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U.S. GULF OF MEXICO MARINE STOCK ENHANCEMENT FIVE-YEAR PROGRAM: 1999 - 2004

PROGRAM MANAGEMENT FOR PLANNING, EXECUTION, REVIEW, and EVALUATION

[1)]Gary D. Pruder, [2)]David A. Ziemann, [3)]Kenneth L. Leber, [4)]Jeffrey M. Lotz, [5)]William E. Hawkins, and [6)]Lytha D. Conquest

[1)]The Oceanic Institute, 41-202 Kalanianaole Hwy., Waimanalo, HI 96795;
phone (808) 259-7951, fax (808) 259-5971, E-mail: gpruder@teligentmail.com
[2)]The Oceanic Institute, 41-202 Kalanianaole Hwy., Waimanalo, HI 96795;
[3)]Mote Marine Laboratory, 1600 Ken Thompson Pkwy., Sarasota, FL 34236;
[4)]University of Southern Mississippi, Gulf Coast Research Labaoratory, Ocean Springs, MI 39564;
[5)]University of Southern Mississippi, Gulf Coast Research Labaoratory, Ocean Springs, MI 39564;
[6)]The Oceanic Institute, 41-202 Kalanianaole Hwy., Waimanalo, HI 96795

ABSTRACT

Many marine fisheries in the United States are under stress from overexploitation and/or habitat degradation; in response, Congress has mandated the restoration of depleted U.S. fisheries, within a given time period. Preliminary estimates indicate that conventional restrictive management protocols alone cannot satisfy these congressional mandates. The tools and options of marine fishery management need to be expanded to include proactive actions and activities. One such potentially proactive option is stock enhancement. A decision has been made to fund a research stock enhancement program to better evaluate its potential value. The U.S. Gulf of Mexico Marine Stock Enhancement Program is a multi-institutional, multi-year and multi-million dollar integrated scientific effort to develop and demonstrate sound and broad-based stock enhancement methods to augment conventional management strategies. The authors identify and characterize the critical components of an integrated, scientifically sound investigation of a highly complex stock enhancement system. It initiates use of a computerized management approach which enhances planning, review, and evaluation efforts by identifying and tracking critical activities, institutional assignments and responsibilities, developing time line and completion projections, and managing resource allocation.

INTRODUCTION

The United States, through the National Oceanic and Atmospheric Administration (NOAA), Regional Fisheries Management Councils and Interstate Marine Fisheries Commissions (IMFC), manages, conserves, and protects living marine resources within its Exclusive Economic Zone. Their aim is to maximize benefits to the nation from these living resources without compromising the long-term health of coastal and marine ecosystems. The Magnuson-Stevens Fishery Conservation Act, as amended by the Sustainable Fisheries Act, requires that fishery management plans contain both conservation and management measures that prevent overfishing while achieving optimum yield from each fishery.

Many factors, both natural and human-related, affect the status of stocks and ecosystems. Although it is virtually impossible to control or even alter most factors, scientific information concerning trends and relationships has supported the development and utilization of sophisticated fishery management tools and practices. Nonetheless, many marine fisheries are under stress from overexploitation and/or habitat degradation. One-third of all fish stocks, for which there is population information, are overutilized, and nearly half are below optimum population size. Congress mandated the restoration of U.S.

fisheries, within a given time period, through the elimination of overfishing and habitat destruction. Preliminary estimates indicate that conventional restrictive management protocols (restricting harvest and preventing habitat loss) alone cannot satisfy these congressional mandates.

The tools and options of marine fishery management need to be expanded to include proactive actions and activities. One such potentially proactive option is stock enhancement. Historically, massive releases of fish stocks did not produce the desired results. Stock enhancement, as a means to replenish fisheries, has been largely ignored for the last 30-40 years. It appears, however, that previous efforts in stock enhancement were without scientific merit as they were essentially limited to the production and release of fish. Recent, and more sophisticated small scale efforts to replenish salmonids, scallops, and Hirame flounder fisheries through stock enhancement have shown clear promise.

A decision has been made to fund a research stock enhancement program to better evaluate its potential value. The U.S. Gulf of Mexico Marine Stock Enhancement Program (USGMMSEP) is a multi-institutional, multi-year, and multi-million dollar integrated scientific effort to develop and demonstrate sound and broad-based stock enhancement methods to augment conventional management strategies. This stock enhancement program is based upon solid scientific principles and utilizes many recent advances in aquaculture and stock and ecosystem assessment. This paper does not extend the discussion of the potential value of stock enhancement. Rather, it begins subsequent to a decision to proceed. The question addressed is how to best manage, execute, review, and evaluate effective management of a complex program. In part, the success of USGMMSEP will depend upon the quality of program planning, review, and evaluation efforts.

This paper identifies and characterizes the critical components of an integrated, scientifically sound investigation of a highly complex system. It initiates use of a computerized program management approach which enhances planning, review, and evaluation efforts by identifying and tracking critical activities, institutional assignments and responsibilities, developing timeline and completion projections, and managing resource allocation. The computerized program management must be maintained in real time, being updated and modified as new and better information becomes available.

The paper describes "*Cornerstone Issues*" outlining the approach, justification, and strategies for this stock enhancement initiative. The paper suggests an interface between conventional stock management activities by NOAA and others and this stock enhancement initiative; it follows by identifying the *critical projects* upon which the success or failure of the stock enhancement initiative will depend. These critical activities and their subsets are organized in project manager format. From that format, *institutional assignments, a five-year timeline*, and *resource allocation* are addressed. The plan provides a sound basis for *review and evaluation* of efforts expended, technical highlights, cost and/or institutional problem areas - if and when they develop. The plan also reflects corrective actions as taken to resolve any problems.

CORNERSTONE ISSUES

The mission of the U.S. Gulf of Mexico Marine Stock Enhancement Program (USGMMSEP) is the refinement, field testing, and demonstration of successful marine fishery management for the Gulf of Mexico that blends aquaculture technology with traditional fishery management practices. Responsible stock enhancement will be developed to supplement wild stocks production without significantly altering the genetic diversity of resident populations. Upon development and validation, responsible stock enhancement can be used to augment traditional management strategies of catch restriction and habitat restoration.

The USGMMSEP is solidly based upon scientific principles, innovative technologies, and a sophisticated approach. It intends to augment and ease, but not replace, conventional restrictive fisheries management strategies. Successful stock enhancement to restore certain fish populations could simultaneously speed restoration and minimize the need for the most draconian restrictions. There are many factors which strongly influence both the structure and approach of this initiative. The "Cornerstone and Long-Term" issues that must be recognized and honored for this program to succeed are:

1. Dramatic advances in marine aquaculture, stock enhancement and fisheries management technologies have made possible a new integrated, proactive, and holistic approach to fisheries restoration and management.
2. Congress has mandated the restoration of U.S. fisheries, within a given time period, through the elimination of both overfishing and habitat destruction (Magnuson-Stevens Act as amended by the Sustainable Fisheries Act); however:
   A. Existing restrictive fisheries management strategies alone cannot satisfy the congressional mandate.
   B. Stock enhancement activities alone cannot restore fisheries and satisfy the congressional mandate.
   C. The combination of selected fisheries management strategies and stock enhancement could satisfy the congressional mandate for at least some fisheries.
3. The design and execution of cost-effective stock enhancement requires a thorough understanding of the selected fishery and its existing limitations, including the rationale underlying existing and planned fisheries

management restrictions.

4. Only those fisheries constrained by inadequate spawning populations, or such constraints that can be overcome by the release of fish, will be selected for enhancement activities.
5. There are downside health, genetic, and ecosystem risks associated with the production and release of unhealthy and/or genetically compromised fish. These may include, but not be limited to, introduction of disease, reduction of genetic diversity, and the alteration of communities and ecosystems.
6. There is a paucity of data on the health status, genetic status, and community and ecosystem structures of important Gulf of Mexico fisheries. Data must be collected, analyzed, and used as selection criteria among candidate fish species being considered for this stock enhancement program.
7. Only high health (specific pathogen-free) fish, with appropriate genetic characteristics should be considered for release.
8. Preliminary stock enhancement releases must be undertaken under suitable experimental designs which address release sites, release periods, size at release, etc., in order to determine appropriate release strategies.
9. Physical, chemical, and biological tags must be developed and utilized to track released fish, including future generations, to obtain quantitative estimates of the impact of the fishery and support cost per benefit analyses.
10. The stock enhancement program must develop and utilize a broad and all-inclusive integrated scientific approach. It is the only responsible means for the development and integration of marine stock enhancement in fisheries management strategies.
11. No single institution is capable of addressing all critical issues; therefore, a multi-institution consortium was formed where each institution contributes specialities within a coordinated effort.
12. Current consortium institutions include the Gulf Coast Research Laboratory (GCRL), Mississippi; The Oceanic Institute (OI), Hawaii; and Mote Marine Laboratory (MML), Florida. Together, they have the necessary expertise in fish maturation and reproduction, fry production, fry transport, fish health, fish genetics, fisheries ecology, fishery biology, fish behavior, fish tagging, risk assessment, mathematical modeling, fishery economics, and fishery management. Additional institutions will be invited to participate to meet program requirements.
13. With demonstrated success in the Gulf of Mexico, a U.S.-wide stock enhancement program will be developed in multiple geographic areas.

CRITICAL PROJECTS AND SUBPROJECTS

Conventional Fishery Management Program

It is essential that the stock enhancement initiative interface closely with the conventional fishery management programs. Conventional fishery management programs are guided and funded by NOAA's National Marine Fisheries Service (NMFS), and the Gulf of Mexico Fisheries Management Council (GMFMC). It is generally understood that successful stock enhancement efforts must be an integral part of, and are dependent upon, comprehensive fishery management activities. Essential fishery management activities include, but are not limited to, stock assessment, the identification of overfished stocks, factors contributing to the overfished condition, and subsequent regulations to restore or sustain a fishery. Decisions guiding the stock enhancement initiative and monitoring its long-term results are and will be based upon the information provided by, and controls imposed by, fisheries managers. Figure 1 shows conventional stock management activities (solid lines) augmented by stock enhancement (dotted lines) as an additional management tool.

Stock Enhancement Program

Institutional principal investigators (K. Leber, J. Lotz, and D. Ziemann) individually analyzed the overall stock enhancement initiative, and identified and recommended consideration of certain critical technical activities and subactivities. Their input was integrated then subdivided into ten categories as follows: (A) Species Selection; (B) Fishery Demographics and Ecology; (C) Disease and Parasites; (D) Fish Culture for Release; (E) Genetics; (F) Tags and Tagging Technologies; (G) Cost and Benefit Analysis; (H) Release and Recovery Strategies; (I) Fish Behavior and Conditioning; and (J) Multiple Experimental Releases and Evaluation (Figure 2). Note that the purpose of this paper is to describe a management program for enhancing the planning, review, and evaluation functions. These functions require a clear picture of specific activities to be undertaken and their interactions. The categories selected above, while rational, do not represent the only possible breakdown or even the ultimate breakdown of activities. However, they do provide a point of departure.

It is noted here that the first activity required under each critical project is a review paper generated from a comprehensive workshop. This stock enhancement program will publish a book reviewing the status of all critical activities in this stock enhancement research program, targeting "Red Snapper" in the Gulf of Mexico.

A. *Species Selection*

Species selection involves a primary and secondary

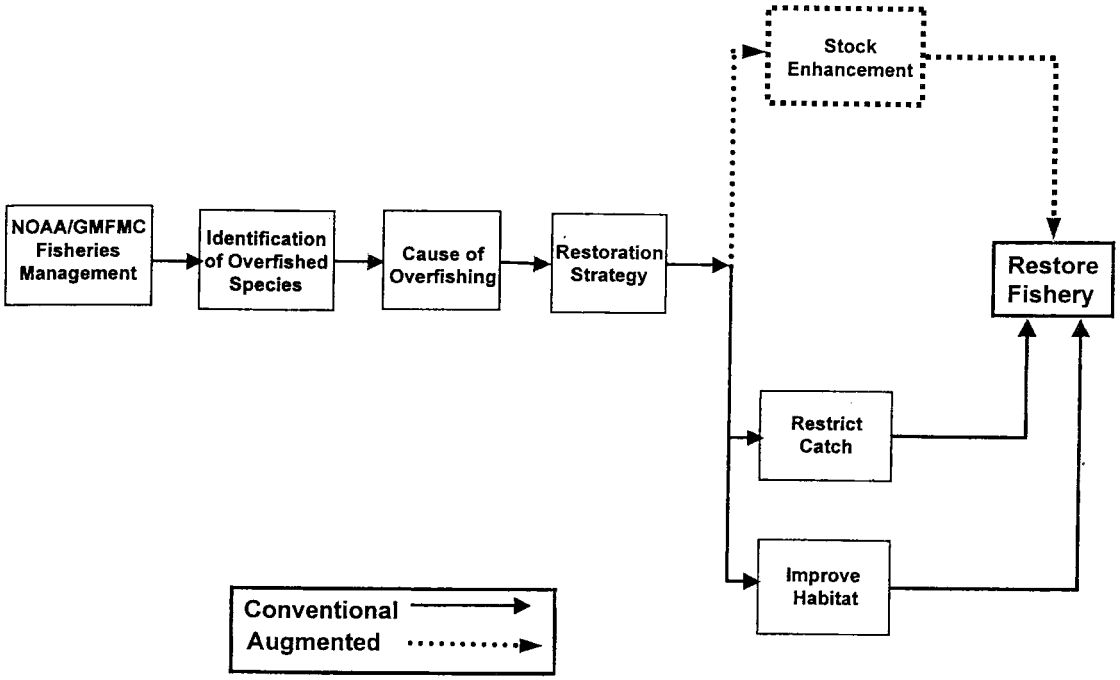

Figure 1. Augmented Fisheries Management

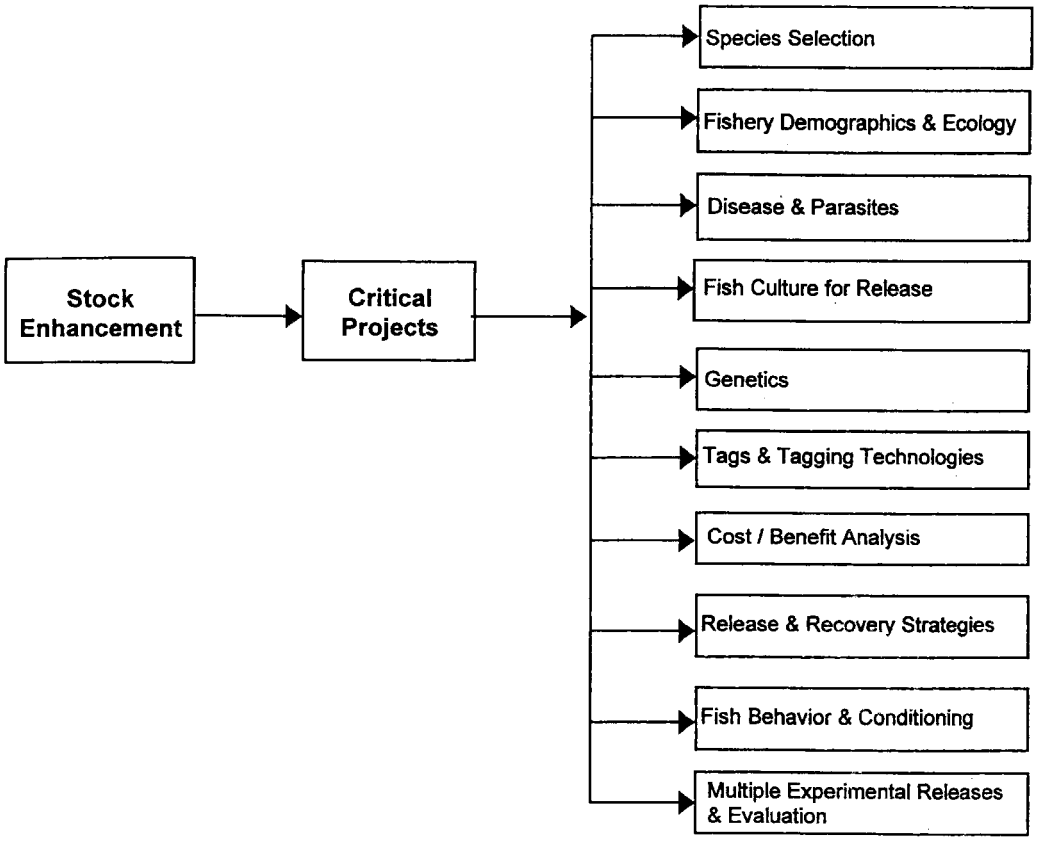

Figure 2. Critical Projects for Stock Enhancement

selection process, which are:

a. Primary selection: the species must be designated as overfished by NOAA, GMFMC or IFMC. In the case of the Gulf of Mexico, there are four fisheries that are designated as overfished; these are Red Snapper, Nassau Grouper, Jewfish and Red Drum. Therefore, the final species selection for this stock enhancement initiative must be Red Snapper, Nassau Grouper, Jewfish or Red Drum.

b. Secondary Selection: Leber (1994) organized and executed a species selection workshop titled "Species Prioritization of Marine Finfish for Stock Enhancement in Hawaiian Waters." In planning sessions, a consensus was reached on both the prioritization and relative weights given to various selection criteria; the most significant issues in ranking and weight are extracted as follows:

Selection Criteria for Stock Enhancement Species Selection

Rank	Criterion for Selection	Weight	Importance
1	Commercial / Recreational Demand	108	12.6
2	Ease of Maturation and Reproduction	104	12.2
3	Releasing Juveniles Should Increase Population	90	10.5
4	Ease of Larval Rearing	83	9.7
5	Cost-Effectiveness of Stock Enhancement	64	7.5
6	Ease of Juvenile Rearing	61	7.1
7	Ease of Experimental Design and Monitoring	58	6.8
8.5	Extent of Recruitment Limitation	51	6.0
8.5	Likelihood of Rapid Success	51	6.0
10	Impact of Resident Biota	29	3.4
11	Low Mortality : Growth Ratio	24	2.8
12	Documented Decline in Fish Stock Landings	23	2.7
13.5	Availability of Habitat	19	2.2
13.5	Residential versus Migratory	19	2.2

Also listed, in descending order, were: socioeconomic attractiveness; inshore seasonal availability; fishing pressure; facilities; ease of protection until market size; reproduction in a habitat that is limited or degraded; availability of food; ease of transport and distribution; cost of monitoring effect; seasonal/environmental factors; mitigation issues; nonconsumptive uses; and size at capture.

This study serves to illustrate the potential complexities involved in species selection. It is important to note that in addition to being complex, there is a paucity of data on the criteria identified. As the information base is expanded, more precise species selection will be possible.

In early 1998, USGMMSEP convened a meeting of stakeholders to select a candidate species, among Red Snapper, Nassau Grouper, Jewfish and Red Drum. Red Snapper was virtually the unanimous choice. The selection was based primarily on the importance of the fishery to both commercial and recreational interests. When time allows, a more formal selection process will be revisited, for information purposes only, using a full set of selection criteria.

B. *Fishery Demographics and Ecology*

The first critical activity in this category is completion of a review paper "Demographics and Ecology of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities included in this category are:

a. Habitat Assessment
   - Habitat assessment surveys and experimental site selection
   - Determine essential fish habitat - SCUBA video, reef rugosity

b. Population Structure
   - Wild population demographics: stock substructure, distribution, age structure, sex ratio, fecundity, variation
   - Populations surveys - SCUBA, hook and line, baited video, trapping and tagging
   - Population model

c. Ecology of Resident Population
   - Growth and reproduction
   - Dietary requirements, preferences, feeding rates, feed Availability at candidate release sites
   - Mortality (age dependent)
   - Prey-predator relationships
   - Wild fish behavior-aggregation, schooling, horizontal movement, circadian rhythm
   - Wild juvenile behavior
   - Juvenile recruitment patterns and abundance
   - Ecophysiological requirements

C. *Disease and Parasites*

The first critical activity in this category is completion of a review paper "Diseases and Parasites of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Assess the Disease and Parasite Status of Wild Populations

b. Develop Health Specification for Fish to be Released

c. Develop Health Management and Quarantine Guidelines
   - Broodstock acquisition and holding
   - Maturation/reproduction

Larval production
Fry culture
d. Monitor Disease and Parasite Status of Fish Across All Culture Stages
e. Assess the Disease and Parasite Status of Recovered Fish (Environmental Indicator).

D. *Fish Culture for Release*

The first critical activity in this category is completion of a review paper "Fish Culture of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Broodstock Acquisition
Establish primary broodstock acquisition site
Establish alternative broodstock acquisition sites
Develop broodstock quarantine, screening, and holding facilities
Develop alternative quarantine, screening, and holding facilities
Collect broodstock, screen, hold, and condition
Produce healthy, mature, and genetically diverse broodstock
b. Maturation and Reproduction Operations
Develop maturation and spawning protocols
Produce sufficient numbers of fertilized eggs
c. Hatchery Operations
Develop hatchery protocols including live feed production
Produce sufficient number of healthy and genetically diverse fry
d. Nursery Operations
Develop nursery protocols to improve fish fitness and tolerance
Improve growth rate and survival
Condition fish for wild feeds
Condition fish for predator avoidance
Tag individuals
Produce sufficient numbers of healthy, genetically diverse, conditioned, and tagged fingerlings for release purposes.

E. *Genetics*

The first critical activity in this category is completion of a review paper "Genetics of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Wild Stock Variability
Genetic structure or structures
Develop genetic analytical protocols
b. Broodstock Genetic Structure
Establish reliable sources for broodstock acquisition
Establish stock genetic diversity
Develop a broodstock selection and management plan
Monitor genetic structure of broodstock acquired
c. Develop Genetic Protocols and Guidelines for Fish-for-Release
d. Monitor and Screen the Genetics of Fingerlings for Release Purposes
e. Monitor and Screen the Genetics of Recaptured Fish
f. Seek Cooperation and Inclusion in NMFS Red Snapper Genetics Program

F. *Tags and Tagging Technologies*

The first critical activity in this category is completion of a review paper "Individual Tags for the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Technology Development
Adapt existing tag and tagging technology
Determine tag reliability
Evaluate tagging effect on hatchery fish
Adapt mass marking technologies
Establish quality control for tag implant performance
Develop tag coding management
Develop tagging facilities
Computerize tag decoding capabilities
b. Genetic Tags
Identify genetic markers
Broodstock - molecular tags
Fingerling - molecular tags

G. *Cost/Benefit Analyses*

The first critical activity in this category is completion of a review paper "Cost/Benefit Analysis for Stock Enhancement of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Culture Costs
Adapt hatchery-cost model
Analyze laboratory scale process in use by USGMMSEP and scale to full production and preparation of fingerlings for release
Complete sensitivity studies to identify areas for cost reduction
b. Release Costs
Analyze laboratory scale releases and expand to estimate full scale Release costs
Complete sensitivity studies to identify areas for cost reduction

c. Monitoring and Recovery Costs Projected for Inclusion in Fisheries Management protocols

H. *Release and Recovery Strategies*

The first critical activity in this category is completion of a review paper "Release and Recovery Strategies for Stock Enhancement of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Release Strategies
   - Site Selection Guidelines
   - Microhabitat, feed, predator refuge
   - Fish size and release number guidelines
   - Seasonal/chronological guidelines
   - Site, fish size, release number, and seasonal interaction guidelines
   - Transport, delivery, and injection methods and materials
   - Acclimation in release habitat
   - Experimental releases

b. Recovery Strategies
   - Random sampling in test and control sites
   - Random stratified sampling in test and control sites
   - Guidelines for recovery from recreational fishery
   - Guidelines for recovery from commercial fishery
   - Recovery of experimental releases

I. *Fish Behavior (hatchery and wild) and Conditioning*

The first critical activity in this category is completion of a review paper "Fish Behavior and Conditioning for Stock Enhancement of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Compare Behavior of Hatchery and Wild Fish
   - Nursery aggregation, schooling, horizontal movement, circadian
   - Rhythm, predator avoidance, and feeding activities

b. Characterize Learning Ability of Red Snapper

c. Develop Conditioning Methods for Predator Avoidance

d. Develop Conditioning Methods for Natural Feeds

e. Condition Fingerlings for Release Purposes

J. *Multiple Experimental Fish Releases and Evaluation*

The first critical activity in this category is completion of a review paper "Multiple Experimental Research Releases for Stock Enhancement of the Gulf of Mexico Reef Fish: Red Snapper." This manuscript will be produced as part of a book "Stock Enhancement of Red Snapper" produced by a workshop to be held in 1999.

Other critical activities and subactivities in this category are:

a. Assessment and Improvement of Techniques

b. Assessment of the Impact on Wild Stock
   - Demographics
   - Genetics
   - Disease and parasites
   - Predators
   - Prey
   - Carrying capacity
   - Ecological community

c. Assessment of Release/Recovery
   - Survival rate after release
   - Growth rate after release

d. Assessment of Stock Enhancement Success
   - Contribution to juvenile recruitment
   - Contribution to adult recruitment
   - Contribution of released fish to reproduction and recruitment
   - Contribution to fishery landings
   - Contribution of released fish to wild stock abundance.

PROJECT MANAGER FORMAT DEVELOPMENT

The first task of identifying the critical projects and subprojects is complete. It is clear that the program is technically broad-based and complex with many internal and external interdependencies. Additional complexities arise from the fact that the program is both multi-year and multi-institutional. Fundamental questions arise, including:

- What needs to be done ?
- What are the interdependencies between needs ?
- Who will do it ?
- When will it be done ?
- What happens if something is not done ?
- What happens if it is not completed in time ?
- How much will it cost ?
- How much did it cost ?
- How does one review and evaluate accomplishments ?

From the outset, it is important to understand that effective review and evaluation starts with effective planning. There needs to be clarity among the investigators and administrators by identifying and addressing these questions in advance. The program management effort previously established a relationship between conventional and research activities and identified the critical projects.

Figure 3 depicts the critical projects and subprojects and how they related to research trials in an interactive way through multiple research releases and recoveries leading to the final goal of a transferrable stock enhancement technology package. It is envisioned that full scale stock enhancement releases will fall under the purview of state and federal agencies. It is recognized that there are many

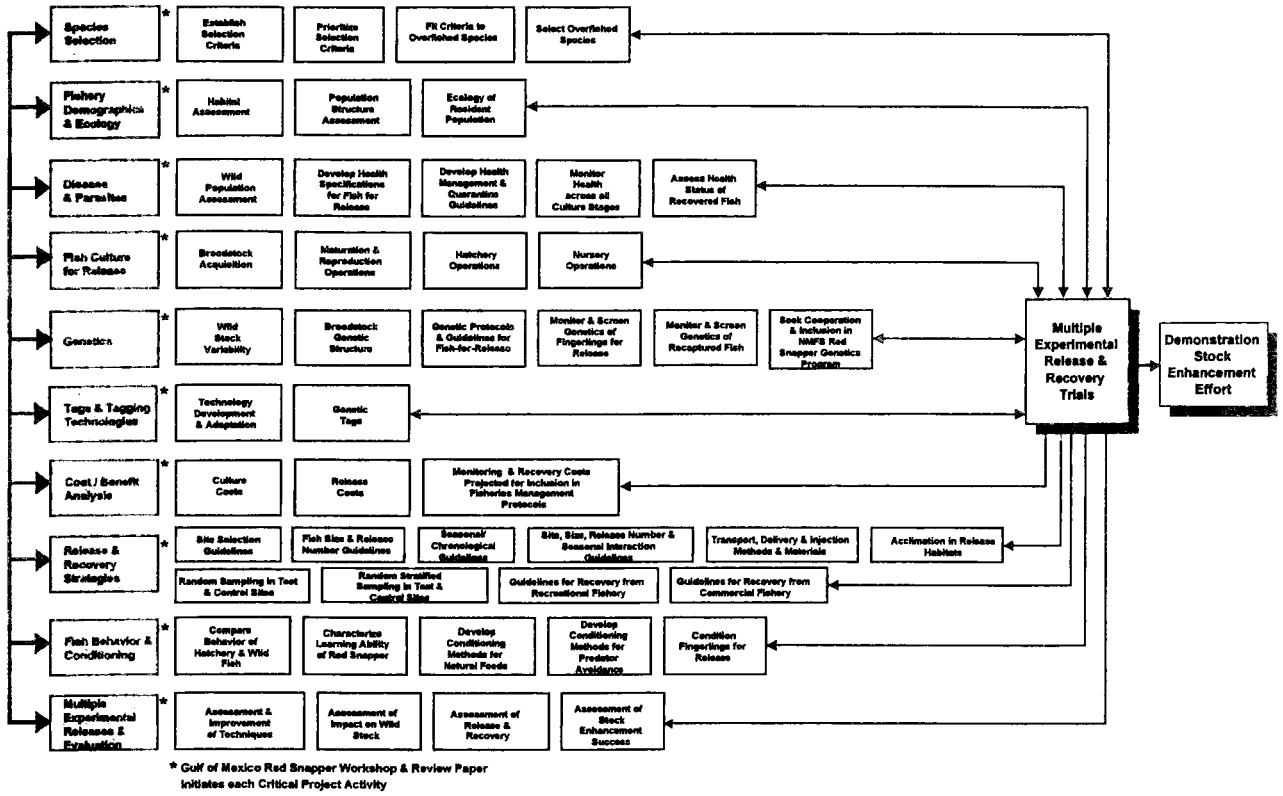

Figure 3. Critical Projects & Sub-projects for Stock Enhancement

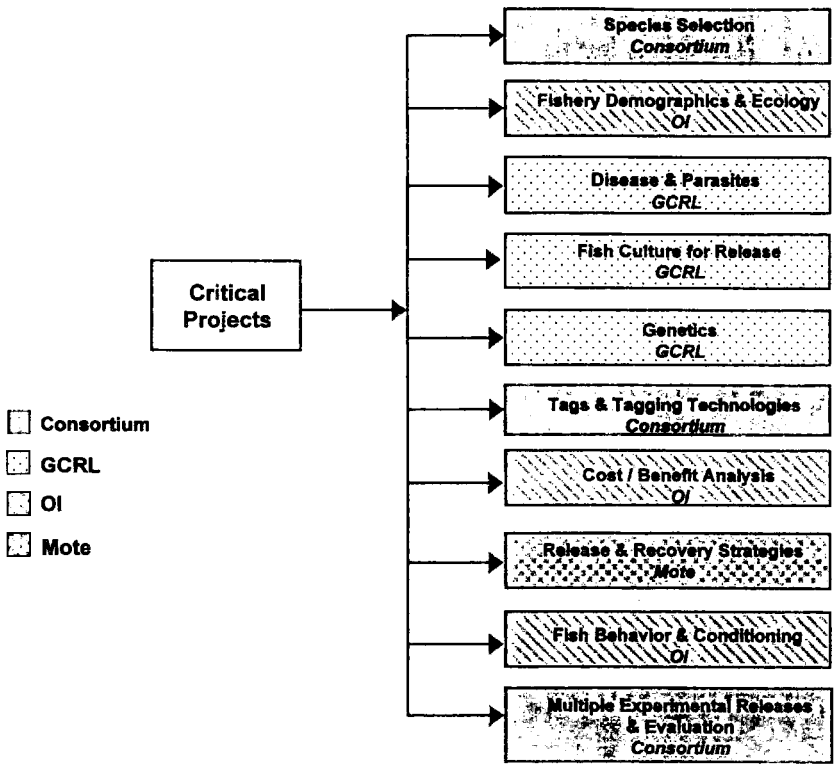

Figure 4. Principal Institutional Assignments

interdependencies between critical projects and sub-projects. Some projects must be started before others can be started. Other projects must be completed before other projects are started. The fundamental message is that none of the critical projects stands alone. The process of identifying these interdependencies is underway.

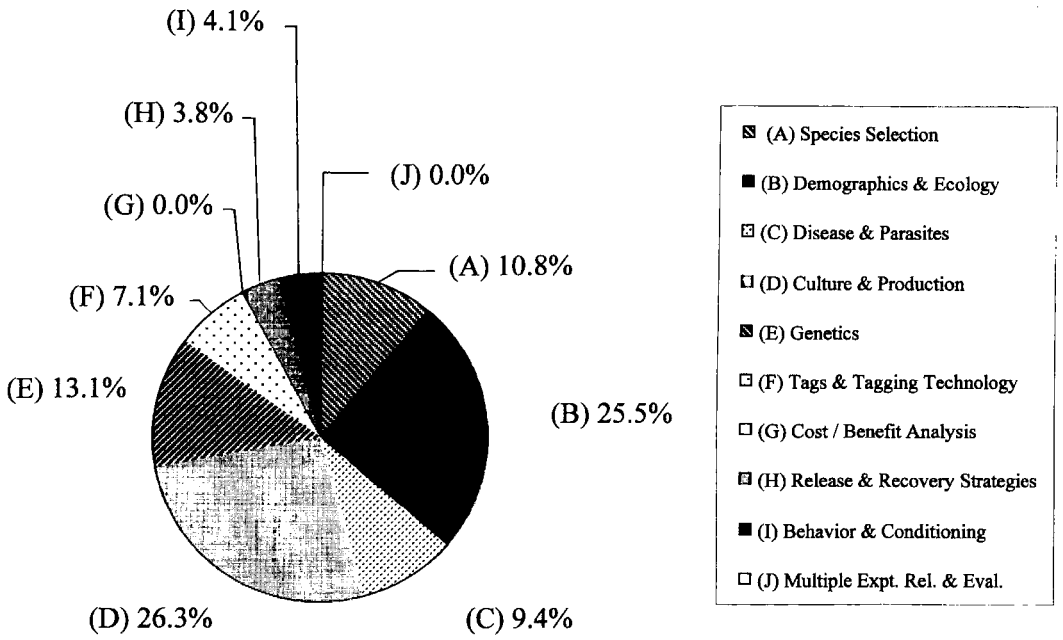

Figure 5. Resource Allocation by Project Activity-Year 1

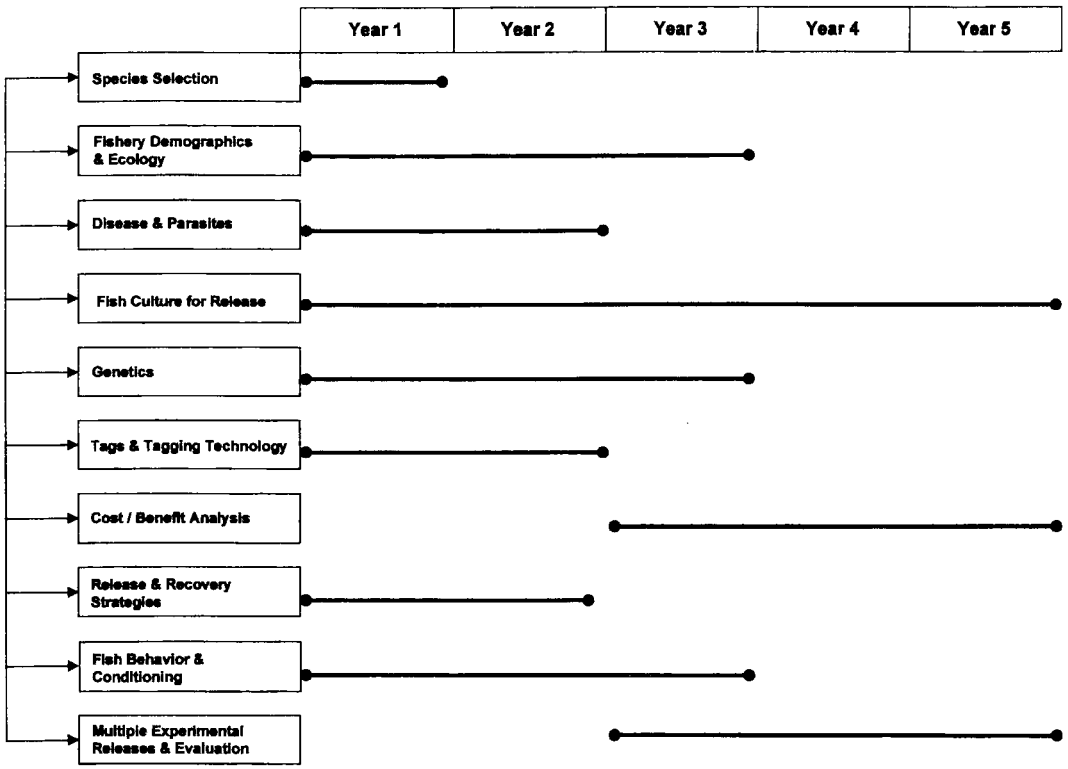

Figure 6. Timeline of Major Project Activities for Stock Enhancement

INSTITUTIONAL ASSIGNMENTS

This program currently involves three institutions, and may be expanded, and each institution has multiple investigators. Only institutional assignments of critical projects is completed (Figure 4). Responsibilities are designated as GCRL, OI, MML, or Consortium for the purposes of clarity. There are many subprojects and many more sub-subprojects that should be covered by institutional assignments. This work is in progress.

RESOURCE ALLOCATION

Resource allocation estimates for each of the critical projects are expected to change from year to year as some projects are completed and others are initiated. The percent allocation for each critical project for Year 1 are shown in Figure 5. The percentage allocations and funds available are expected to change with time as projects are completed and projects initiated. Unanticipated difficulties may require allocation changes to be implemented as the program continues.

FIVE-YEAR TIME LINE

It is difficult to estimate activities in outyears of complex projects. However, planning for outyears is essential. Programs such as this operate both in parallel and part in series. It is not effective to delay planning for subsequent steps until current steps are completed. Therefore, the program management plan focuses on a five-year period. This requires continual recognition of the ultimate goal, which in this instance is the transfer of stock enhancement technologies to suitable state or federal agencies for full scale exploitation and fisheries restoration. Year-by-year projections of times required for projects and subactivities are shown in Figures 6 and 7.

REVIEW AND EVALUATION PROCESS

Maximum value from this approach to management planning is derived by periodically (yearly) reviewing and evaluating project performance and accomplishments within the overall or long term picture (Figure 8). Especially important is the recognition of what must be

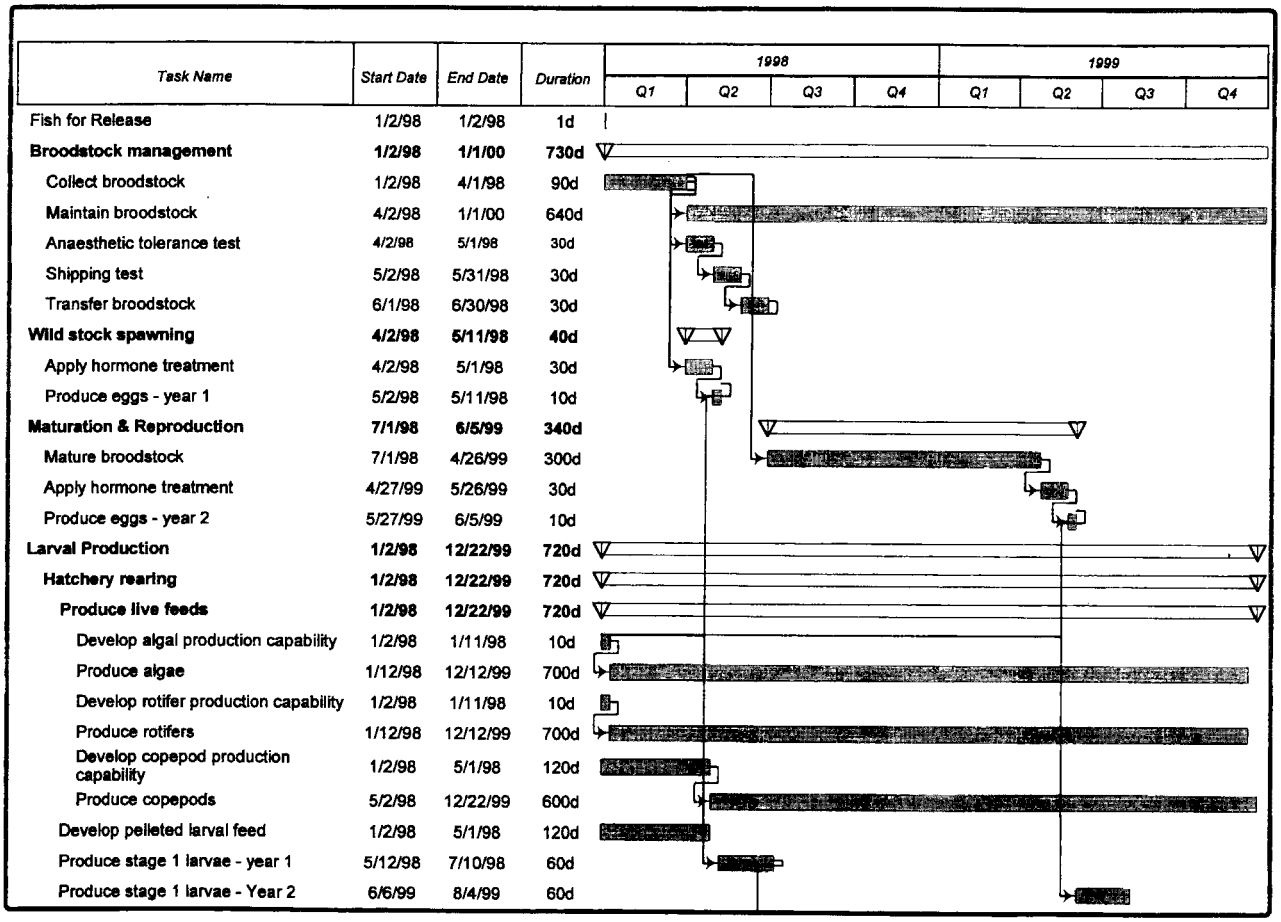

Figure 7. Detailed Timeline for Stock Enhancement Project Activities - Year 1

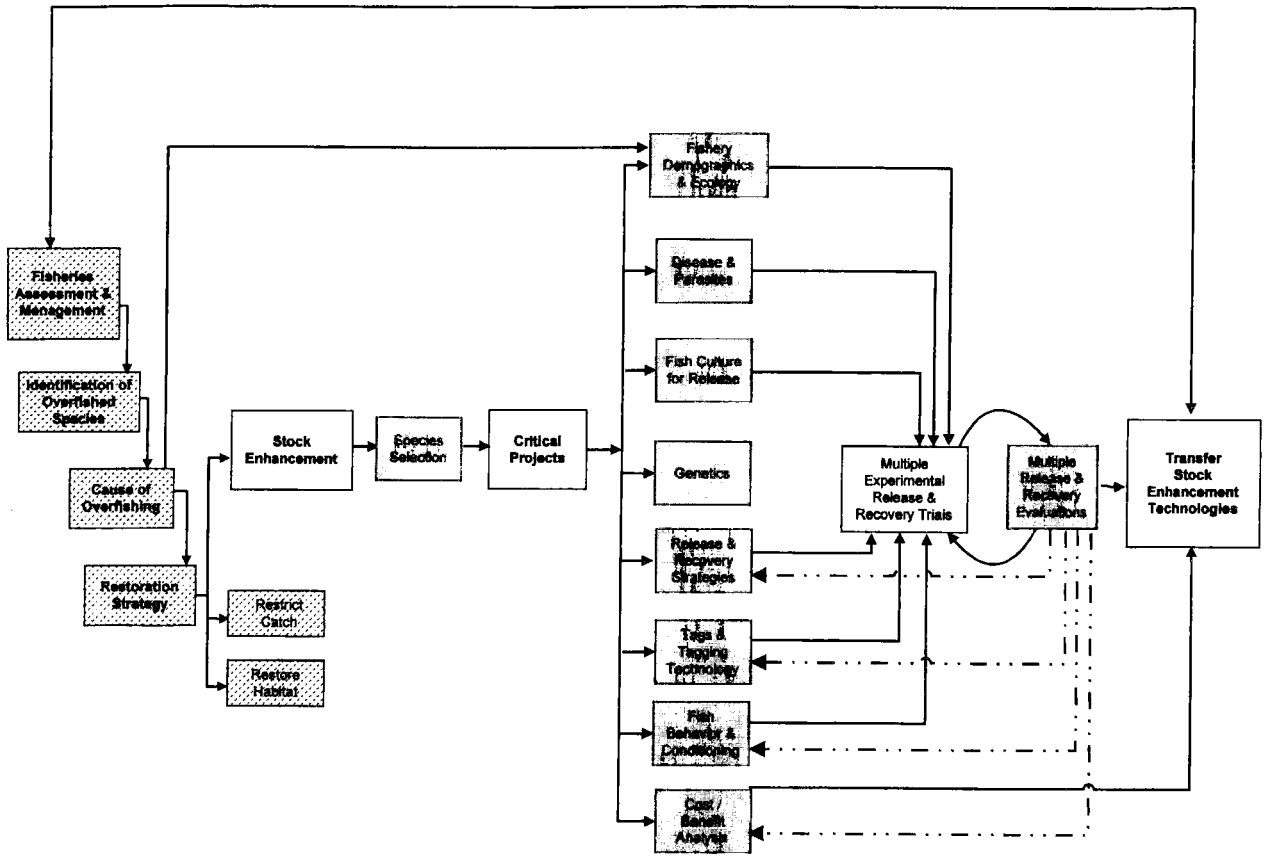

Figure 8. Major Stock Enhancement Program Actibities and Interactions

done differently to meet the long term objectives. The review and evaluation process must be followed by corrective actions which include: modification of assignment responsibility, modification of allocations, and recognition of alternative pathways to accomplish critical points.

These program management plans should be updated and used to guide the effort, review, and evaluation efforts for the next time period. The plan itself must be continually updated following rigorous review of the issues. Merely stretching timelines while failing to make corrective action renders the activity as useless.

ACKNOWLEDGMENTS

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