The Paradigm Shift in Coastal and Offshore Marine Stock Enhancement & Proliferation of a Responsible Approach



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Research Using Aquacultured Marine Fishes & Invertebrates

- To investigate effectiveness of stocking estuaries & offshore environments to help recover recruitment-limited populations
- To test ecological hypotheses about population and community dynamics
 - Habitat-mediated growth & survival
 - Habitat connectivity
 - Density-dependent mechanisms
 - Carrying capacity in nursery habitats

Marine Stock Enhancement Circa 1880's) is a "New Science"

Symptoms:

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

Now Seeing a Paradigm Shift in Marine Fisheries Enhancement

- A fundamental change moving from an aquaculture-based activity to a fishery-management based endeavor in planning and conducting stock enhancement.
- Field is now an active-adaptive management experiment (Hilborn & Walters)
- And has been reconstructed around the basic principles of a responsible approach to planning, evaluating, and using stocking.

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 I dentify 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. AFS Symposium 15:167-175)
PDF is online at www.StockEnhancement.org/science/publications.html

Environmental Impacts of Coastal Ocean Stocking: Genetic Issues

- "Type-1" * hazards: Translocation
 - Hatchery-mediated translocation of exogenous genes into native populations
 - Can break down local adaptations through introgression of maladapted genomes, affecting fitness of the wild stock
 - Type 2" * hazards: Genetic changes in the hatchery
 - Resulting from broodstock sampling, breeding, and rearing
 - Cause stochastic differences in allelic and genotypic frequencies or reduced genetic variation, domestication, inbreeding depression
- "Type-3" * hazards (Ryman/Laikre): Genetic Swamping
 - Genetic swamping of natural populations through successive enhancement efforts
 - Post stocking alterations in the native gene pool
 (*Tringali and Leber, 1999)

Responsible Action: Genetic Issues

"Type-1" hazards: Translocation:

Propagate only indigenous genotypes

Type 2" hazards: Genetic changes in the hatchery

- Use only wild-caught adults as broodstock
- Minimum no. of breeders per generation interval (GI)
- For offspring, shorten time in hatchery as much as possible
- Avoid potential sources of artificial selection as much as possible

"Type-3" hazards": Genetic Swamping

- Minimum number of "effective" hatchery breeders per GI
- Limit maximum relative contributions of hatchery releases per GI

Environmental Impacts of Coastal Ocean Stocking: Health Issues

- Disease or parasite introduction:
 - Hatchery-mediated translocation of exotic diseases into native populations
- Disease or parasite enhancement:
 - Reintroduction or elevation of ... in wild stocks
- Responsible Action:
 - "Heard management" with aquatic veterinarian
 - USDA certification process

Environmental Impacts of Coastal Ocean Stocking: Ecological Issues

Density-dependent displacement of wild stocks:

- Is there sufficient carrying capacity in juvenile habitats to support a larger population?
- Do excess hatchery fish result in competitive exclusion of wild fish?

Cannibalism of wild stocks:

- Is age-1 cannibalism of age-0 individuals significant?
- Responsible Action:
 - Field experiments designed to evaluate densitymediated survival, coupled with pre- and post-release monitoring of juvenile density (wild & cultured individs.)
 - Trophic analyses of hatchery and wild individuals

The Evidence that Documents Enhancement is Finally Being Treated Scientifically

- Hypotheses are being formed and tested
- Terminology & expectations more clarified
- Increase in number and quality of stockenhancement presentations at fisheries and aquaculture conferences
- Clear increase in peer-reviewed scientific journal publications on stocking effects and effectiveness
- Greater use of 'Responsible Approach'

Types of "Emancements"

Bell et al., 2008. Reviews in Fisheries Science)

"Restocking" - the release of cultured juveniles into wild populations to restore severely depleted spawning biomass to a level where it can once again provide regular, substantial yields (may involve releases by 'conservation hatcheries' to help restore endangered species).

"Stock Enhancement" - the release of cultured juveniles into wild populations to augment the natural supply of juveniles and optimize harvests by overcoming recruitment limitation.

"Sea Ranching" - the release of cultured juveniles into unenclosed marine and estuarine environments for harvest at a larger size in 'put, grow and take' operations.

Science Consortium for Ocean Replenishment

BULLETIN OF MARINE SCIENCE

vol. 62, no. 2, pp. 303-714 (1998).

PROCEEDINGS OF THE SYMPOSIUM MARINE STOCK ENHANCEMENT: A NEW PERSPECTIVE

THE 1996 WILLIAM R. AND LENORE MOTE INTERNATIONAL SYMPOSIUM November 20-23, 1996, held in Sarasota, Florida, USA

Critically Assessing Stock Enhancement: An Introduction to the Mote Symposium

JOSEPH TRAVIS, FELICIA COLEMAN, CHURCHILL GRIMES, DAVID CONOVER, THERESA BERT, AND MICHAEL

TRINGALI

Cod Enhancement Studies in Norway---Background and Results with Emphasis on Releases in the Period 1983--1990 TERJE SVÅSAND

Assessment of Stock Enhancement of Barramundi, *Lates calcarifer* (Bloch), in a Coastal River System in Far Northern Queensland, Australia M. A. RIMMER AND D. J. RUSSELL

Stock Enhancement in Japan: Review and Perspective REIJI MASUDA AND KATSUMI TSUKAMOTO

Survival of Stocked Red Drum in Texas

LAWRENCE W. MCEACHRON, ROBERT L. COLURA, BRITT W. BUMGUARDNER, AND ROCKY WARD

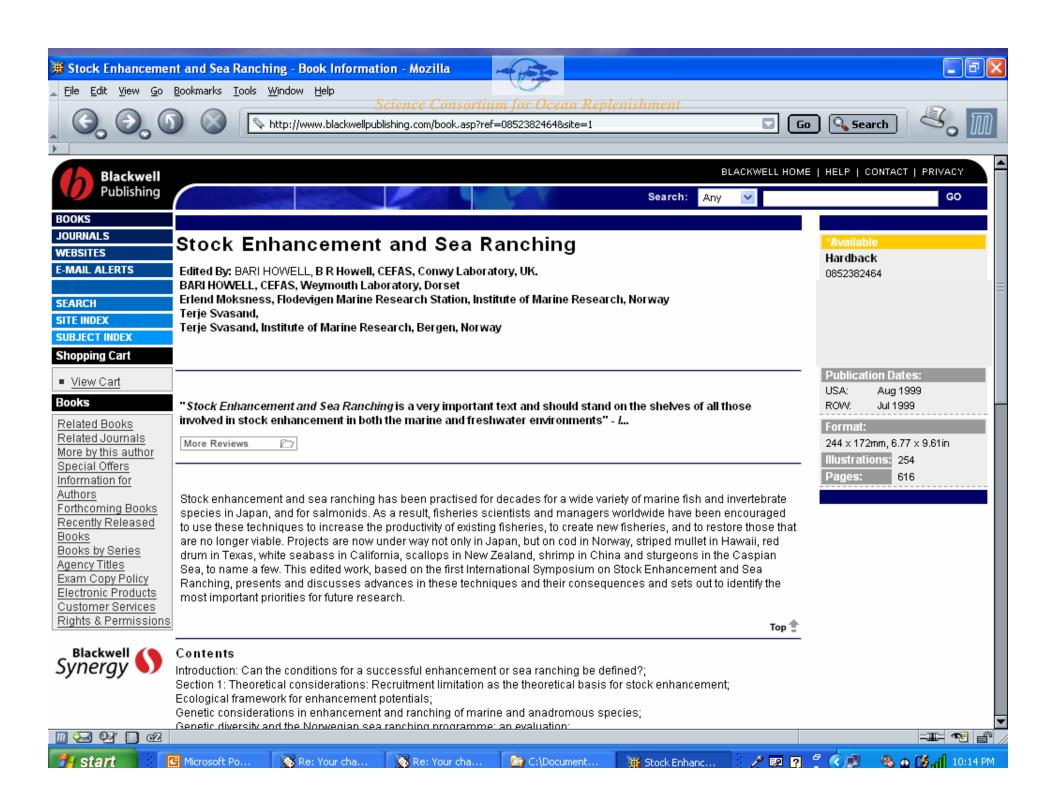
Enhancing Lobster Stocks: A Review of Recent European Methods, Results, and Future Prospects R. C. A. BANNISTER AND J. T. ADDISON

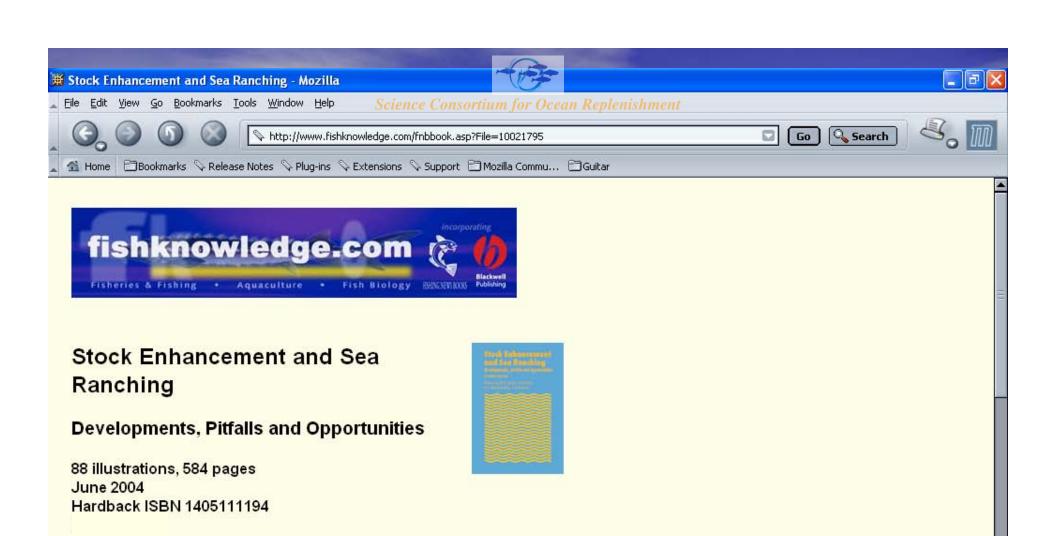
Recruitment Patterns of Cultured Juvenile Pacific Threadfin, *Polydactylus sexfilis* (<u>Polynemidae</u>), Released along Sandy Marine Shores in Hawaii
KENNETH M. LEBER, NATHAN P. BRENNAN AND STEVE M. <u>ARCE</u>

D3K



At 1"

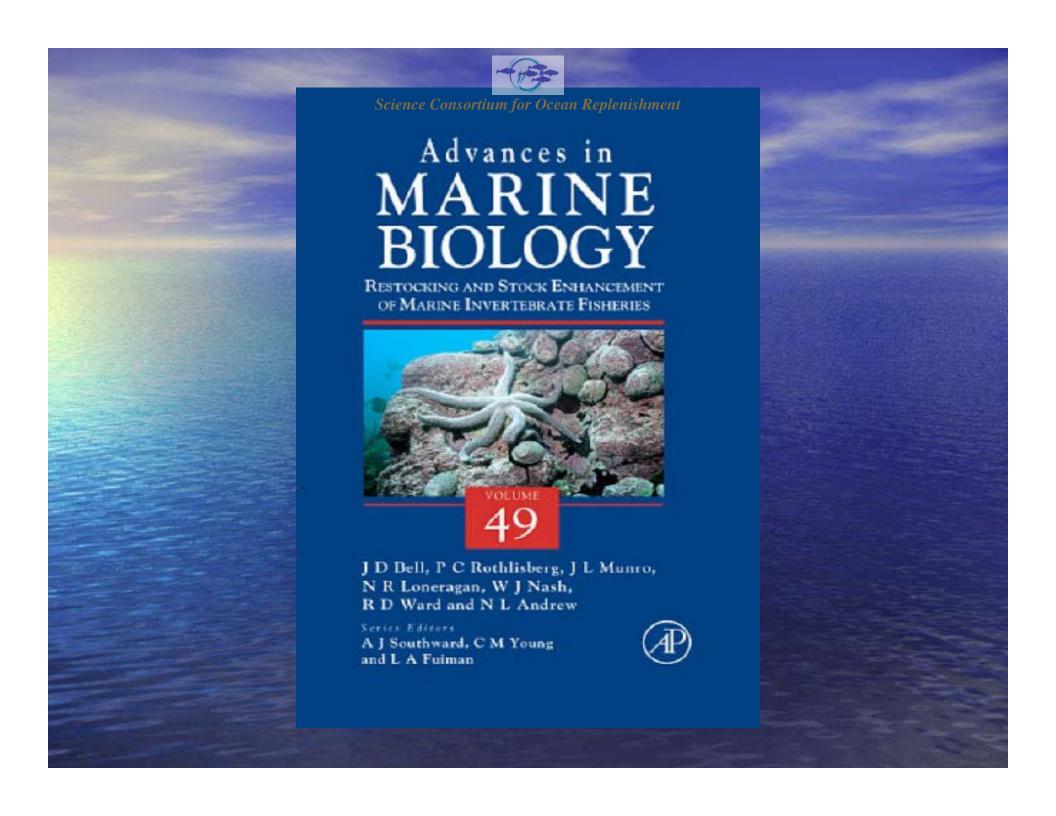




Editors: KENNETH M LEBER, SHUICHI KITADA, H.L. BLANKENSHIP, T SVÅSAND

The collapse of many of the World's fisheries continues to be of major concern and the enhancement of fish stocks through techniques such as ranching is of huge importance and interest across the globe. This important book, which contains fully peer reviewed and carefully edited papers from the 2nd International Symposium in Stock Enhancement and Sea Ranching is broadly divided into sections covering the following areas:







Overview and Progress Towards a Responsible Approach

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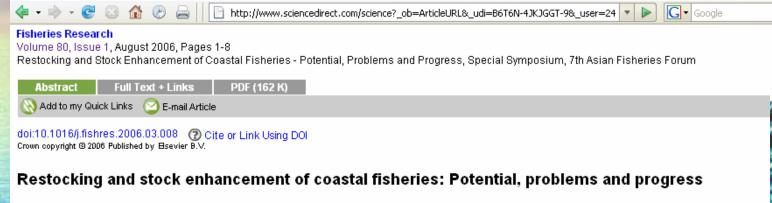
4.1. RESTOCKING INITIATIVES

4.1.1. General trends

A key feature of the restocking initiatives for marine invertebrates described in this review is that the cultured juveniles have always been produced in hatcheries. This is not just a result of the parlous state of the stocks, which greatly reduces the scope for collecting juveniles from the wild. It is because methods for attracting and collecting large numbers of postlarvae of giant clams, sea cucumbers and topshell have not been developed and are unlikely to be cost-effective.

The only exception to the uniform use of hatchery-reared juveniles for restocking is the translocation of adults to form a critical mass of spawners. This is proposed for topshell because it seems to be more cost-effective than depending on survival of enough very small juveniles that are highly susceptible to predation, or rearing sufficient cultured animals to spawning size in cages, to form effective aggregations of adults. This begs the question 'should translocation of adults be examined more closely for restocking other sedentary species with limited larval dispersal?' The sea cucumber *Holothuria scabra* is a possible candidate for this approach in locations where its longer-lived larvae are retained by local currents (Chapter 2, Section 2.3.9). It has also been proposed for abalone in programmes where the primary need for release of juveniles is to rebuild severely depleted stocks (Chapter 3, Section 3.3.4).





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Available online 29 March 2006.

Abstract

The demand for fish is expected to rise substantially by 2020. Although aquaculture must provide much of the additional fish, it remains to be seen whether restored or enhanced capture fisheries can also help fill the projected gap in supply. The key challenges for capture fisheries involve reducing fishing effort, removing excess fishing capacity and building the institutional arrangements needed to restore spawning biomass to more productive levels, and to reverse degradation of the supporting habitats. Two interventions, based largely on hatchery technology, have the potential to reduce the time needed to rebuild some severely over-exploited fisheries, or improve the productivity of other 'healthy' fisheries. These interventions are 'restocking', which involves releasing cultured juveniles to restore spawning biomass to levels where the fishery can once again



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Downloadable Materials

Welcome to the Third International Symposium on Stock Enhancement and Sea Ranching website. The Symposium took place in Seattle, September 18-21, and was a great success.

Please check back as the website will be updated with presentations and additional materials for your use!

At a Glance



Many of the world's marine fisheries no longer yield the benefits they once did, due to over fishing and degradation of the supporting ecosystems. Governments are responding to the fisheries crisis by reducing fishing efforts and protecting fisheries habitats. However, fisheries managers are also asking whether the advances in aquaculture, that now enable juveniles of many species to be produced en masse, can be applied to speed up

recovery of some stocks, or increase the production of others.

The First and Second International Symposiums on Stock Enhancement and

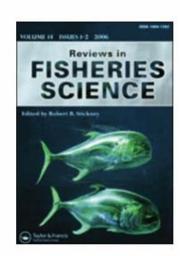
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3rd International Symposium on Stock Enhancement & Sea Ranching

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A New Era for Restocking, Stock Enhancement and Sea Ranching

of Coastal Fisheries Resources

JOHANN D. BELL, KENNETH M. LEBER, H. LEE BLANKENSHIP,

NEIL R. LONERAGAN AND REIJI MASUDA

Current I ssues Important in Marine Stock Enhancement Research

The Need for an integrated Approach

Systematic, transparent and stakeholder participatory planning process to determine whether stocking has a cost-effective, socially and environmentally beneficial role to play in managing a fishery (Lorenzen, 2008)

Interactions between released and wild stocks

Genetic issues; health issues; stocking magnitude issues; riskanalysis frameworks are being developed

Scale and diversity of research required

 Life histories can be complex; a multidisciplinary team is needed to develop culture and release strategies responsibly and at a meaningful scale

Current Issues Important in Marine Stock Enhancement Research

- Role of stocking in fisheries management
- Ensuring that releases add value to other forms of management
- Institutional and socio-economic issues
- Optimizing release strategies
- Biological insights from releases of hatcheryreared juveniles
- Development and application of tagging technologies



- Current awareness of mistakes made during 80-90 years of stock enhancement in the absence of a scientific approach has enabled a paradigm shift in stock enhancement.
- The paradigm shift has placed greatly increased emphasis on gaining knowledge about how to manage hatchery releases as an effective and environmentally sound fisheries management tool.
- Scientific publications are now rapidly increasing in this field and there is clearly an emerging awareness of the environmental and sociological requirements for using stocking effectively.
- Continued rigorous application of the responsible approach concept is needed as attempts are made to implement stock enhancement.



- This presentation was made 5 Sept 2007 at the 137th Annual Meeting of the American Fisheries Society in the session "Environmental Impacts of Coastal Ocean Aquaculture"
 - For more information on this topic, see combined issues 1 & 2 in Volume 16 of the journal "Reviews in Fisheries Science" (2008 by Taylor & Francis, Inc.)