



# Perspectives on 'A Responsible Approach to Marine Stock Enhancement: An Update'

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Shanghai Ocean University, April 2011



# *As seafood demand outpaces supply, how will we sustain fisheries?*

## Fishery Management 101: fishery yields

- ***Harvest Management:*** control fishing catch & effort – area closures, seasonal closures, size and catch limitations, number of angler licenses, provide incentives (catch shares)
- ***Habitat Management:*** We can identify, protect and restore essential habitat
  - EFH; MPAs [Marine Spatial Planning]
- ***Stock Enhancement:*** Fishery managers can also increase the number of new young fish (recruits) by stocking hatchery-reared fish



# Coupling Fisheries Management and Aquaculture

- Marine fisheries enhancement – is a set of management approaches involving release of cultured organisms to enhance/restore ‘fisheries’
  - *Stock Enhancement*: release of cultured organisms into wild populations to increase the natural supply of juveniles
  - *Restocking*: release of cultured organisms into wild populations to restore severely depleted spawning biomass to a self-sustaining level
  - *Sea Ranching*: release of cultured juveniles into the ocean for harvest at a larger size (put-grow-take)

# *Putting Theory to Practice*

- The Promise
- The Deficit
- Constraints to progress
- Enlightenment and Policy Change
- Careful Approach for Putting Theory to Practice



# *The Promise*

- Stocking cultured fishes into the sea could restore abundance lost from overfishing is a popular idea that dates back at least to the 19<sup>th</sup> century, when millions of marine fish eggs and yolk-sac larvae were released per year.
- The expectation has been that stocking would increase yields in fisheries, aid in restoring depleted, threatened and endangered species, and provide partial mitigation for habitat loss.

# *The Deficit*

- Although stocking made sense as an early fishery management policy, 80 years of stocking produced no evidence that fish stocks had been increased.
- After nearly a century of stocking fish as the principal way to maintain fisheries, agencies began to close marine hatcheries in the 1950's and use harvest management (control of catch and fishing effort) and dismissed stocking.



# *Constraints to Progress*

- During that early period of stocking, marine aquaculture provided only the ability to produce eggs and very young larvae – extremely vulnerable ages to stock.
- And prior to the 1970's no method existed for identifying released hatchery organisms – there was no marking or tagging technology that was sufficient for the small sizes released.

# *Fisheries Enhancement Lacked the Science Needed to Use it Effectively*

And Has All the Symptoms of a New Science:

- No Agreed Upon Terminology
- No Textbooks on Stock Enhancement
- Enhancement Paradigm Only Recently Emerged – e.g. Hilborn; Walters; Lorenzen
- Scientific Method was Essentially Lacking in All Investigations Until 1970's (salmon)
- Nothing Published on “Effectiveness” of Stocking Marine Organisms, Until 1989



# *Enlightenment and Policy Change*

- After two generations of fishery scientists in the USA had rejected stock enhancement, some began to notice a logarithmic increase in stocking literature in scientific journals over the past 2 decades
- New interest in the potential of using stock enhancement, restocking and sea ranching has emerged, following a few “success stories” – leading to a policy shift towards an ‘increase’ in funding for stocking and research to evaluate it.

# Historical Background: Evaluation of Marine Stock Enhancement

- Early Constraints to Successful Enhancement
  - Aquaculture constraints
  - Assessment constraints

1880's – 1980's
- Pioneering Work to Quantify Stocking Effects
  - Svåsand, Jørstad, Kristiansen and colleagues in Norway
  - Tsukamoto; Kitada; Tanaka; Yamashita; colleagues in Japan
  - Bannister and colleagues in the UK
  - Støttrup and colleagues in Denmark
  - Bell in Solomon Islands
  - Stoner; Willis; Smith; Kent; Blankenship & colleagues in US
  - Rimmer, Russell and colleagues in Australia

1990's
- Recent Approach
  - Improved Experimental Design
  - Comprehensive Assessment Efforts

2000's



# ***“A Responsible Approach to Marine Stock Enhancement” \****

*(Spawned by Lee Blankenship, Devin Bartley, Don Kent, Ken Leber, Stan Moberly, Terje Svåsand, Katsumi Tsukamoto [and Rich Lincoln])*

- **Stay Within Context of Fisheries Management Plan:**
  - 1. Prioritize Species for Enhancement
  - 2. Make Stocking Plan that Fits with and 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. Am. Fish. Soc. Symposium 15:67-175)

PDF is online at [www.StockEnhancement.org/science/publications.html](http://www.StockEnhancement.org/science/publications.html)

# **Fisheries Science, Management, and Enhancement Have Developed Rapidly**

- ✱ **With a significant drive towards fully integrating enhancements into fishery management frameworks & decisions**
- ✱ **Many other enhancement aspects have seen substantial incremental development**
- ✱ **Now necessary to revise the 'responsible approach' to account for the paradigm shift towards managing enhancements from a fishery management perspective.**
- ✱ **The developments also provide the tools for implementing the shift**



# Updated “Responsible Approach to Marine Stock Enhancement” \*

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## Responsible Approach to Marine Stock Enhancement: An Update

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*Marine stock enhancement is a set of management approaches involving the release of cultured organisms to enhance or restore fisheries. Such practices, including sea ranching, stock enhancement, and restocking, are widespread, of variable success, and often controversial. A set of principles aimed at promoting responsible development of restocking, stock enhancement, and sea ranching has been proposed by Blankenship and Leber [American Fisheries Society Symposia 15: 167–175 (1995)], and has gained widespread acceptance as the ‘Responsible Approach’. Fisheries science and management, in general, and many aspects of fisheries enhancement have developed rapidly since the responsible approach was first formulated. Here we provide an update to the Responsible Approach in light of these developments. The updated approach emphasizes the need for taking a broad and integrated view of the role of enhancements within fisheries management systems; using a stakeholder participatory and scientifically informed, accountable planning process; and assessing the potential contribution of enhancement and alternative or additional measures to fisheries management goals early on in the development or reform process. Progress in fisheries assessment methods applicable to enhancements and in fisheries governance provides the means for practical implementation of the updated approach.*

(Lorenzen, Leber, and Blankenship. 2010. Rev. Fish. Sci. 18(2):189-210)

# Most Enhancements are Weak in 4 Areas

- ✱ Fishery stock assessments & modeling are integral to exploring the potential of stocking, yet both are found lacking in most stock enhancement efforts
- ✱ Establishing an institutional framework for enhancements is largely ignored
- ✱ Involvement of stakeholders in planning and execution of stocking programs is key from the start, but is rarely an integral part
- ✱ Adaptive management is not well integrated into enhancement plans



# Updated “Responsible Approach to Marine Stock Enhancement”

## Stage 1: Initial Appraisal & Goal Setting

1. Understand the role of enhancement within the fishery system
2. Engage stakeholders & develop a rigorous & accountable decision-making process
3. Quantitatively assess contributions of enhancement to fisheries management goals / compare with harvest & habitat management
4. Prioritize and select target species and stocks for enhancement
5. Assess economic and social benefits and costs of enhancement

## Stage 2: Research & Technology Development & Pilot Studies

6. Define enhancement system designs suitable for the fishery and management objectives
7. Develop appropriate aquaculture systems and rearing practices
8. Use genetic resource management to avoid deleterious genetic effects
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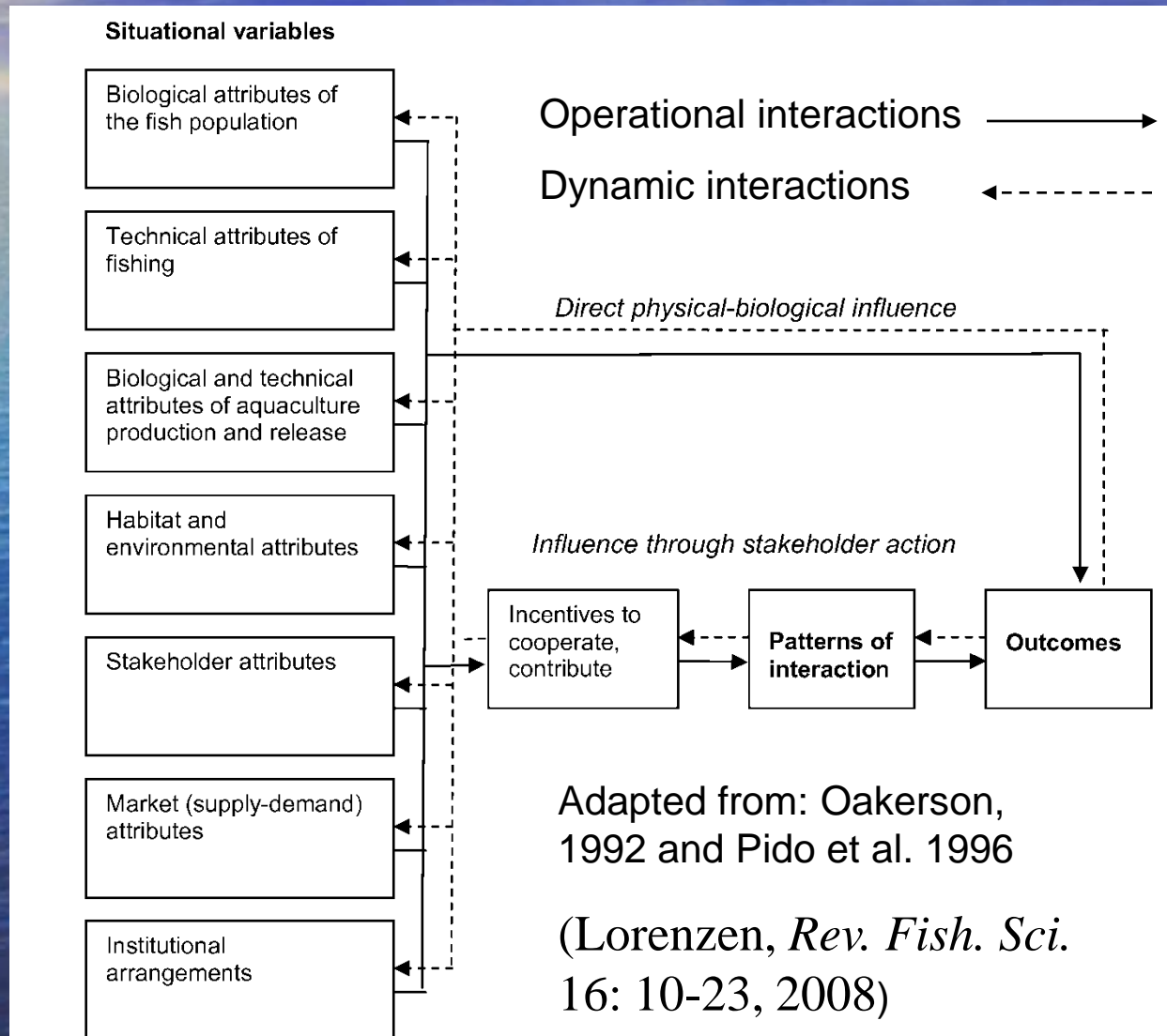
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# Human-Biological Interactions: *Institutional Analysis and Design*: the key is to provide incentives to individuals to cooperate & contribute positively to the outcomes



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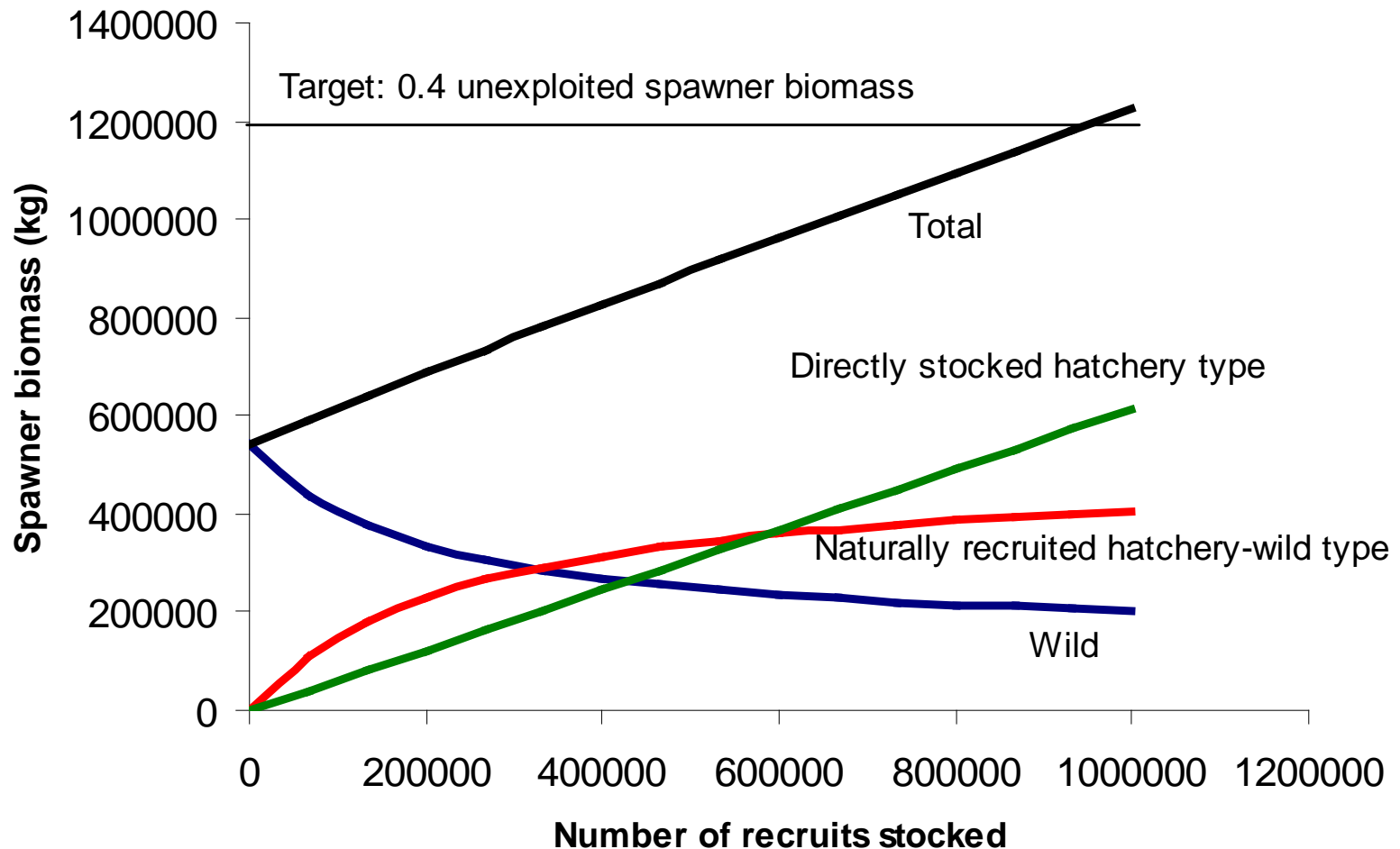
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# Effect of Enhancements, harvest and habitat management should be modeled, a priori, and integrated into the decision making process



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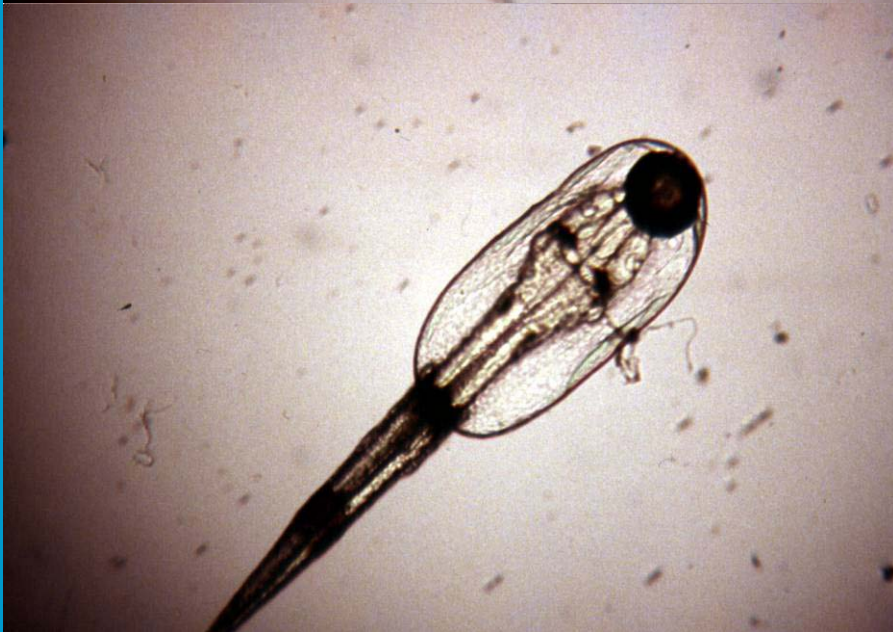
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# System Design affects production efficiency & fitness of released fish

- Sourcing of broodstock
- Production of 'wild-like types'
- Minimize domestication





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# Genetic Management Is Essential

The background of the slide is a photograph of several fish, likely sea bass, swimming in clear, turquoise water. The fish are positioned at various depths and angles, creating a sense of movement. One fish is prominent in the upper left, another in the center, and a third in the lower right. The lighting is bright, highlighting the scales and fins of the fish.

- Avoid transfer of exogenous alleles
- Avoid change in gene frequencies
- Avoid inbreeding and outbreeding depression



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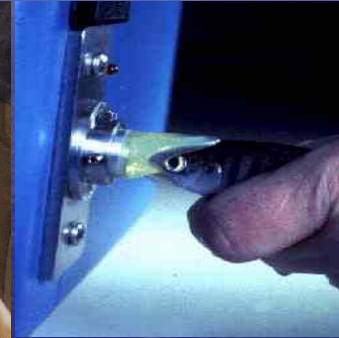
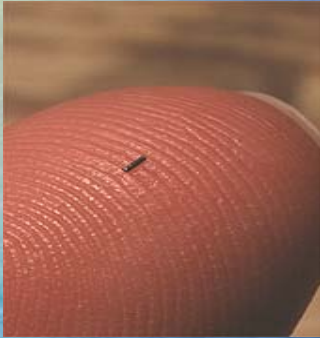
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*Virtually all aspects of enhancement research and management require the ability to identify released fish*





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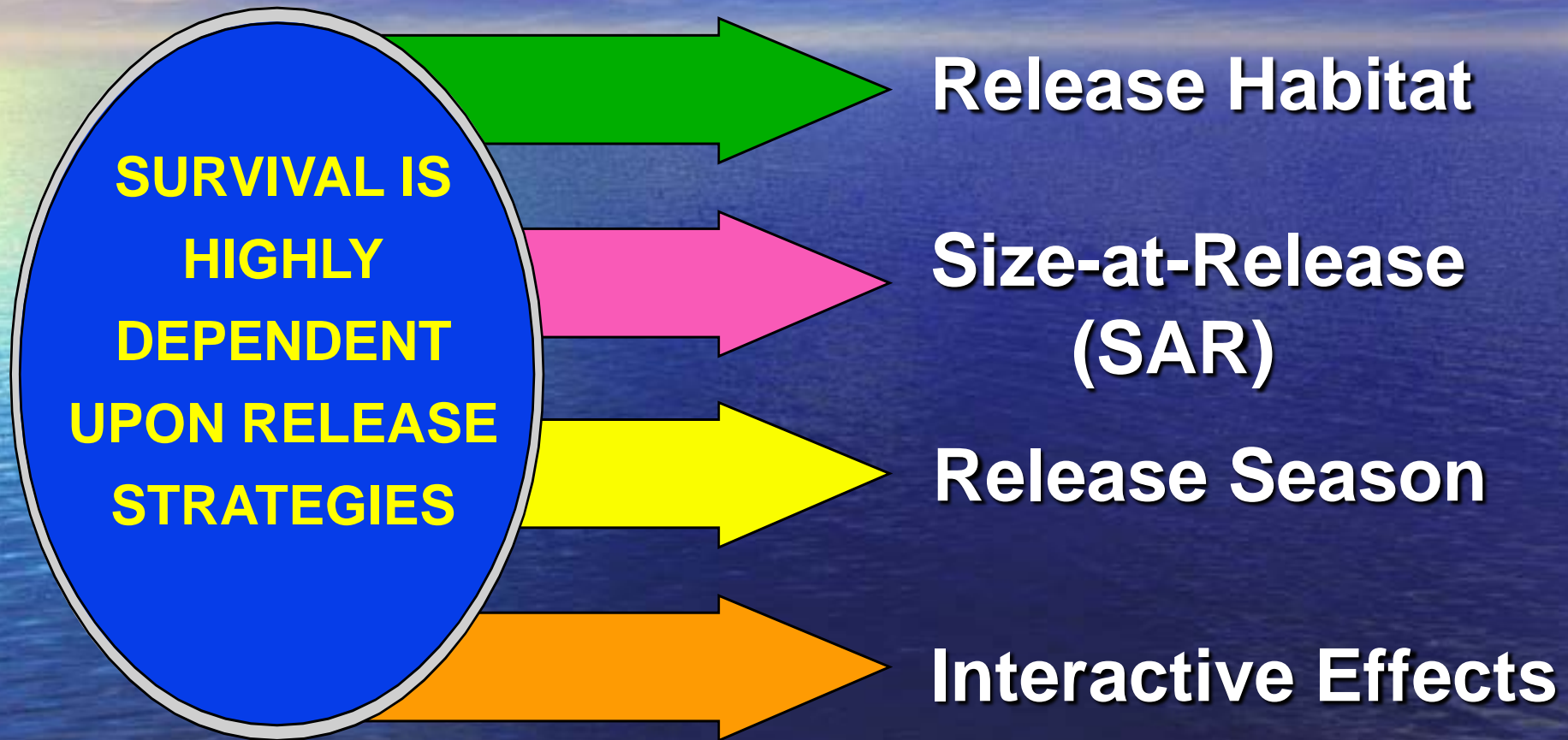
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# *Results of Pilot Studies to Optimize Release Protocol*



# *Release Variables: Critical Uncertainties*

- Critical Choices Managers of Hatchery Releases Need to Make

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

*Optimize Release Strategies*

*To Maximize Survival*



# Release Design

## Day 1: Stocked Acclimation pens



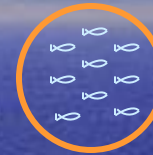
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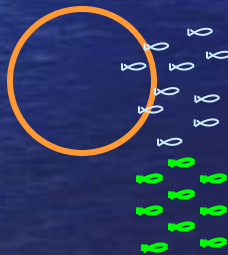


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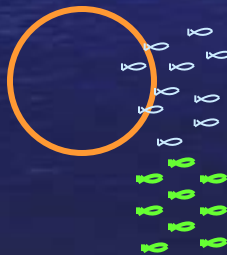
## Day 3: Released snook from acclimation pens & also Stocked non-acclimated snook



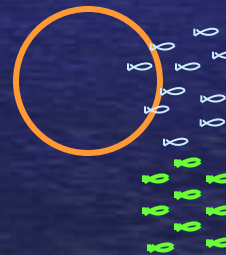
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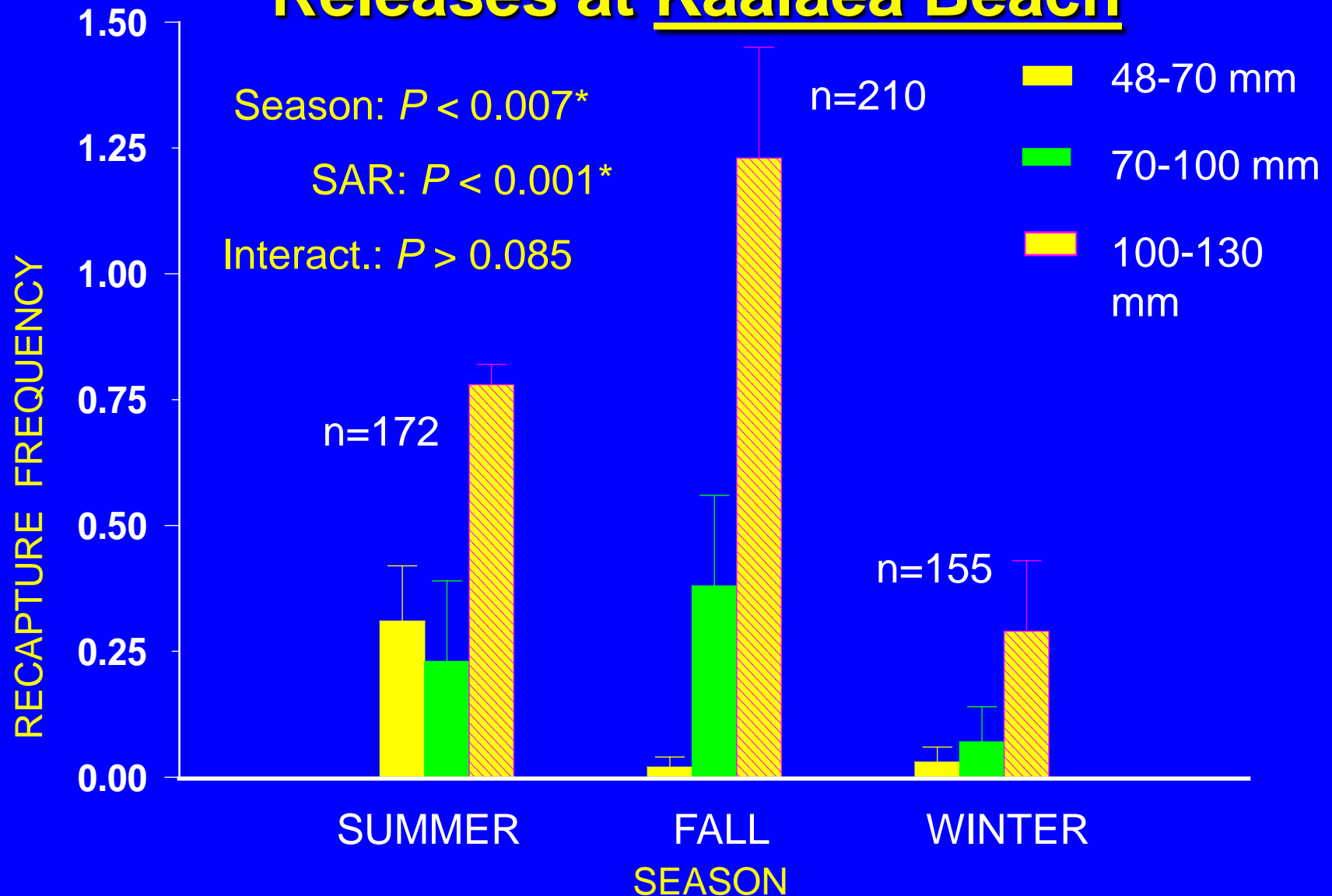
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Replicated this experiment 3 times

(Brennan, Darcy and Leber, 2006. J. Exp. Mar. Biol. Ecol. 16(1):1-9)

# Pacific Threadfin in Hawaii

## Releases at Kaalaea Beach

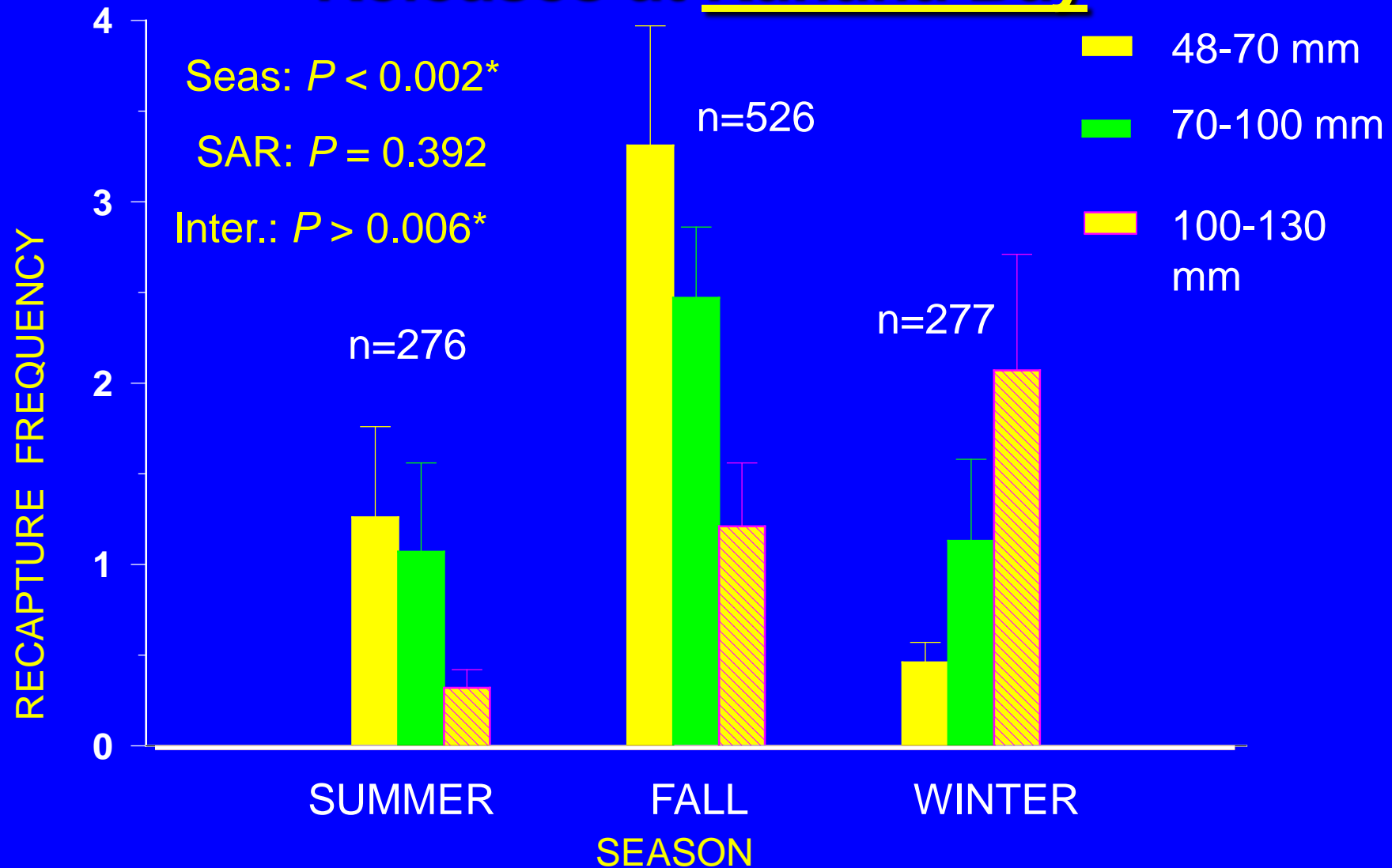


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...and assess enhancement  
Effectiveness





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Requires  
evaluation of  
hatchery-wild  
interactions...



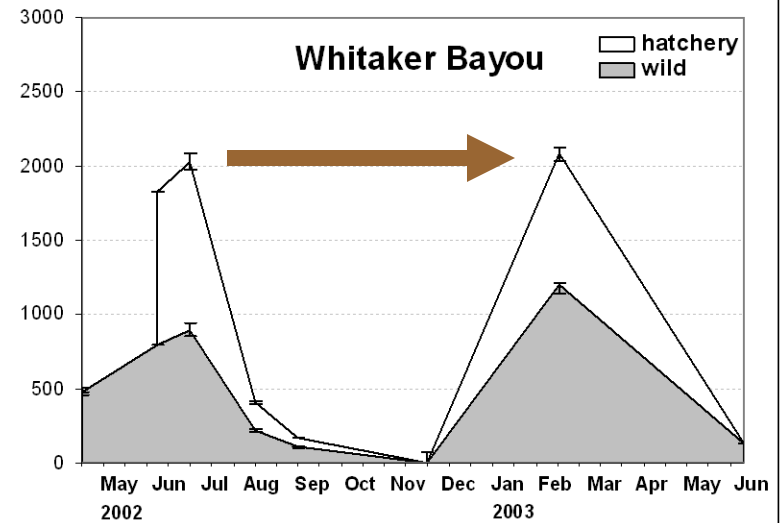
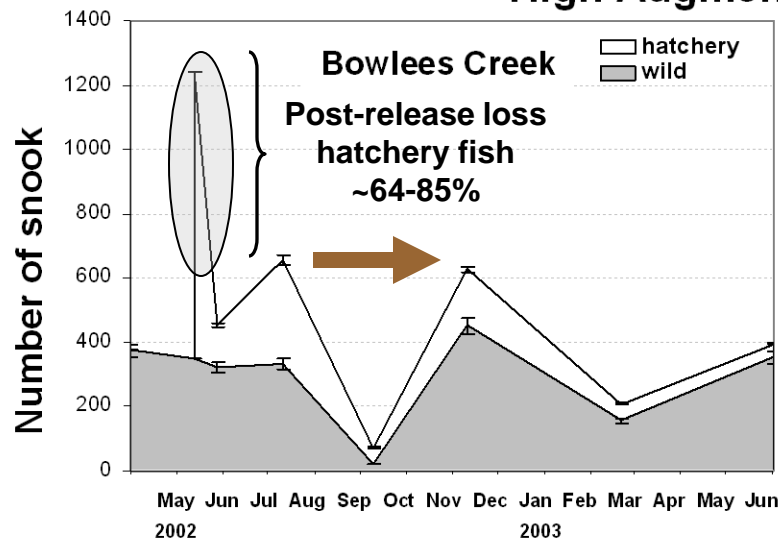
...at all three  
stages of  
developing  
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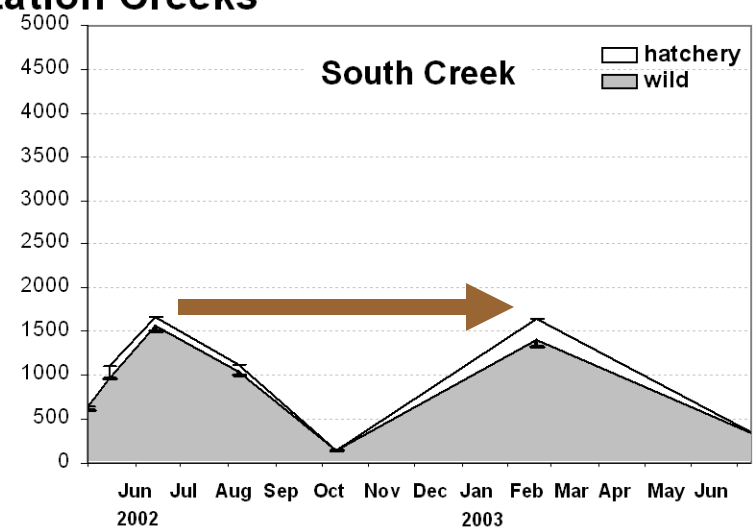
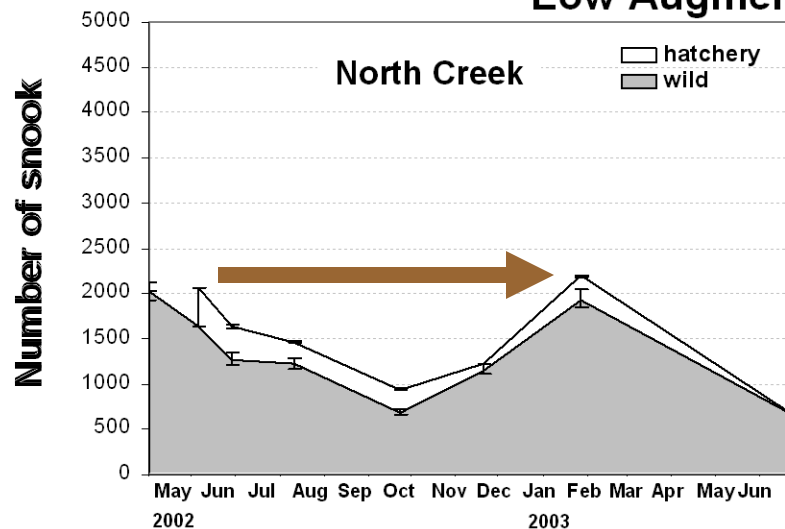


## High Augmentation Creeks

3<sup>rd</sup> ISSESR



## Low Augmentation Creeks



(Brennan, N.P., C.J. Walters and K.M. Leber. 1998. Rev. Fish. Sci. 16(1-3):228-241)

# Updated “Responsible Approach to Marine Stock Enhancement”

## Stage 1: Initial Appraisal & Goal Setting

1. Understand the role of enhancement within the fishery system
2. Engage stakeholders & develop a rigorous & accountable decision-making process
3. Quantitatively assess contributions of enhancement to fisheries management goals / compare with harvest & habitat management
4. Prioritize and select target species and stocks for enhancement
5. Assess economic and social benefits and costs of enhancement

## Stage 2: Research & Technology Development & Pilot Studies

6. Define enhancement system designs suitable for the fishery and management objectives
7. Develop appropriate aquaculture systems and rearing practices
8. Use genetic resource management to avoid deleterious genetic effects
9. Use disease and health management
10. Ensure that released hatchery fish can be identified
11. Use an empirical process for defining optimal release strategies

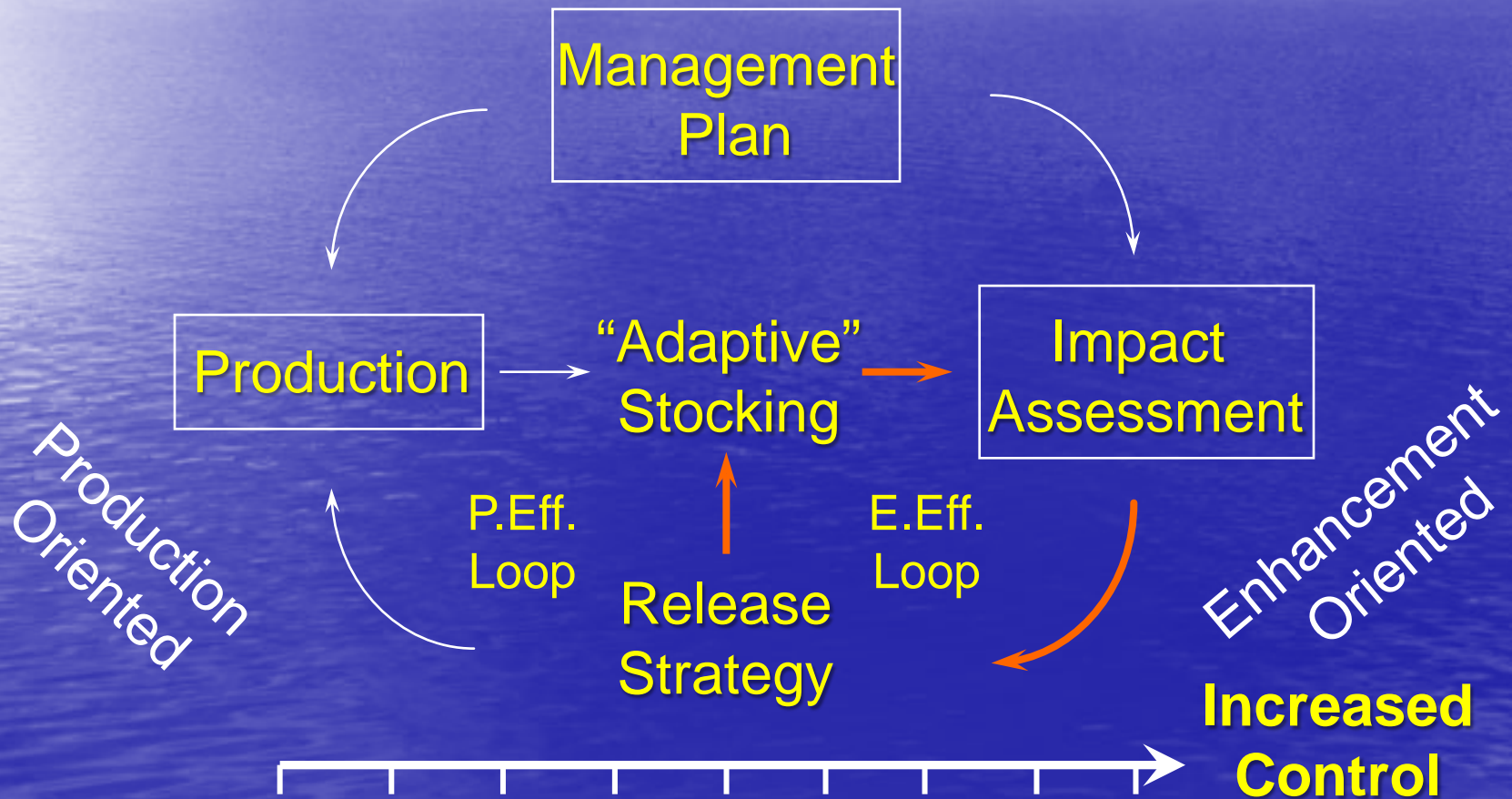
## Stage 3: Operational Implementation & Adaptive Management

12. Devise effective governance arrangements
13. Define a fisheries management plan with clear goals, measures of success and decision rules
14. Assess and manage ecological impacts
15. **Use adaptive management**



# *Adaptive Management is Crucial*

## Recognized “Production - Enhancement” Management Dichotomy



# Summary

- ✱ We have provided a set of issues that need to be addressed if enhancements are to be developed or reformed responsibly
- ✱ The new responsible approach differs from its predecessor in that it takes a broad systems view of enhancements and accords equal weight to the dynamics of their biological and human components
- ✱ It requires an integrated, quantitative and participatory analysis of the contribution enhancement could make to fishery management goals, which should be conducted at the very beginning of any enhancement initiative