Quantitative Assessment of Nursery Habitats for Fishery Stock Enhancement

Completion Report for Grant # R-31-2-00

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Research Report

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Sea Grant
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Submitted to:

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By

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ACCOMPLISHMENTS

Major Goals:

The primary research goal of this study was to measure the demographic rates of juvenile snappers (Lutjanidae) within three distinct non-reef habitats and determine the contribution of these habitats to reef-based populations. The three habitats include two nursery habitats (mangrove lagoon, *Thalassia* grass bed) and one non-nursery site (*Syringodium* sea grass and *Dictyota* drift algae). We tested two null hypotheses:

1. Post-larval settlement, growth and survival are similar among the nursery and non-nursery habitats and the adjacent coral reef, and
2. Nursery and non-nursery habitats contribute a similar proportion of Lutjanid juveniles to adjacent coral reefs.

Accomplishments:

1. Demographic Rates of Juvenile Yellowtail Snapper

i. Patterns of Settlement and Distribution

Monthly fish surveys were conducted at six sites in Mangrove Lagoon, Sprat Bay, and Brewer's Bay starting May 2000 through October 2001 with the exception of the Mangrove Lagoon, which was not surveyed in Sept or Oct 2000. Six to ten transects were completed each month on the nursery habitat and on the adjacent coral reef (Table 1). In general Brewer's Bay nursery and coral reef habitats had higher densities of newly settled reef fish (all species) than Mangrove Lagoon or Sprat Bay habitats (Figure 1). Older stages of reef fishes were similar among sites and habitats (Figure 1). Differences were found in the abundance of Yellowtail Snapper (*Ocyurus chrysurus*) among nursery habitats and between nursery and reef habitats. Newly settled yellowtail snapper (< 3 cm) were most common in nursery habitats and decreased in abundance with each successive size class at all sites except Mangrove Lagoon where juvenile fish (4-10 cm) were most abundant (Figure 2). On coral reef habitat, juvenile yellowtail snapper were more abundant than smaller or larger size classes. This pattern was consistent among sites (Figure 2). Settlement patterns for *O. chrysurus* show that Brewer's Bay nursery habitat had significantly more newly settled fish (Figure 2, $p<0.01$) than Sprat Bay and Mangrove lagoon.

ii. Growth rates

Fifteen juvenile Yellowtail Snappers were tagged with tetracycline in July 2001 and held in a cage for fifteen days to determine growth rates and to validate formation of daily otolith increments. Otoliths were removed and examined under UV light microscope. All but one fish showed a distinct tetracycline mark. Of the 15 otoliths the daily growth increments could be seen clearly on 10 fish. The tetracycline mark indicated that the daily growth increments were formed daily.

During the summer of 2000 and 2001, 142 and 102 juvenile fish (age <1yr), were caught from sites and their otoliths removed for aging. From each adjacent reef site sub-adult fish (age > 1yr) were caught from Brewer's Bay (n= 33), Mangrove Lagoon (n=25) and Sprat Bay (n=29). All juvenile fish were measured and weighed before otoliths were extracted. Lapillar otoliths from all juvenile fish were polished and mounted on glass slides for age and growth analysis. Otoliths from the sub-adult fish were removed, sectioned and were prepared for chemical analysis. Data on juvenile fish growth rates, based on otolith increment width, showed a large difference between the nursery habitats (Figure 3). The fish from Sprat Bay seagrass and Mangrove Lagoon mangrove habitats had a smaller average thickness of otolith increments than Brewer's Bay control habitat indicating slower growth rates in the traditional nursery habitats.

Another measure of the quality of the three nursery habitats is the condition factor, which is a relationship between weight and length. Fish with a higher condition factor are heavier per unit length that fish with a lower condition factor. Fish from the mangrove habitat had a significantly lower condition factor than fish from Sprat Bay or Brewer's Bay (Figure 4, $p<0.001$). This corresponds to the growth rates based on otolith increment data. Length/weight ratios from yellowtail snappers from all sites show an increase in weight per unit length beginning about 10 cm total length (Figure 5). The age/length relationship has been calculated for a total of 58 fish from the three nursery sites (Figure 6). Mangrove lagoon and Brewer's Bay had similar length/age relationships whereas in Sprat Bay fish were smaller at a particular age than the other two sites.

iii. Mortality Rates

Retention studies were performed at all six sites. In Brewer's Bay, 76 fish were tagged and released at the same location in the control habitat and 121 were tagged and released on the adjacent reef. In Mangrove Lagoon, 54 were tagged and released among the mangrove roots and 35 were tagged and released on the reef. In Sprat Bay, 45 were tagged and released in the grass bed and 47 were tagged and released on the adjacent coral reef. In the days following the release of the tagged fish divers visually searched for the fish, and traps were also set to try to recapture the tagged fish. The number of tagged snappers recaptured or seen in the nursery habitats was lowest in Brewer's Bay and highest in Mangrove Lagoon (Figure 7). In Brewer's Bay nursery habitat no tagged snappers were seen by divers. All of the tagged snappers were recaptured using juvenile fish traps. This was probably due to the expansive nursery habitat in Brewer's Bay and the large number of untagged newly settled yellowtail snappers (Figure 2). Alternatively, the configuration of both Sprat Bay and Mangrove Lagoon was conducive to thorough searches since the nursery areas were more restricted and surrounded by shoreline on three sides.

With the exception of Brewer's Bay, no tagged snappers that were released on the adjacent coral reef were seen or recaptured (Figure 7). The higher level of retention of tagged snappers on Brewer's Bay coral reef was probably due to the fact that the largest number of tagged snappers were released here, and divers were able to search more frequently here than on other sites. Predation on tagged yellowtail snappers were observed at each site. During the release of one group of fish in Sprat Bay, divers witnessed a Graysby (*Epinephulus cruentatus*) eat one of the snappers. In the Mangorve Lagoon divers witnessed a Lizardfish (*Synodontidae sp.*) eat one of the snappers and in Brewer's Bay a bar jack (*Caranx ruber*) attacked a group of recently released snappers. Separating the effects of mortality versus migration is difficult, since, on one occasion a fish that was tagged and released on Sprat Bay coral reef, was recaptured back on the sea grass bed several days later. This indicates that juvenile yellowtail snapper have a strong preference to remain in their natal seagrass habitats.

2. Fish production from nursery habitats
Sagittal otoliths from all juvenile fish collected in 2000 and 2001 were analyzed with ICP-MS at Old Dominion University for 9 different chemical signatures relative to the concentration of Calcium (Ca). These elements were: Magnesium (Mg), Manganese (Mn), Copper (Cu), Sr (Strontium), Barium (Ba), Lead (Pb). Initial ICP-MS of otoliths was conducted approximately 300 um from otolith centrum which placed the sampling area about 1 week post settlement. Differences in elemental signatures were analyzed with ANOVA. Mn, Sr and Pb showed significant differences between sites, Mg and Mn showed significant differences between years, Sr and Ba showed significant interaction between site and year and Cu showed no significant differences (Table 2). Based on this preliminary analysis Pb seems to be the most likely candidate Data from the three replicate rasters (100um x 100um area sampled with laser) from each otolith occasionally showed considerable variation within and between otoliths from a site. It was hypothesized that this variation was due to some of the rasters falling within the larval period of the otolith. Since funding was still available additional samples were also taken from the edge and centrum of each otolith and included three additional elements: Zinc (Zn), Rubidium (Rb) and Yttrium (Y). Thus samples near the edge of the otolith represented dates close to the day of capture and the centrum samples represented the larval period. Thus we would expect the elemental analysis of the initial samples to be more similar to the edge of the otolith since both of these should represent the post-settlement of juvenile period. These additional data still need to be analyzed and compared to adult yellowtail otoliths.

Table 2. Significance levels for two-way analysis of variance of elemental signatures in juvenile yellowtail snappers from three sites (Brewer's Bay, Mangrove Lagoon, Sprat Bay) and two years (2000, 2001). ns = not significant

Factor	Mg	Mn	Cu	Sr	Ba	Pb
Site	ns	0.001	ns	.021	ns	0.015
Year	0.43	0.001	ns	ns	ns	ns
Site*Year	ns	ns	ns	0.01	0.05	ns

<u>Training and Development:</u>

To date, 8 UVI students have been involved with this research study. These include Jack Devan and Matthew Edwards between May to December 2000, Amandy Williams, Breanna Smith, Temesha Buckley, Brandi Lyon and Devon Tyson between May 2001 to December 2001, Amandy Williams, Temesha Buckley, and Devon Tyson from March to December 2002 and Devon Tyson and Daya Stridiron from March to December 2003. Ms. Buckley, Ms. Lyon and Mr. Tyson worked on otolith dissection, preparation and aging.

Research technicians trained in juvenile fish transects, otolith dissection and analysis using video imaging Laurie Requa (accepted to graduate school at Cal. State Northridge), Adam Quandt (UVI alumni), and Jeremiah Blondeau.

Dr. Simon Thorrold coordinated the preparation and cleaning of otoliths for ICP-MS analysis and Dr. Zhongxing Chen completed ICP-MS analysis of all otoliths.

Dissemination of results, outreach:

The results of this research program were also disseminated locally through several UVI Research and Public Service newsletters. Moreover, results of this research were also incorporated into the presentations of the Virgin Islands Marine Advisory Service, an outreach program partly funded by Puerto Rico Sea Grant.

PRODUCTS

Peer Reviewed Publications and Conference Proceedings: (federal support acknowledged)

Watson, M. and **R.S. Nemeth.** (in revision) Spatial and temporal distribution patterns of coral reef fish larvae in the Virgin Islands archipelago. Environmental Biology of Fishes.

Nemeth, R. (in prep) Settlement, growth and survival of juvenile yellowtail snapper in mangrove, seagrass and algal habitats in St. Thomas USVI.

Nemeth,. R. (in prep) Contribution of nursery habitats to the yellowtail snapper fishery.

Presentations (federal support acknowledged):

Ms. Lyon and Ms. Buckley presented a joint poster at the UVI summer science research symposium in September at the University of the Virgin Islands. Ms. Buckley presented an oral paper at the UMET conference in Puerto Rico in October and another poster at the Annual Biomedical Research Conference for Minority Students (ABRCMS) in Orlando, Florida in November 2001. Ms. Lyon presented an oral presentation at ABRCMS and a poster at the 54th Gulf and Caribbean Fisheries Institute conference in Turks and Caicos in November.

Web site:

Some results are posted at www.marsci.edu

Networks and Collaborations:
A research collaboration was established with Dr. Sinom Thorrold, Research Professor Woods Hole Oceanographic Institute and Dr. Zhongxing Chen, Director of the Laboratory for Isotope and Trace Element Research (LITER), Department of Chemistry and Biochemistry, Old Dominion University and Mr. James Warren, Fisheries Otolith Analysis Lab, University of Southern Mississippi.

Technologies and Techniques.
None

Inventions:
None

Other Products
None

IMPACTS

The results of this project may provid some of the first quantitative information on the contribution of nursery habitats to fisheries production. These data will greatly support the protection of nursery habitats and facilitate the management of coastal marine resources throughout the Caribbean.

PARTICIPANTS

Note: All participants were non-Hispanic ethnicity and without disabilities so these categories were dropped and role of participant was added. All participants including undergraduate students worked more than 160 hours on project.

Name	Sex	Race	Citizen-ship	Role and Contribution
Richard S. Nemeth	M	W	USA	PI– all aspects of project
Simon Thorrold	M	W	USA	Co-PI, technical advisor for ICP-MS analysis
Zhongxing Chen	M	W	USA?	ICP-MS otolith analysis
Adam Quandt	M	W	USA	Res. Tech – all field and lab work, data entry and analysis
Laurie Requa	F	W	USA	Res. Tech – all field and lab work, data entry and analysis
Jack Devan	M	W	USA	Undergraduate student helped in diver surveys, data entry.
Matthew Edwards	M	W	USA	Undergraduate student helped in diver surveys, data entry.
Amandy Williams	F	B	St. Lucia	Undergraduate student helped in otolith prep and analysis
Brianna Smith	F	W	USA	Undergraduate student helped in diver surveys and lab work
Temesha Buckley	F	B	USA VI native	Undergraduate student helped in diver surveys and lab work
Brandi Lyon	F	W	USA	Undergraduate student helped in diver surveys and lab work
Devon Tyson	M	B	USA VI native	Undergraduate student helped in diver surveys and lab work
Daya Stridiron	F	B	USA VI native	Undergraduate student helped in otolith prep and analysis

ADDITIONAL INFORMATION

This project received considerable delays from the ICP-MS analysis of otoliths. Shortly after receiving funding in 2000 Dr. Thorrold took a position at Woods Hole Oceanographic Institute. He anticipated that this move would delay his part of the project until spring of 2002 due to time required to set up his new lab and ICP-MS equipment. However after continued delays UVI assumed responsibility from WHOI over the otolith analysis aspect of the project and contracted Old Dominion University to complete the work. Dr. Thorrold's lab was responsible for cleaning otoliths prior to ICP-MS analysis. Otoliths from juvenile yellowtail snapper from years 2000 and 2001 were cleaned and analyzed in August and November, 2003 respectively. The final set of adult yellowtail otoliths were received in August 2004. Reanalysis of juvenile otoliths using ICP-MS was completed in October 2004. We have not had sufficient time to analyze these results.

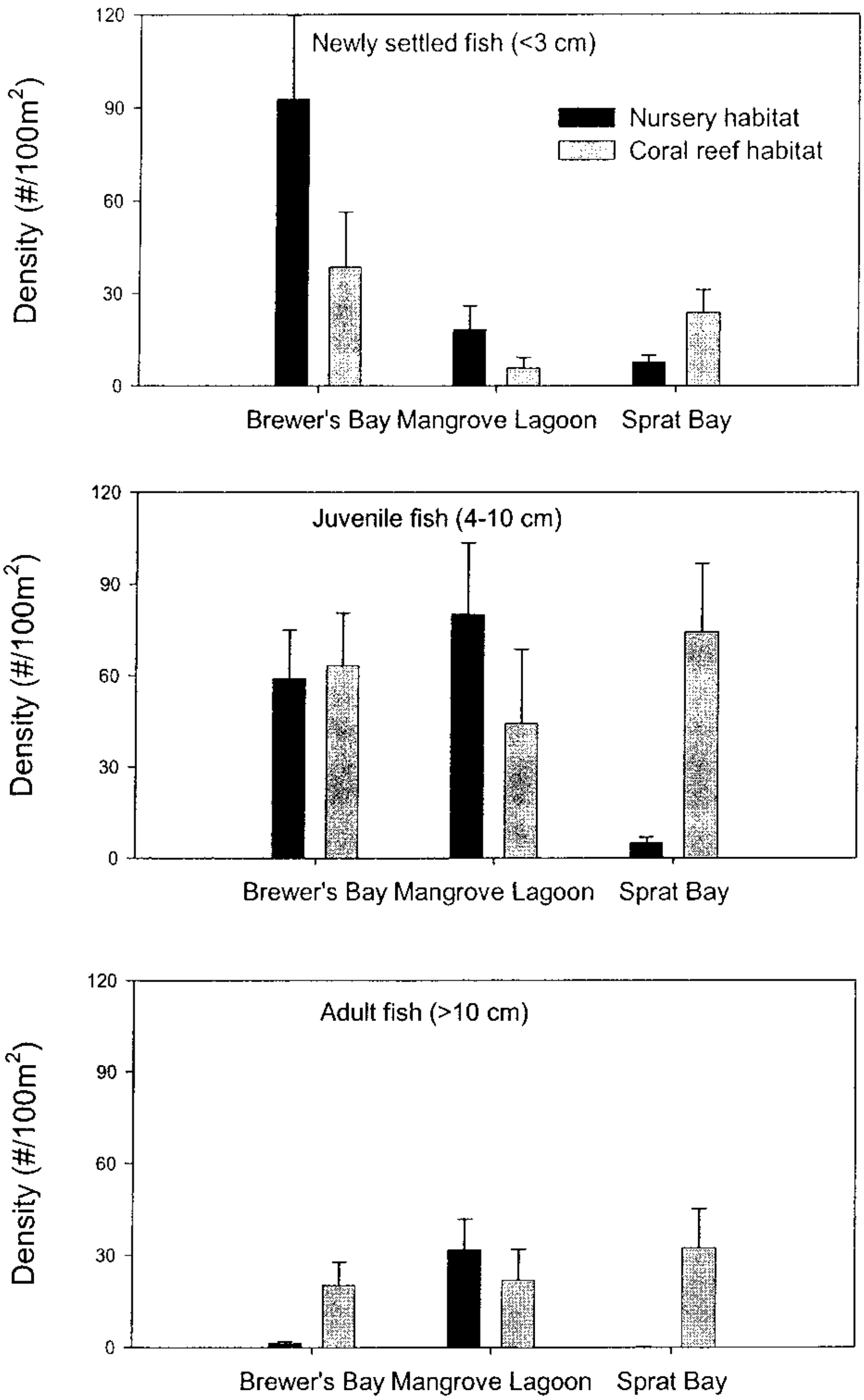

Figure 1: Density of all species of newly settled, juvenile and adult fish in Brewer's Bay control (n=96 transects), Brewer's Bay reef (n=96), Sprat Bay seagrass (n=90), Sprat Bay reef (n=91), Mangrove Lagoon mangrove (n=84) and Mangrove Lagoon reef (n=72). Size classes based on total length.

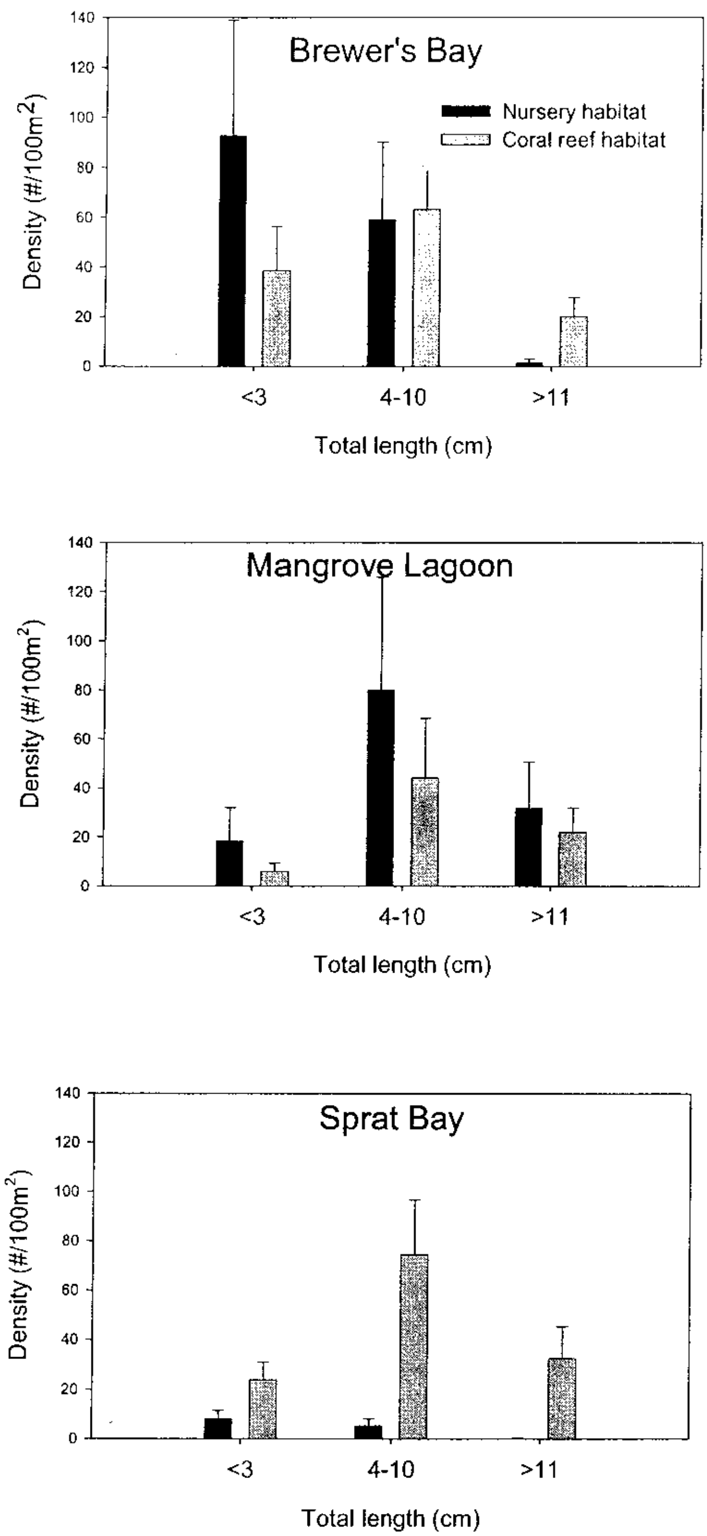

Figure 2: Density of newly settled (<3 cm), juvenile (4-10), and adult (>11) Yellowtail Snapper (*Lutjanus chrysurus*) in Brewer's Bay control (n=96 transects), Brewer's Bay reef (n=96), Sprat Bay seagrass (n=90),Sprat Bay reef (n=91), Mangrove (n=84), and Mangrove Lagoon reef (n=72).

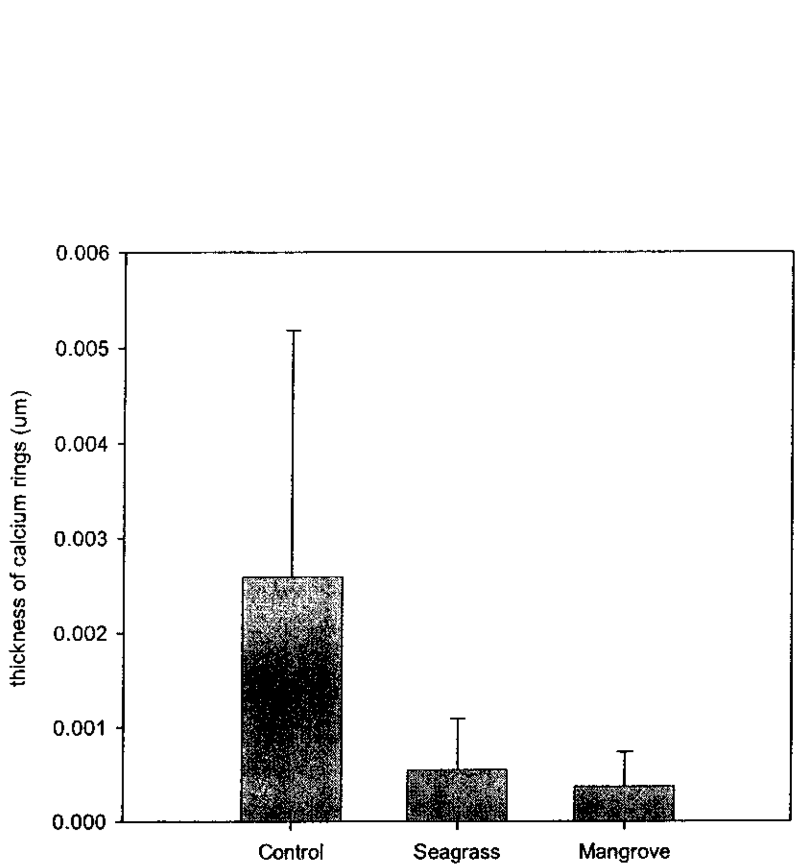

Figure 3: Width of juvenile Yellowtail Snapper (*Lutjanus chrysurus*) otolith growth increments from the three nursery sites, control n=26, seagrass n=39, and mangrove n=28.

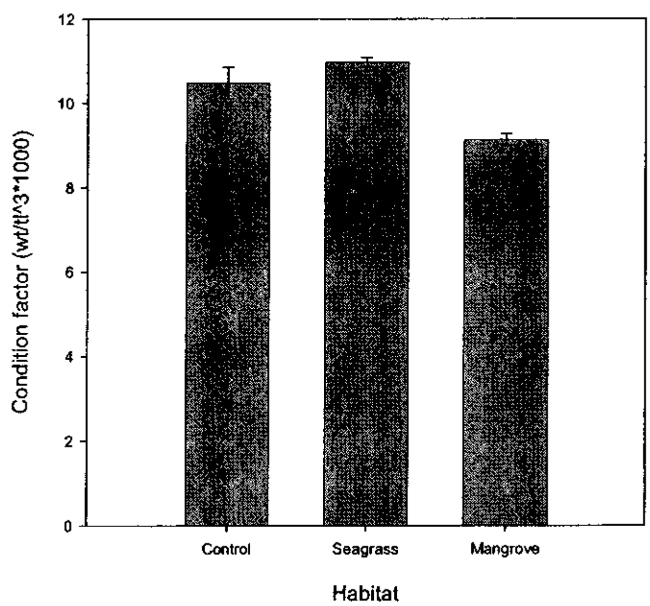

Figure 4: Average condition factor (±s.e.) of juvenile Yellowtail Snapper (*Lutjanus chrysurus*) from Brewer's Bay control, Mangrove Lagoon and Sprat Bay seagrass.

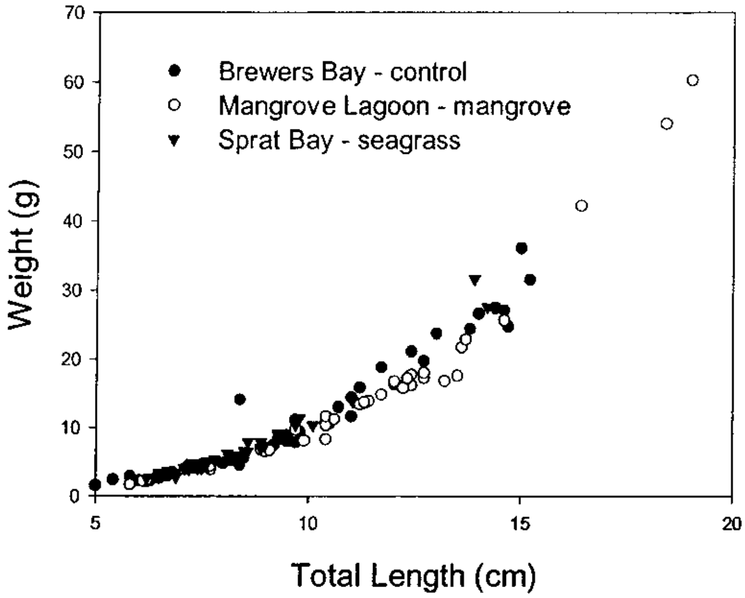

Figure 5: The relationship between total length and weight of yellowtail snapper from three nursery sites: Brewer's Bay, Sprat Bay, Mangrove Lagoon.

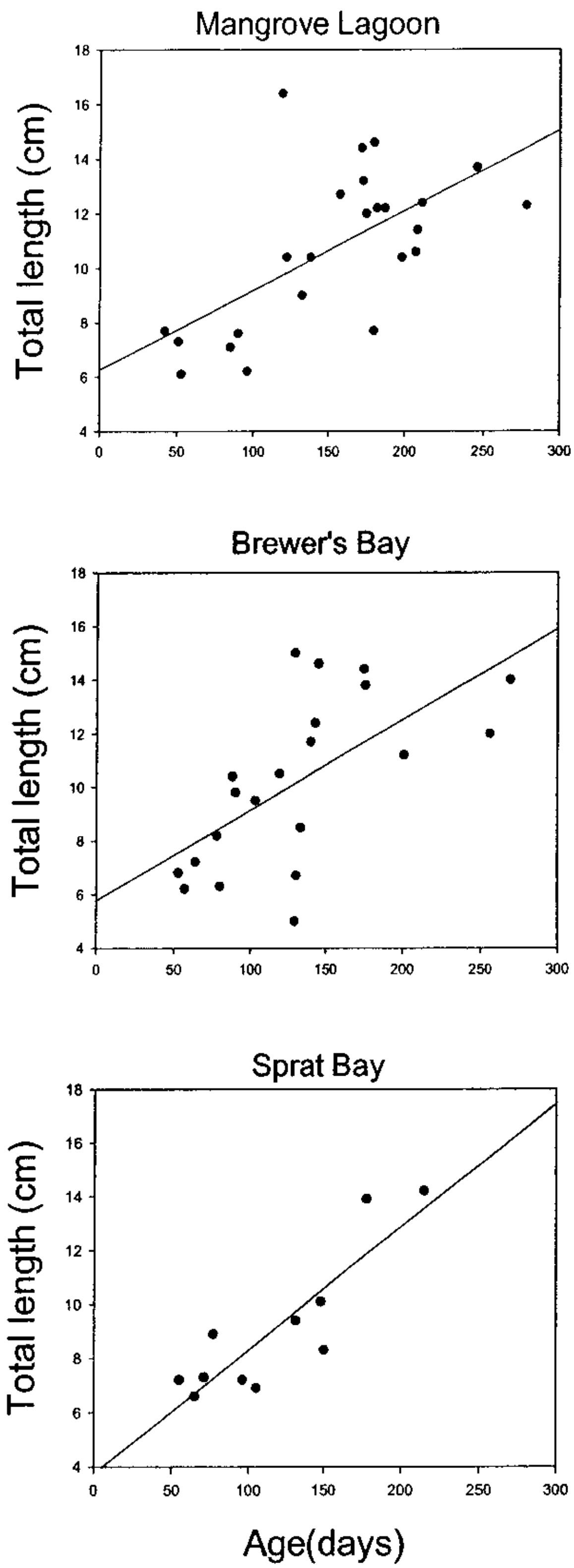

Figure 6. Relationship between size and age in Mangrove Lagoon mangrove habitat, Brewer's Bay control habitat and Sprat Bay seagrass habitat.

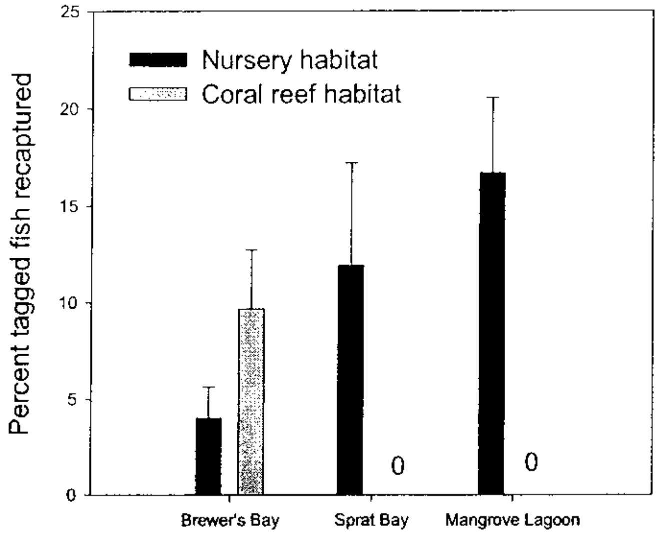

Figure 7: Retention of tagged juvenile Yellowtail Snappers (*Lutjanus chrysurus*) from the nursery (Brewers control, Sprat seagrass, and Mangrove mangroves) and coral reef habitats (Brewer's reef, Sprat reef, Mangrove reef).

Table 1: Summary data and progress of work conducted to October 30, 2004.

Site	# 30m fish Transects	# Fish caught	Otoliths removed	Otoliths polished	Otoliths mounted	Otoliths aged (1st/2nd/3rd/4th)	ICP-MS analysis mount	ICP-MS analysis polish & clean	ICP-MS analysis chemical analysis
0+ aged fish Year 2000									
Brewer's Bay control	36	48	48	43	40	26/15/7/3	15	15	15
Sprat Bay Sea Grass	30	54	54	54	17	16/15/12/8	15	15	15
Mangrove Lagoon False Entrance	24	40	44	38	29	28/15/12/7	15	15	15
Total 0+ fish	90	142	146	135	86	45/70	45	45	45
0+ aged fish Year 2001									
Brewer's Bay control	60	41	41	38	38	21/15/8/3	15	15	15
Sprat Bay Sea Grass	60	33	33	31	30	15/15/8/3	15	15	15
Mangrove Lagoon False Entrance	60	28	28	28	28	15/15/14/6	15	15	15
Total 1+ fish	180	102	102	97	96	45/51	45	45	45
1+ aged fish year 2000									
Brewer's Bay Reef	36	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sprat Bay Reef	30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mangrove Lagoon Reef	12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total 1+ fish	78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1+ aged fish year 2001	# 30m fish Transects	# Fish caught	Otoliths removed	Otoliths sectioned	Otoliths mounted	Otoliths aged	ICP-MS otoliths mounted	ICP-MS otoliths cleaned	ICP-MS otoliths analyzed
Brewer's Bay Reef	60	33	20	20	20	n/a	20	20	15
Sprat Bay Reef	61	29	10	10	10	n/a	10	10	10
Mangrove Lagoon Reef	60	25	20	22	22	n/a	20	20	15
Total 1+ fish	181	87	50	60	60	n/a	50	50	40

Tetracycline treated fish	Number of days at liberty	# otoliths removed	# with mark visible	# age validated
15	14	15	14 of 15	10 of 15