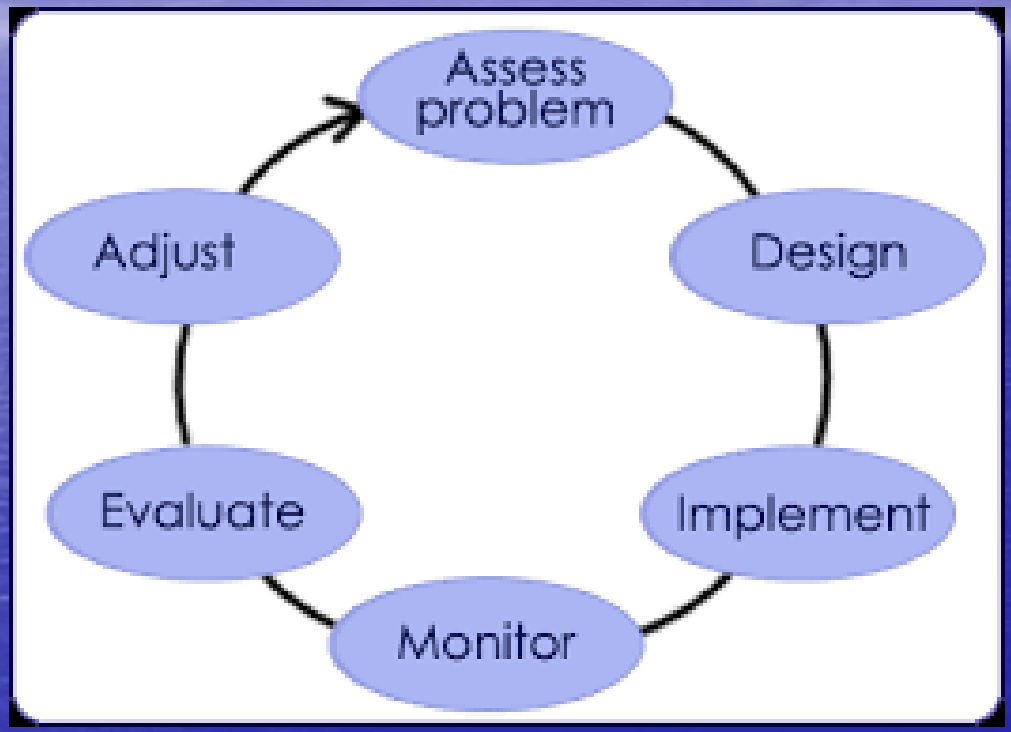
Over the last two decades a large body of literature on control and optimization of dynamic systems has developed. There have been attempts to apply some of the concepts and techniques to problems in resource ecology, particularly in relation to harvesting policies for exploited populations. This review seeks to provide a non-mathematical overview with emphasis on the anatomy of optimization formulations, the technical problems of obtaining solutions, and the prospects for good decision making in the face of uncertainty.

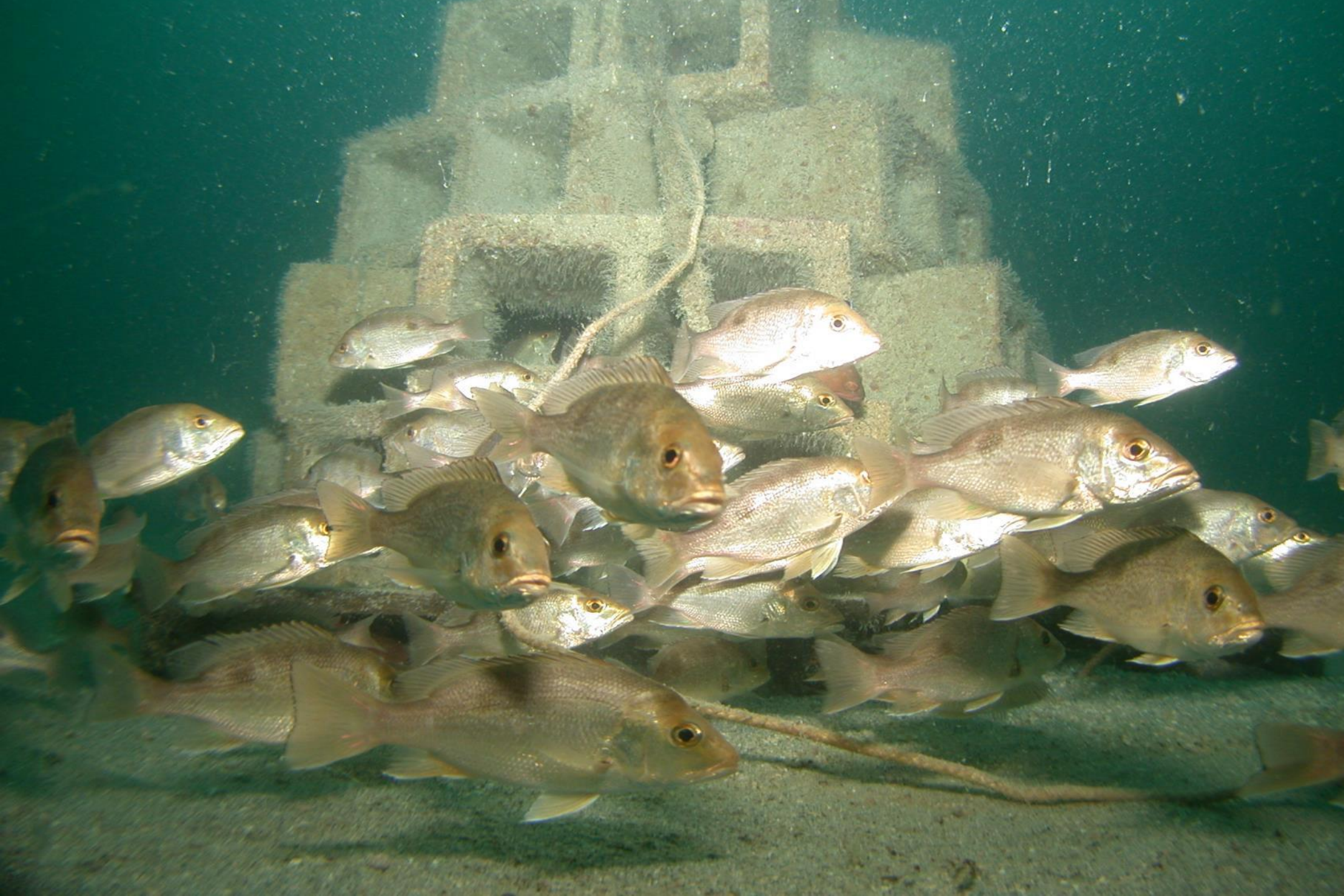
Uncertainty is a pervasive feature of ecological management problems. Rarely is it possible to predict even the short-term effects of major interventions. Given complete biological understanding, we would still be faced with the unpredictability of various environmental agents. Usually our perceptions are further clouded by statistical problems of measurement and aggregation. The practice in fields such as fisheries management has often been to develop deterministic prediction models based on the best available estimates of dynamic parameters, then to hedge against uncertainty by adopting somewhat more conservative behavior than the models predict to be optimal. While the pretense is scientific management, mistakes and failures are seldom treated as useful adaptive experiments or tests of understanding; we bury our mistakes instead of learning from them.

In this paper we explore the consequences of uncertainty by examining various optimization analyses for managed populations, beginning with deterministic optimal control models that presume full knowledge and ending with adaptive control models that presume almost complete ignorance. No real population has been managed for a sustained period by consistently applying any of the analyses we will

0066-4162/78/1120-0157$01.00

Adaptive Management





A few Examples of Taking Inventory to Maximize Survival

Adaptive Stocking Fuels Efficiency & Effectiveness

FAS 6932 Fisheries Enhancement

OAHU, HAWAII


Kaneohe Bay
James Campbell National Wildlife Refuge
Kahuku
Kamehameha Hwy
Pūpūkea
Laie
Waimea Bay Beach Park
Hauula
Koolauloa
83
Haleiwa
Mokuleia Beach Park
930
Waialua
North Shore
Ka'ena Point State Park
803
99
801
804
Kaaawa
Kahana Valley State Park
Kualoa Regional Park
93
Wahiawā
Waipio Acres
Kaneohe Bay
Mākaha
Waianae
Kahaluu
Mililani
Pearl City
Ahuimanu
MCBH
Waianae
Mililani Memorial Park
Heeia
93
Maili
Waipio
Kaneohe
Kailua
360
Waimalu
John A. Burns Fwy
H3
61
Nānākuli
Waipahu
Aiea
72
Kailua
Moanalua
Likelike Hwy
H1
H201
63
Pali Hwy
Makakilo
Hickam AFB
Waimanalo
Kapolei
Ewa
Kalihi - Palama
61
Waimanalo Beach Park
Ko Olina Beach Park
Ewa Beach
Manoa
Palolo
Honolulu
Māmala Bay
H1
Waikiki
Kaimuki
72
Koko Head Park
Kapiolani Park

Effect of Release Habitat on striped mullet in Hawaii

- Kahaluu Steam (control site)
- Shoreline of Kaneohe Bay (treatment site)

	Number Released	*Replicates (Lots)*	*Number Recaptured*
Control Site	11676	2	20
Treatment Site	31146	3	0

Leber, K. M. 1995. Significance of fish size-at-release on enhancement of striped mullet fisheries in Hawaii. Journal World Aquaculture Society 26(2):143-153.

Assessment of Release Strategies

~ Size-at-release (SAR) ~

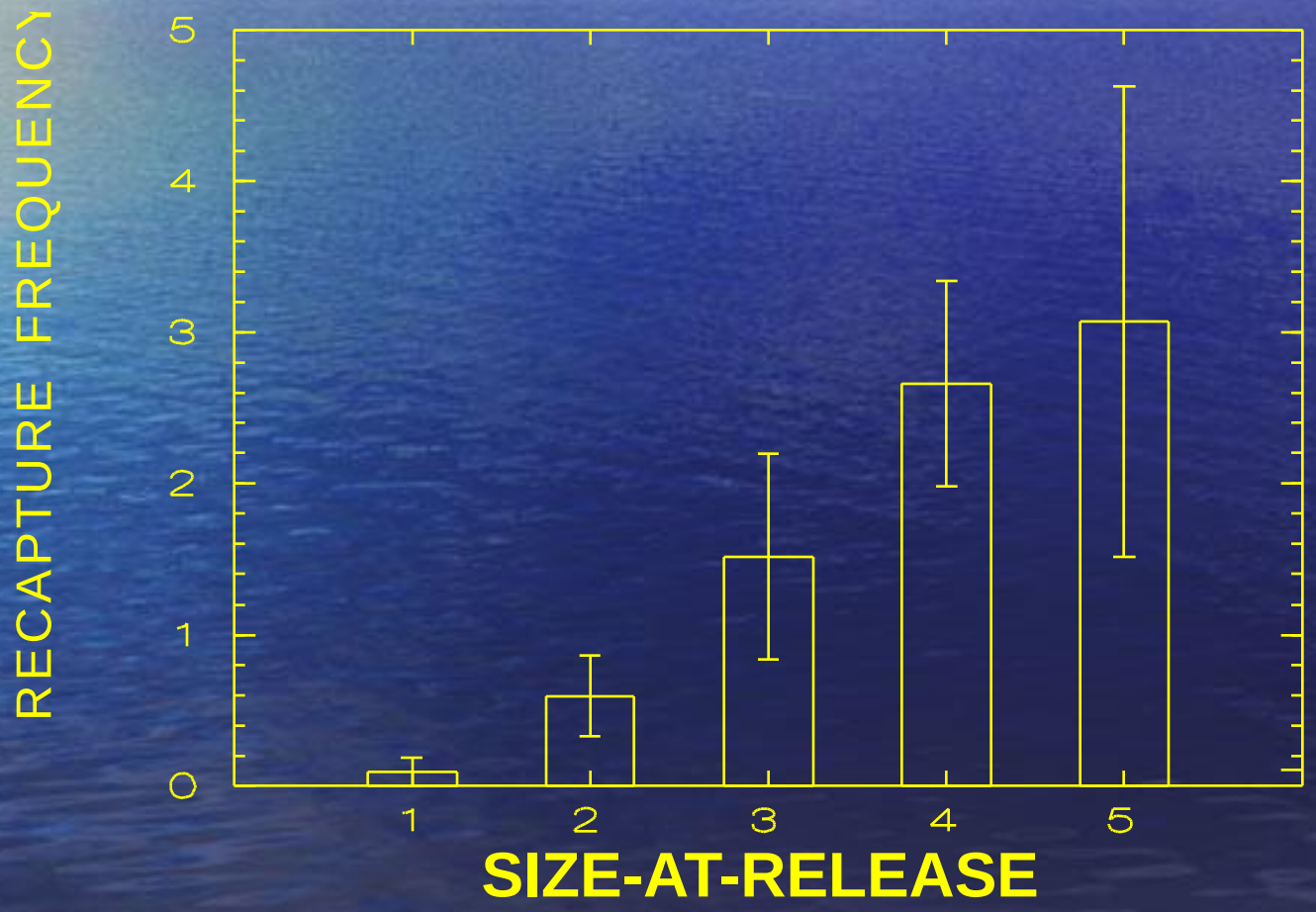
~ Seasonal timing ~

&

~ Effects of interactions ~

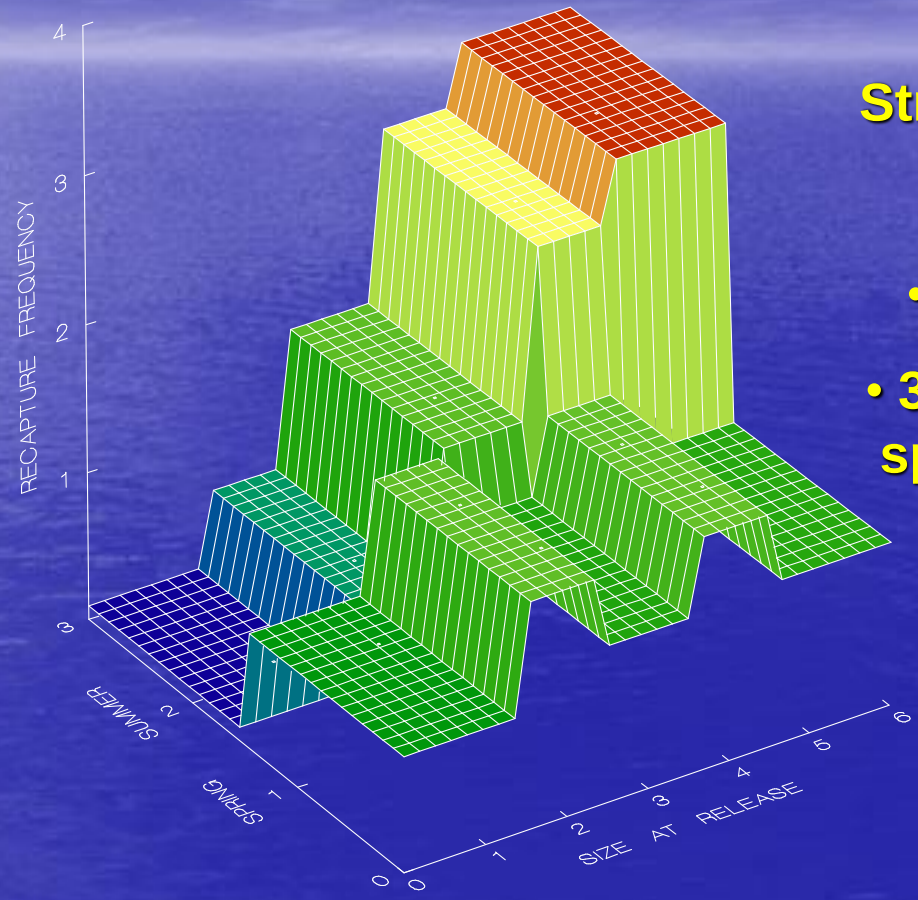
Size-at-Release Impact in Kaneohe Bay, Hawaii

RECAPTURES FOLLOWING SUMMER RELEASES



Leber, K. M., H. L. Blankenship, S. M. Arce, and N. P. Brennan. 1997. Influence of release season on size-dependent survival of cultured striped mullet, *Mugil cephalus*, in a Hawaiian estuary. Fishery Bulletin, 95(2):267-279.

Release Season Interaction With Size-at-Release Effect



Striped Mullet in Hawaii

- **5 sizes released**
- **Spring vs Summer**
- **3 replicate releases in spring and in summer**

Leber, K. M., H. L. Blankenship, S. M. Arce, and N. P. Brennan. 1997. Influence of release season on size-dependent survival of cultured striped mullet, *Mugil cephalus*, in a Hawaiian estuary. Fishery Bulletin, 95(2):267-279.

Basic Cost Parameters: Fish Size-at-Release (SAR)

- Key Parameters: SAR based-production levels;-production costs;-fishery yields

	SAR LEVEL				
	45-60mm	60-70	70-85	85-110	110-130
#	127,680	120,690	117,936	109,164	103,706
Unit cost	$0.31	$0.37	$0.42	$0.54	$0.68
RF	.001	.006	.016	.027	.031
RCE	$310	$62	$26	**$20**	$22

Enhancement Cost Efficiency

- **RELATIVE COST TO ENHANCE (RCE)**
  - **C.E. = PRODUCTION COST / NO. CAPTURED**

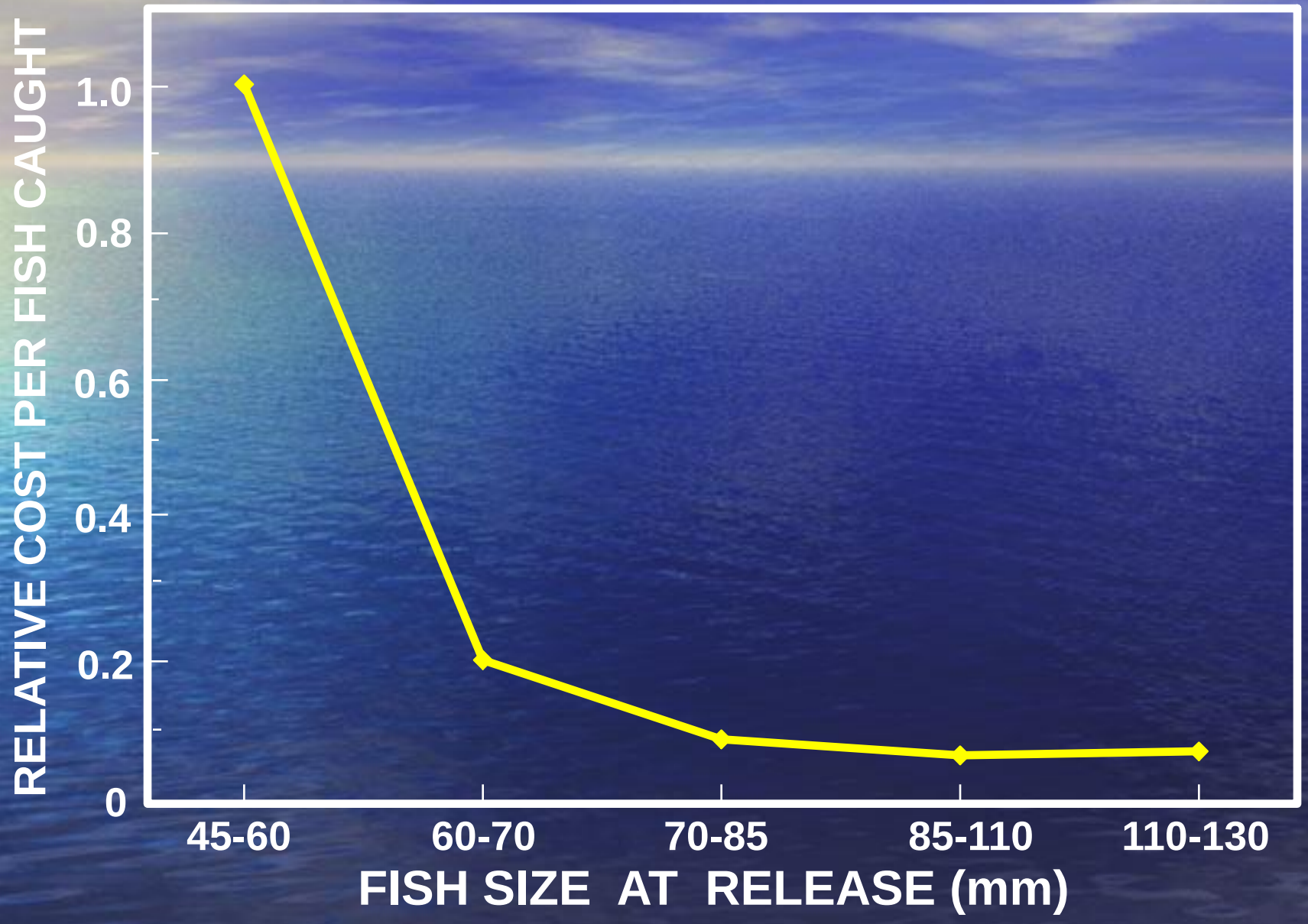
$$= \frac{\text{NO. PRODUCED X UNIT COST}}{\text{NO. STOCKED X RECAP. FREQ}}$$

$$\text{RCE} = \frac{\text{UNIT COST}}{\text{RECAP. FREQ}}$$

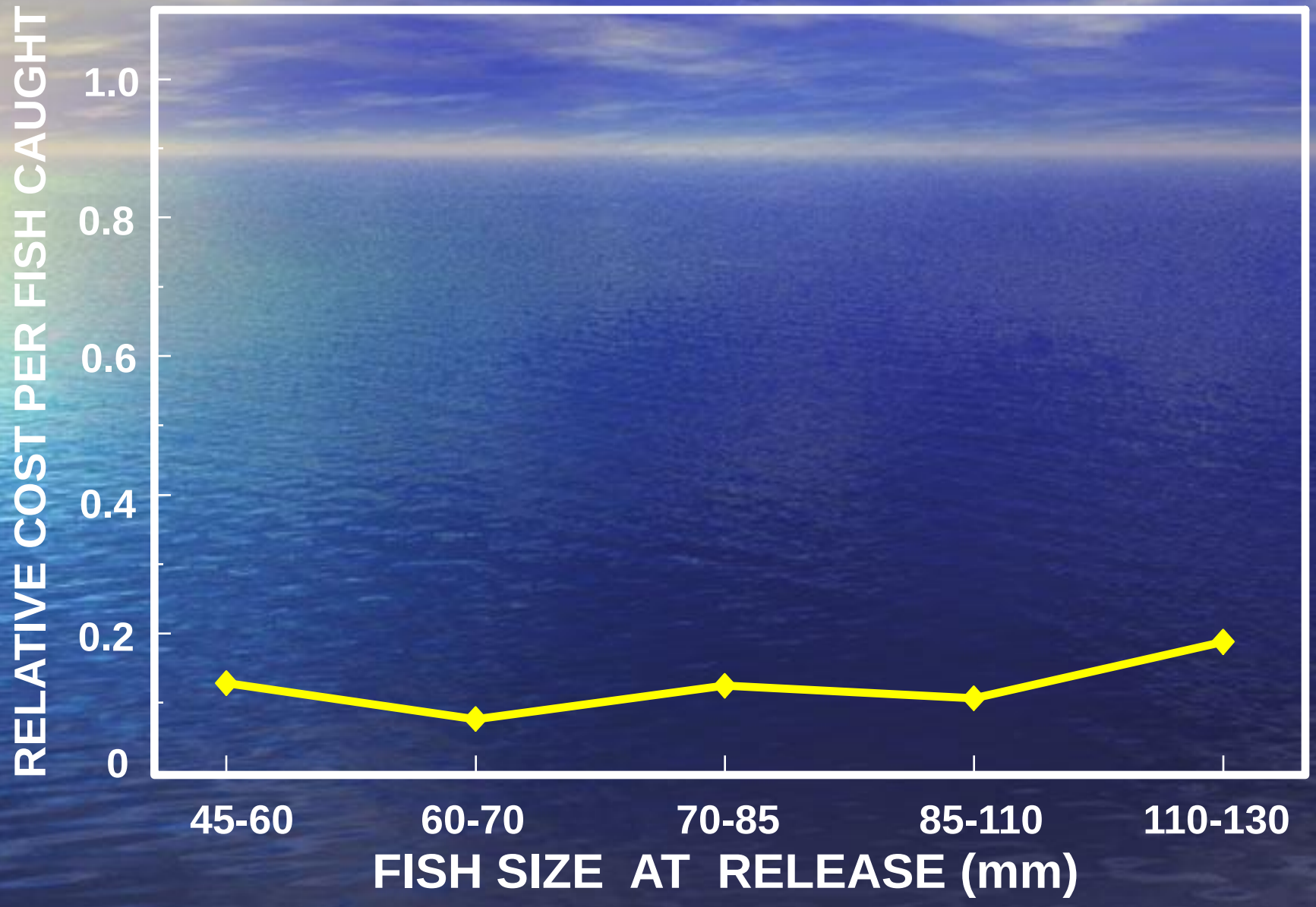
- **Choose release tactic that minimizes CE**

Leber, Cantrell and Leung. 2005. Optimizing cost effectiveness of size-at-release in stock enhancement programs. N. Am. J. Fish. Mgmt. 25:1596-1608

RELATIVE COST (SUMMER RELEASES)

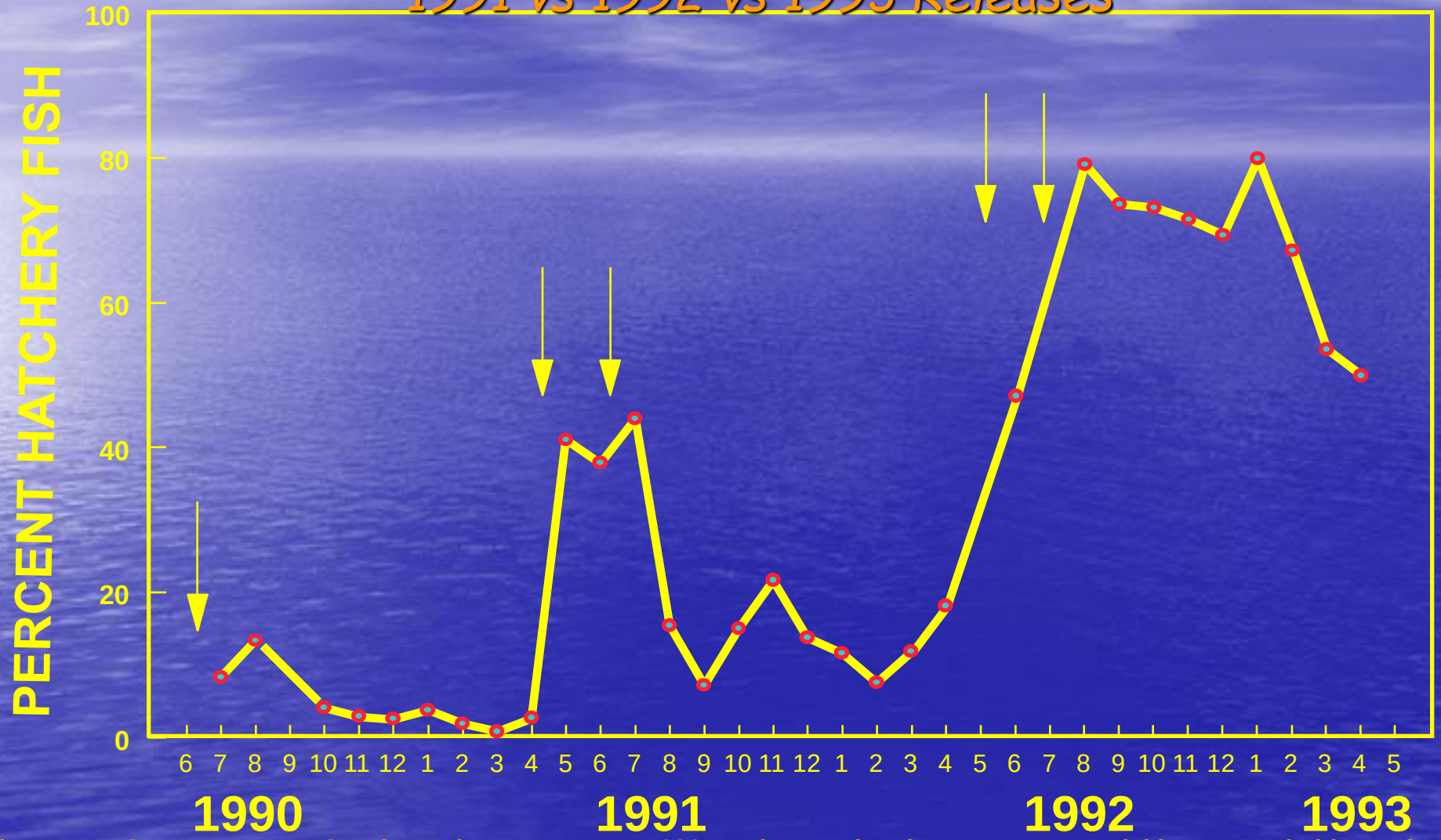


RELATIVE COST (SPRING RELEASES)



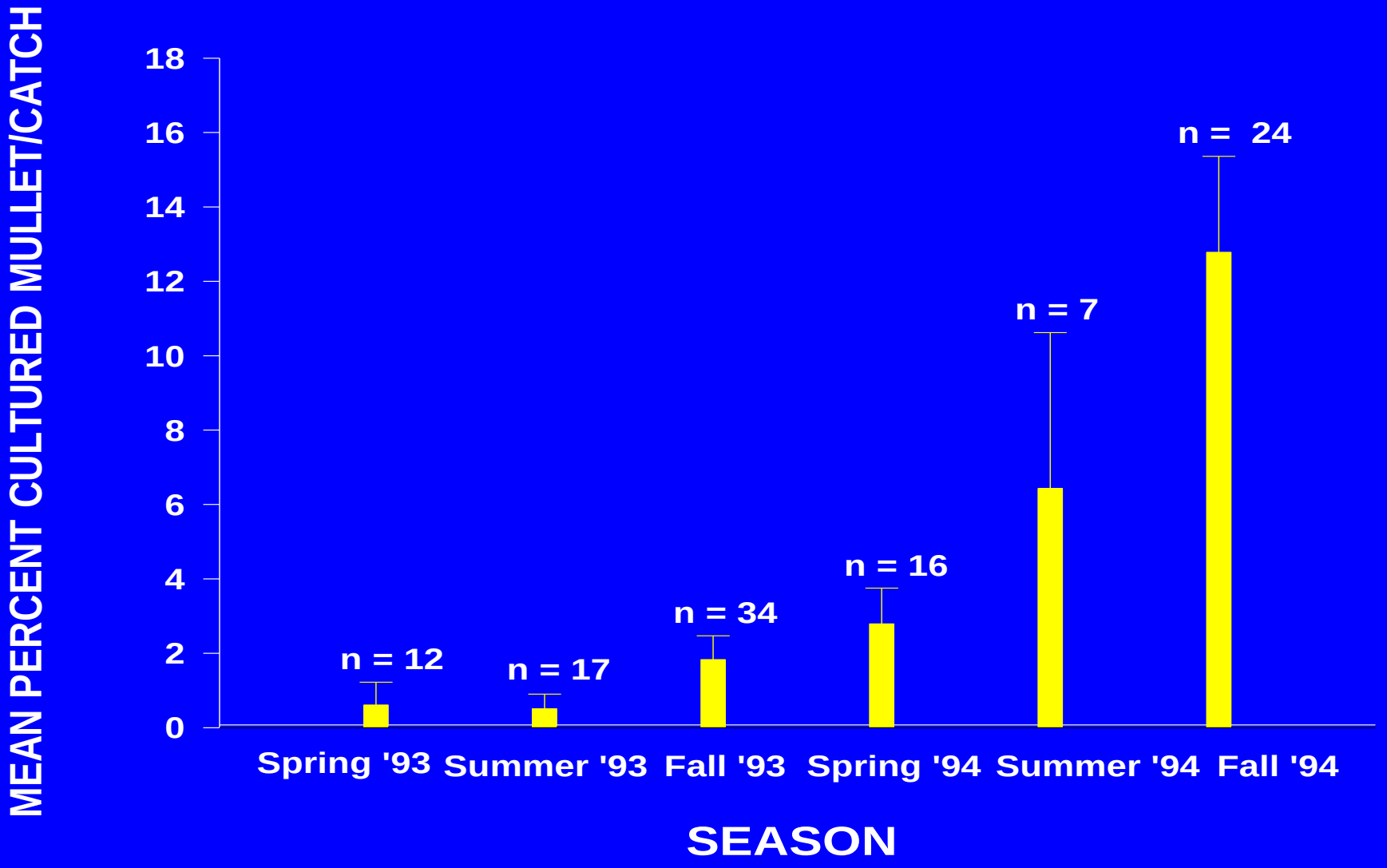
CONTRIBUTION RATE

1991 vs 1992 vs 1993 Releases



Leber, K. M., S. M. Arce, D. A. Sterritt, and N. P. Brennan. 1996. Marine stock-enhancement potential in nursery habitats of striped mullet, *Mugil cephalus*, in Hawaii. Fishery Bulletin 94(3):452-471.

PERCENT CONTRIBUTION OF CULTURED STRIPED MULLET TO KANEOHE BAY COMMERCIAL FISHERY



Leber, K.M and S.M. Arce. 1996. Stock enhancement in a commercial mullet, *Mugil cephalus L., fishery in Hawaii.* Fisheries Management and Ecology 3:261-278.

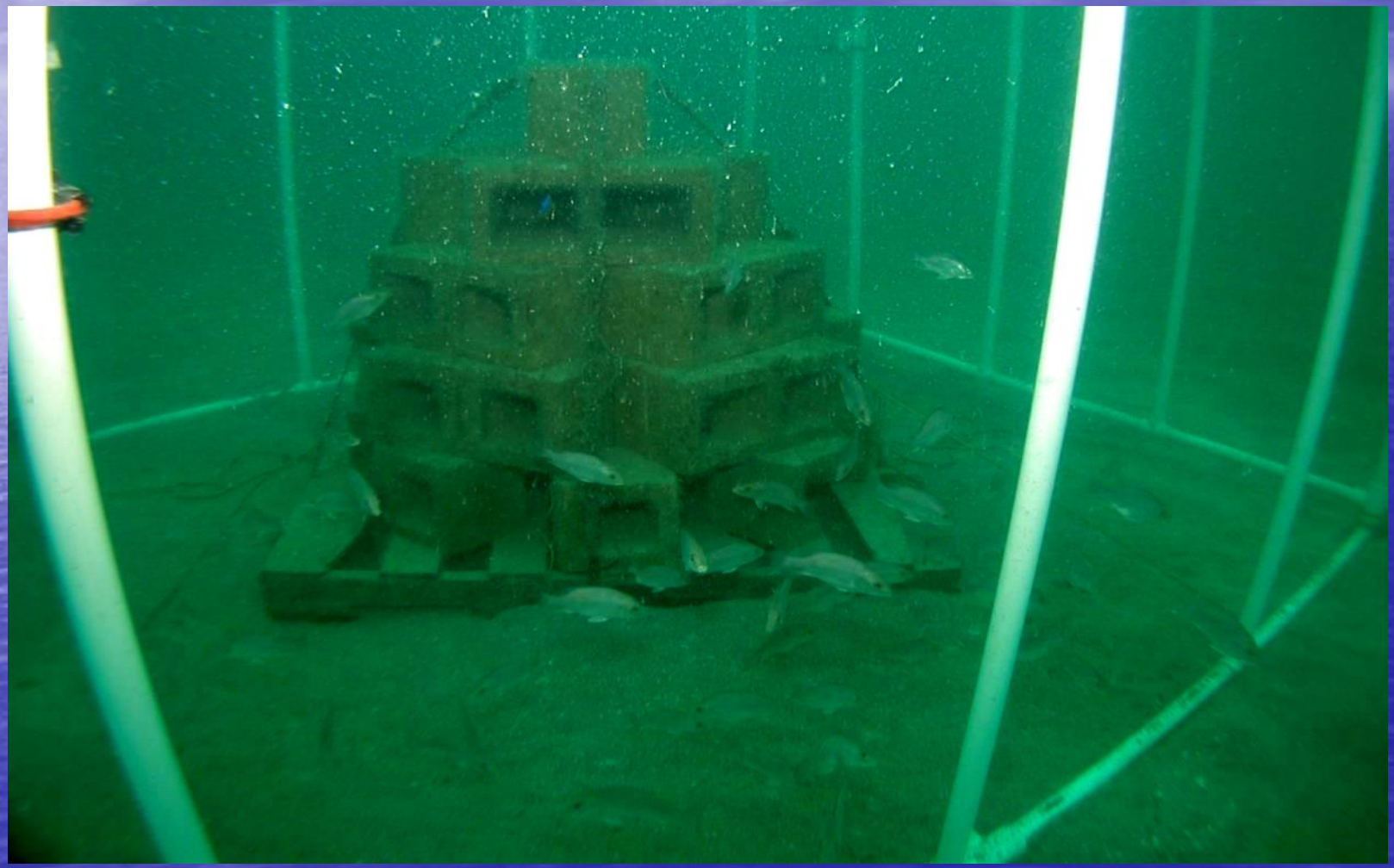
Assessment of Release Strategies

~ Acclimation ~

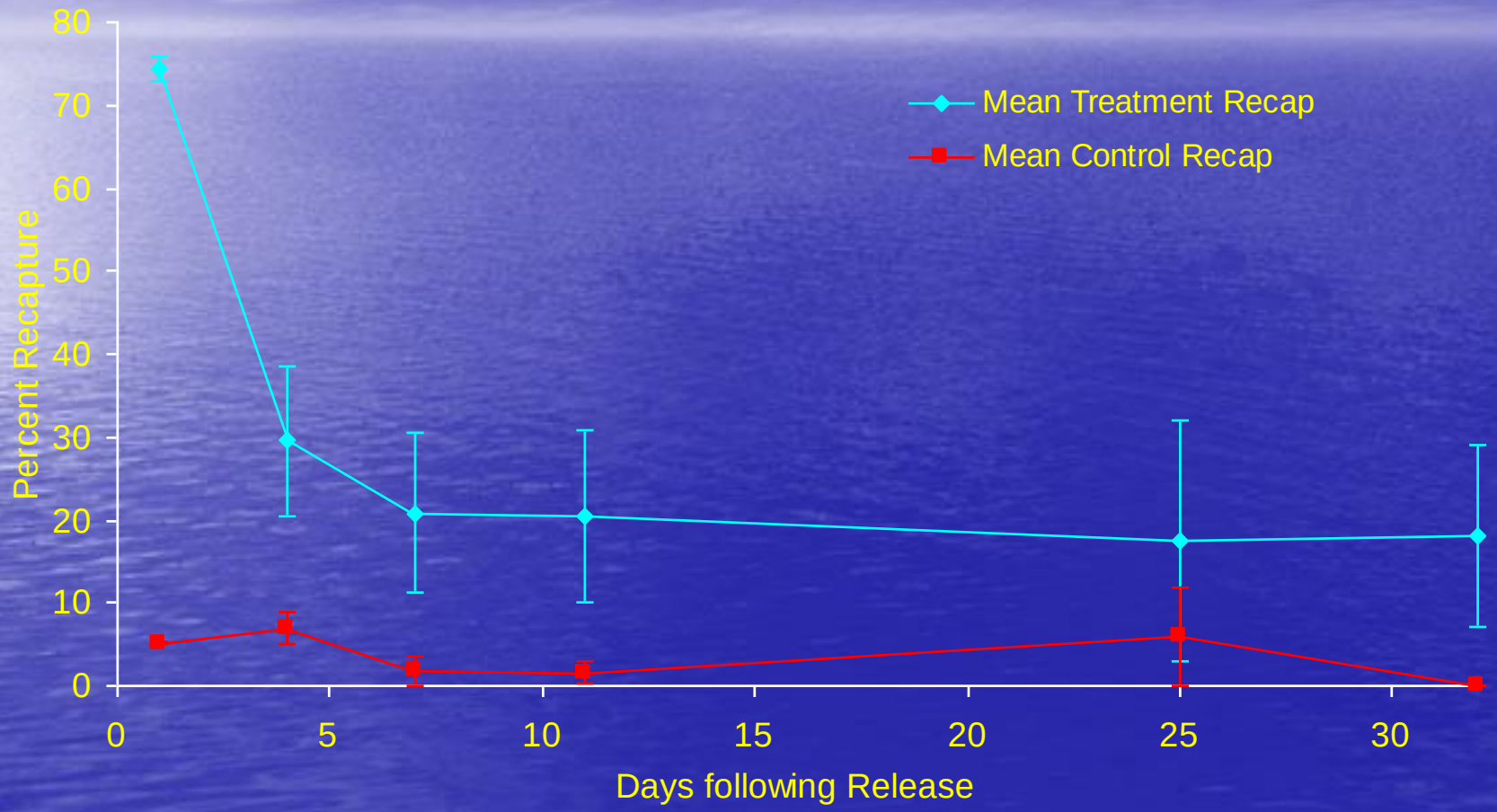

Reef Unit (no acclimation)

Reef Unit Within Acclimation Cage

Caged on Reefs Used for 3 days, Removed to Release Acclimated Fish



Red Snapper Recapture Rates , Fall 2002
Post Release Results of Acclimating for 3 Days

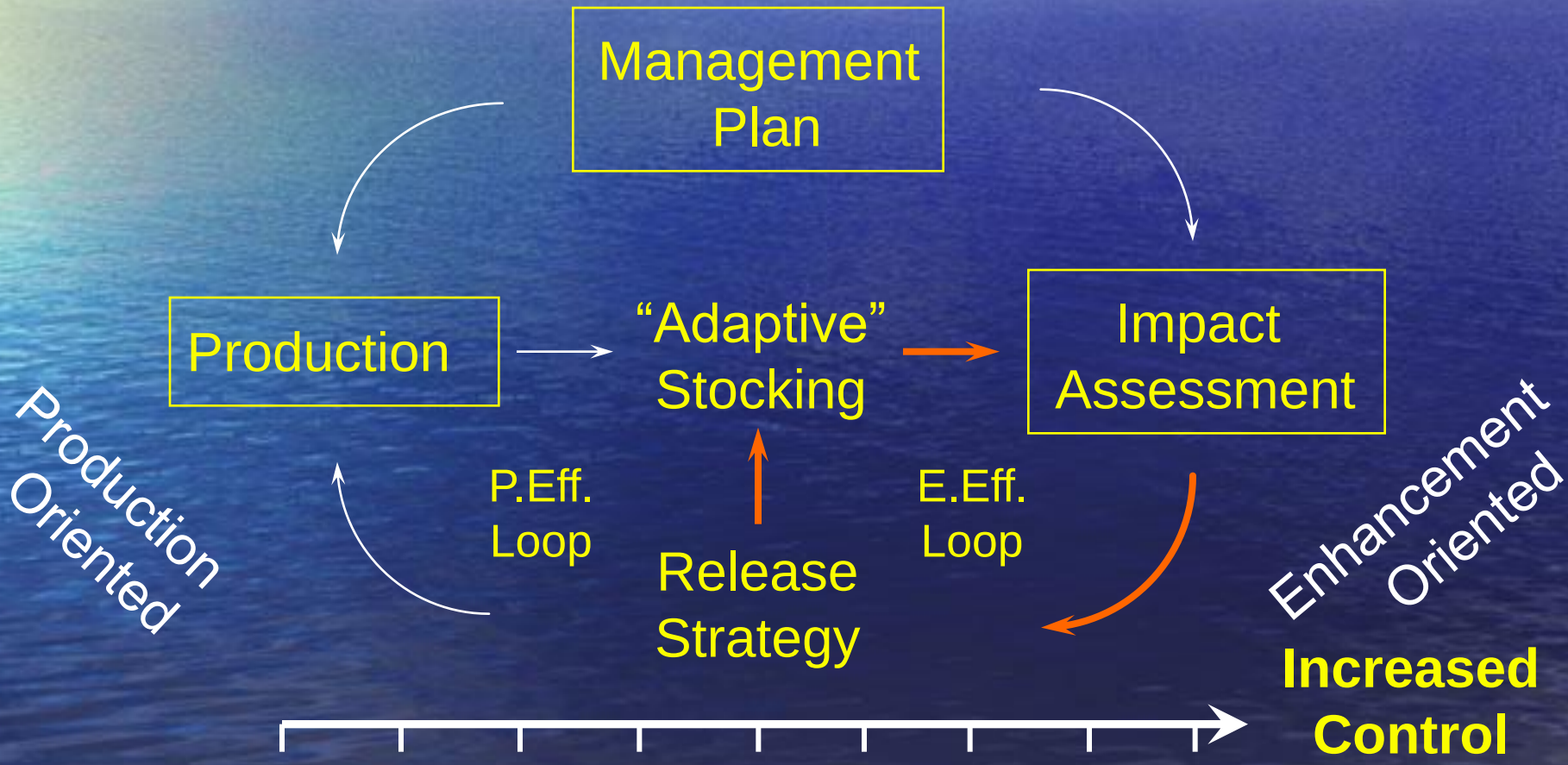


Small-scale stocking actually contributing to Sarasota Bay snook fishery

Adaptive Management is Crucial

Adaptive Stocking Fuels Efficiency & Impact

Taking inventory is fundamental to wise managment



(Leber, 2002. Advances in Marine SE: Shifting Emphasis to Theory & Accountability. *In* Stickney & McVey)

95 Fisheries Enhancement Publications

SCORE Scientist's Publications

Indicates Score Project

Publications on Stock-Enhancement by SCORE Scientists

Responsible approach to stock enhancement

NEW! Leber, K.M. 2012. Marine fisheries enhancement: Coming of age in the new millennium. In: R. A. Meyers (ed), *Encyclopedia of Sustainability Science and Technology*. Springer Science. 20 pages. (Pre-Print / Corrected Proof) >>read now...

Lorenzen, K., K. M. Leber and H. L. Blankenship. 2010. Responsible approach to marine stock enhancement: An update. Reviews in Fisheries Science 18(2):189-210. >>read now...

Blankenship, H. L. and K. M. Leber. 1995. A responsible approach to marine stock enhancement. In Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15:165-175. >>read now...

Bell, J.D., D.M. Bartley, K. Lorenzen and N.R. Loneragan. 2006. Restocking and stock enhancement of coastal fisheries: Potential, problems and progress. Fisheries Research. 80: 1-8. >>read now...

Bell, J.D., K.M. Leber, H.L. Blankenship, N.R. Loneragan and R. Masuda. 2008. A new era for restocking, stock enhancement and sea ranching of coastal fisheries resources. Reviews in Fisheries Science 16: 1-8. >>read now...

Lorenzen, K. 2008. Understanding and managing enhancement fisheries systems. Reviews in Fisheries Science 16: 10-23. >>read now...

Stock enhancement books and symposium proceedings

Johann D. Bell, Kenneth M. Leber, H. Lee Blankenship, Neil R. Loneragan, Reiji Masuda and Geraldine Vander Haegen (Editors). 2008. A New Era for Restocking, Stock Enhancement and Sea Ranching of Coastal Fisheries Resources. (Proceedings of the 3rd International Symposium on Stock Enhancement and Sea Ranching) Reviews in Fisheries Science, Volume 16 Issue 1-3. View on-line abstracts...

Leber, K. M., S. Kitada, H.L. Blankenship and T. Svåsand. 2004. Stock Enhancement and Sea Ranching: Developments, Pitfalls and Opportunities. 2nd Edition. Blackwell Publishing, Oxford. 562 pp. Preview at Blackwell's web site for the book

Bartley, D.M. and K.M. Leber, Editors. 2004. Case Studies of the Effectiveness of Stocking Aquacultured Fishes and Invertebrates to Replenish and Enhance Coastal Fisheries. Fishery Technical Paper No. 429. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 213 pp. View electronic version...

Nakamura, Y., J.P. McVey, K. Leber, C. Neidig, S. Fox, and K. Churchill, (eds.). 2003. Ecology of Aquaculture Species and Enhancement of Stocks. Proceedings of the Thirtieth U.S. - Japan Meeting on Aquaculture. Sarasota, Florida, 3-4 December. UJNR Technical Report No. 30. Sarasota, FL: Mote Marine Laboratory. >>read now...

Population Dynamics and Quantitative Assessment

Hervas, S. K., S. K. Lorenzen, M. A. Shane, and M. A. Drawbridge. 2010. Quantitative