NOAA Technical Memorandum
NMFS-SEFC-66

NOAA/NMFS FINAL
REPORT TO DOE

# Shrimp and Redfish Studies, Bryan Mound Brine Disposal Site Off Freeport, Texas 1979-1981

A report to the Department of Energy on work conducted under provisions of Interagency Agreement DE-A10178US07146 during 1979-1981.

## Volume II
## SHRIMP MARK-RELEASE

FEBRUARY 1981

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Galveston Laboratory
Galveston, Texas 77550

# NOAA Technical Memorandum NMFS–SEFC- 66

# Shrimp and Redfish Studies; Bryan Mound Brine Disposal Site Off Freeport, Texas, 1979-1981.

## VOL. II -SHRIMP MARK-RELEASE INVESTIGATIONS

By

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A report to the Department of Energy on work conducted under provisions of Interagency Agreement DE-A10178US07146 during 1979-1981.

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U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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## NOTICE TO USERS

Work Unit 4 (Shrimp Mark-Release Investigations) involved the marking and releasing of shrimp. The contractor for Work Unit 6 (Interview Sampling Survey of Shrimp Catch and Effort) and the National Marine Fisheries Service, Southeast Fisheries Center's Galveston Laboratory and Technical Information Management Services were responsible for collecting and processing the data from recaptured tagged shrimp. Analyses of the mark-release-recapture data associated with the Bryan Mound brine disposal site will be conducted as part of an extension of Work Unit 4, which will begin in May 1981, with a final report to the Department of Energy in September 1982. These analyses will be performed to estimate rates of growth, mortality and migration of marked-released-recaptured shrimp for comparison with rates estimated for other regions of the Texas coast.

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Johnson, M. F. 1981. Shrimp mark-release investigations. Vol. II. In: Jackson, W. B. and E. P. Wilkens (eds.). Shrimp and redfish studies; Bryan Mound brine disposal site off Freeport, Texas, 1979-1981. NOAA Technical Memorandum NMFS-SEFC-66, 110 p. Available from: NTIS, Springfield, Virginia.

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## LIST OF VOLUMES

This Final Report is printed in six separate volumes:

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Work Unit 2 - Analysis of Data on Shrimping Success, Shrimp Recruitment and Associated Environmental Variables

Science Applications, Inc.

C. E. Comiskey

Work Unit 3 - Texas Coast Shrimp Catch and Effort Data Analysis

Science Applications, Inc.

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Volume VI - SHRIMP BIOASSAYS

Work Unit 8 - Brine Toxicity and Avoidance/Attraction Bioassays on Shrimp

University of Houston

N. R. Howe, Ph.D.

## INTRODUCTION

In compliance with the Energy Policy and Conservation Act of 1975, Title 1, Part B (Public Law 94-163), the Department of Energy (DOE) implemented the Strategic Petroleum Reserve (SPR) with the goal of storing a minimum of one billion barrels of crude oil. After evaluating several physical storage possibilities, DOE determined that storage in commercially developed salt dome cavities through solution-mining processes was the most economically and environmentally advantageous option.

Four coastal areas along the northwestern Gulf of Mexico were assessed for brine discharge into nearshore waters (Figure 1). This project, "Shrimp and Redfish Studies; Bryan Mound Brine Disposal Site off Freeport, Texas", deals with potential impacts of brine disposal from the Bryan Mound site. Under permit from the Environmental Protection Agency (EPA), this brine discharge site (Latitude 28° 44.28'N; Longitude 95° 14.64'W) was selected about 12.5 miles directly offshore of Bryan Mound.

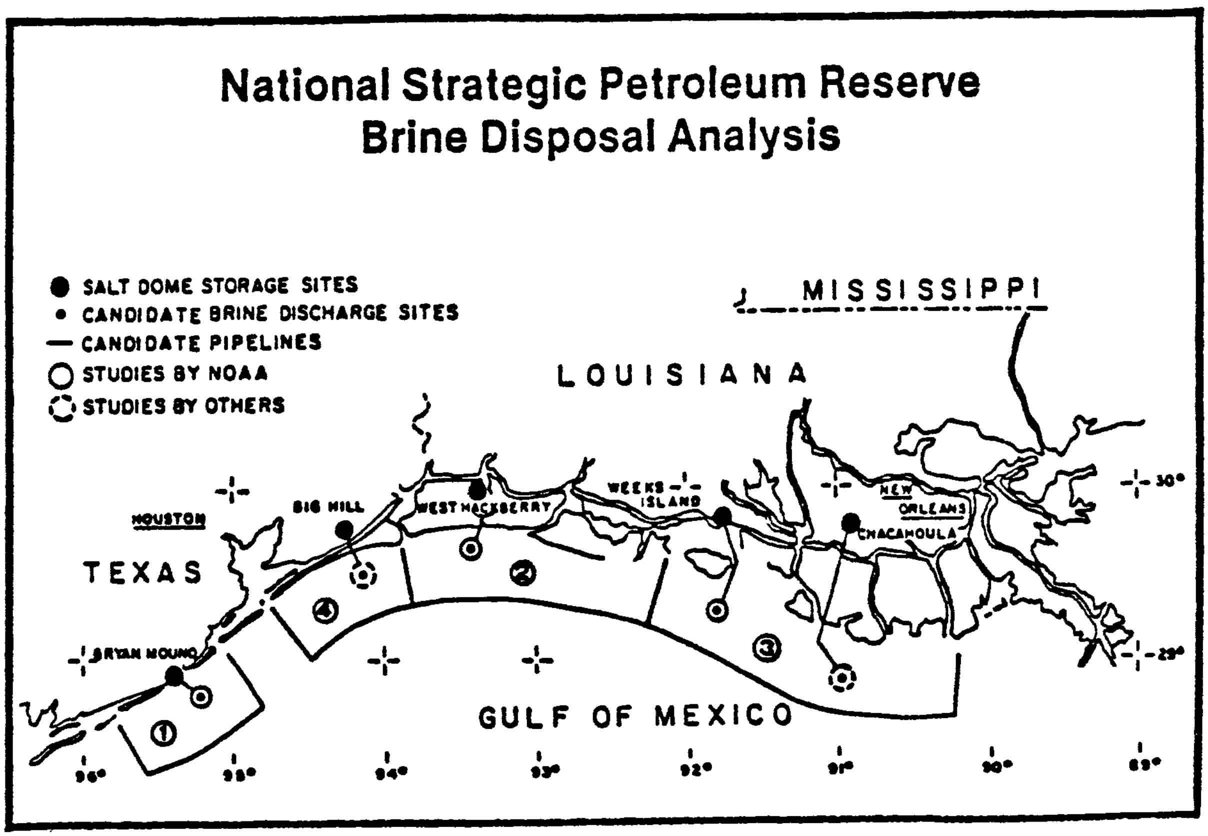


Figure 1. Regions of Study for Brine Disposal Assessment-DOE/NOAA Interagency Agreement (adapted from Environmental Data and Information Service, DOC/NOAA).

The process of creating a storage cavern within a salt dome involves dissolving the solid salts with raw water. The water source for leaching of the Bryan Mound salt dome is the Brazos River. Water from the Brazos River is piped under pressure into the dome. The resultant brine (dissolved salts) is discharged, at variable rates (over 100,000 barrels/day) into the Gulf of Mexico.

To complement the site-specific oceanographic and biological monitoring of brine disposal conducted by Texas A&M University, a regional assessment of important commercial and recreational fisheries was initiated in August, 1979. The objectives of this assessment were (1) to conduct a pre-discharge/post-discharge assessment of shrimp populations in relation to the Bryan Mound salt dome brine disposal site and (2) to determine acute toxicity and avoidance/attraction responses of shrimp and redfish to Bryan Mound brine. These objectives were achieved through field and laboratory investigations and through statistical analysis of the data. Specific studies included (1) analysis of data on shrimping success, shrimp recruitment and associated environmental variables, (2) analysis of Texas coast shrimp catch and effort data, (3) shrimp mark-release investigations, (4) shrimp spawning site survey, (5) interview sampling survey of shrimp catch and effort, (6) brine toxicity and avoidance/attraction bioassays on redfish and (7) brine toxicity and avoidance/attraction bioassays on shrimp.

The major products of the Shrimp and Redfish Studies are: Final Reports available through the National Technical Information Service (NTIS), Springfield, Virginia; data files available through the Environmental Data and Information Service (EDIS), Washington, D.C., and any publications that may be written by participating principal investigators and submitted to scientific or technical journals. Preliminary results have been made available through DOE/NOAA/NMFS project reviews and workshops attended by project participants and various governmental, private and public user groups.

The DOE has developed comprehensive Environmental Impact Statements listed below:

1. Strategic Petroleum Reserve - Seaway Group Salt Domes, June 1978, Final EIS, DOE/EIS-0021.

2. Strategic Petroleum Reserve - Bryan Mound Salt Domes, January 1977, Final EIS, FES 76/77-6.

3. Strategic Petroleum Reserve - Expansion of Reserve, January 1979, Final Supplement to Final EIS, FEA-FES-76-2.

All three reports are available from the U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161.

Texas A&M University (TAMU) has conducted studies of physical oceanography, sediments, water quality, benthos and nekton at the Bryan Mound brine disposal site from September, 1977 to February, 1979. In addition, TAMU has developed a towed sensing system for tracking the brine plume. Results of this research are available in:

Metzbower, H. T., S. S. Curry and F. A. Godshall. 1980. Handbook of the Marine Environment - Bryan Mound. NOAA Report to DOE Strategic Petroleum Reserve Program, Salt Dome Storage/Brine. 92 p.

The Massachusetts Institute of Technology (MIT) has developed a mathematical, 3-dimensional, hydrodynamic simulation model of the brine plume dispersion. The model and test-tank simulations have the capacity to evaluate effects of varying effluent discharge rates and currents and to identify various plume configurations and densities. Salinity dispersion was modeled showing that a dilution rate of 100:1 can be expected within 100 feet of the diffuser head. The MIT analyses are available in DOE's final Bryan Mound EIS (FES 76/77-6) listed earlier.

## LIST OF REPORTS AND PUBLICATIONS


Shrimp and Redfish Studies, Bryan Mound Brine Disposal Site off Freeport, Texas 1979-1981

Comiskey, C. E. 1981. Analyses of data on shrimping success, shrimp recruitment and associated environmental variables. Vol. I. In: Jackson, W. B. and E. Peter Wilkens (eds.). Shrimp and redfish studies; Bryan Mound brine disposal site off Freeport, Texas, 1979-1981. NOAA Technical Memorandum NMFS-SEFC-65. (In preparation).

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Owens, D. W. and J. M. Neff. 1981. Brine toxicity and avoidance/attraction bioassays on redfish. Vol. V. In: Jackson, W. B. and

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Biological/Chemical Survey of Texoma and Capline Sector Salt Dome Brine Disposal Sites off Louisiana, 1978-1979

Boehm, P. D. and D. L. Fiest. 1980. Determine hydrocarbons composition and concentration in major components of the marine ecosystem. Vol. VI. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-30, 136 p. Available from: NTIS, Springfield, Virginia.

Brooks, J. M. 1980. Determine seasonal variations in inorganic nutrient composition and concentration of the water column. Vol. VIII. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-32, 31 p. Available from: NTIS, Springfield, Virginia.

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Landry, A. M. and H. W. Armstrong. 1980. Determine seasonal abundance, distribution and community composition of demersal finfishes and macro-crustaceans. Vol. IV. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-28, 180 p. Available from: NTIS, Springfield, Virginia.

Margraf, F. J. 1980. Analysis of Variance of Gulf Coast shrimp data. Vol. IX. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-33, 293 p. Available from: NTIS, Springfield, Virginia.

Parker, R. H., A. L. Crowe and L. S. Bohme. 1980. Describe living and dead benthic (macro- and meio-) communities. Vol. I. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-25, 103 p. Available from: NTIS, Springfield, Virginia.

Reitsema, L. A. 1980. Determine seasonal abundance, distribution and community composition of zooplankton. Vol. II. In: Jackson, W. B. and G. M. Faw (eds.). Biological/chemical survey of Texoma and Capline sector salt dome brine disposal sites off Louisiana, 1978-1979. NOAA Technical Memorandum NMFS-SEFC-26, 133 p. Available from: NTIS, Springfield, Virginia.

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Caillouet, C. W., F. J. Patella and W. B. Jackson. 1980. Trends toward decreasing size of brown shrimp, *Penaeus aztecus*, and white shrimp, *Penaeus setiferus*, in reported annual catches from Texas and Louisiana. NOAA/NMFS Fishery Bulletin 77(4):985-989.

Caillouet, C. W., D. B. Koi and W. B. Jackson. (1981). Relationship between ex-vessel value and size composition of annual landings of shrimp from the Gulf and south Atlantic Coasts. Marine Fisheries Review (in press).

Caillouet, C. W. and D. B. Koi. (1981). Trends in ex-vessel value and size composition of annual landings of brown, pink and white shrimp from the Gulf and south Atlantic coasts of the United States. Marine Fisheries Review (in press).

# II. PRINCIPAL INVESTIGATORS' SECTION

# WORK UNIT 4 - SHRIMP MARK-RELEASE INVESTIGATIONS

M. F. Johnson, Ph.D.

LGL Ecological Research Associates, Inc.

ABSTRACT

Mark-release experiments were conducted from September to November 1979 during predischarge conditions, and May to July 1980 during brine discharge, to determine the effect of offshore disposal of brine from the Bryan Mound salt domes near Freeport, Texas on the survival and migration of brown shrimp (*Penaeus aztecus*) and white shrimp (*Penaeus setiferus*). Vinyl streamer tags were used to mark the shrimp. In fall 1979 20,232 juvenile white shrimp were released in West Bay (Galveston) and Matagorda Bay (Port O'Connor); 20,085 adult white shrimp and 7,928 adult brown shrimp were released offshore in the vicinity of the brine diffuser. In spring/summer 1980 20,571 juvenile brown shrimp were released in West Bay and Matagorda Bay and 22,222 adult brown shrimp were released offshore in the vicinity of the brine diffuser.

Experiments were conducted on pink shrimp (*Penaeus duorarum*) at 0.1 ha ponds at the Barney M. Davis power plant in Corpus Christi, Texas, to determine shrimp mortality due to tagging with streamer tags, tag loss frequency, growth inhibition, and altered predation by redfish (*Sciaenops ocellata*) as a result of tagging. Pink shrimp were used instead of brown or white shrimp because the latter two species were not present in sufficient numbers to permit the study to be performed at the time the ponds were available. There was no significant difference (p-value <0.05) in mortality between marked and unmarked shrimp in ponds with or without predators. Overall mortality was greater in the presence of predators. Pink shrimp mortality was primarily due to predation by birds. Bird predation was greater on pink shrimp marked with orange streamer tags than on those marked with black streamer tags. Increases in total length and total weight were significantly greater in shrimp marked with streamer tags plus fluorescent pigment than in shrimp marked with streamer tags only. In ponds without predators increase in total length (when adjusted for total weight gain) was significantly greater (p-value <0.05) in unmarked shrimp than in marked shrimp. In ponds containing predators increase in total length was significantly greater (p-value <0.05) in marked shrimp than in unmarked shrimp, whereas no significant difference in weight gain was seen between the unmarked and marked shrimp. Growth of unmarked shrimp was significantly greater (p-value <0.05) in ponds without predators.

Non-reporting of recaptured tagged shrimp, based on random interviews in September 1980, was estimated to be 23% among shrimpers, 6% among fish house employees and 1% among bait dealers. Non-reporting of tags, based on "planting" of tagged shrimp on conveyer belts while shrimp were being unloaded, was 90%.

Continuous bottom temperature measurements were initiated on 8 November 1979 at Buccaneer Gas and Oil Field (BGOF). Temperature data have been collected to date.

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ACKNOWLEDGEMENTS

The success of the tagging program is attributed to the dedication of the LGL technical staff, who worked long hours under adverse conditions to complete this project. Many thanks go to Frederick Lane, Wendy Leavens, Bradley Adams, George Dennis III, Don Plitt, Pamela Snodgrass and others for their high quality fieldwork.

Captain Ludwig Mezulic of the vessel *Tonya and Joe* is gratefully acknowledged. Many thanks go to bait dealers Mary Jo and Jimmy Hudson of the Port O'Connor Fishing Center Bait Camp and Rooster Collins of the West Bay Bait Camp for providing shrimp and permitting the use of their facilities for tagging.

Dr. Addison Lawrence, project leader of the Texas A&M Mariculture program is gratefully acknowledged for making the mariculture facilities at Central Power and Lighting's Barney M. Davis power plant available to LGL. Many thanks also go to David Hutchins, associate mariculture specialist, for assisting in the organization of the pond study and providing technical assistance for daily data collection.

Expert advice and assistance in data analysis and synthesis were provided by Dr. George Lewbel, Scott Anderson and Dr. Walter Campbell. Credit for the excellent job of typing and coordinating this report goes to Jean Erwin. Bonnie Bowers is gratefully acknowledged for the figures.

A special note of thanks goes to Larry Martin, the Project Manager, who was responsible for retrieving the continuous bottom temperature data and frequently served as liaison between National Marine Fisheries Service (NMFS) and the Principal Investigator.

## SECTION 1

## INTRODUCTION

In 1975 the United States Congress passed the Energy Policy Conservation Act directing the Department of Energy (DOE) to develop a Strategic Petroleum Reserve (SPR) Program. The DOE program involved leaching of salt domes to create caverns for storage of crude oil. The Bryan Mound salt dome near Freeport, Texas was selected as one such oil storage site.

The process of creating a storage cavern within the salt dome involves dissolving the solid salts with non-treated, natural water. The resultant brine is discharged into the Gulf of Mexico approximately 20.1 km (12.5 mi) directly offshore of Bryan Mound. Because of the potential impact of the brine on important commercial and recreational fisheries, the DOE is conducting a pre-discharge/post-discharge assessment of shrimp populations in relation to the Bryan Mound salt dome brine disposal site. The present study (Work Unit 4) involves the marking and releasing of brown shrimp (*Penaeus aztecus*) and white shrimp (*Penaeus setiferus*) both inshore and in areas that might be affected by the brine disposal (Fig. 1).

Marking experiments have been used for investigations on shrimp life history in the Gulf of Mexico since the 1930's. Lindner and Anderson (1956) described the early studies. Subsequent shrimp marking experiments are described by Menzel (1955); Costello (1959, 1964); Iversen and Idyll (1960), Klima (1964, 1965, 1974); Allen and Costello (1966); Knight and Berry (1967); Neal (1969); Clark et al. (1974); Welker et al. (1975); Knudsen et al. (1977) and Farmer and Al-Attar (1979).

Several techniques have been utilized to mark shrimp. The Petersen tag was used from 1935 through 1947 by Lindner and Anderson (1956), and later by McRae (1952), Iversen and Idyll (1960), Iversen and Jones (1961) Iverson (1962), Klima (1964), Welker et al. (1975) and Marullo et al. (1976). Several investigators used biological stains to mark shrimp (Menzel 1955; Dawson 1957; Costello 1959; Klima 1964, 1974; Allen and Costello 1966; Knight and Berry 1967; Neal 1969 and Welker et al. 1975). Since the biological stains could not be detected after 40 days, fluorescent pigments were developed as a secondary stain (Klima 1965). Knudsen et al. (1977) utilized fluorescent pigments exclusively in their shrimp marking experiments.

The inability to identify individuals with the staining technique was resolved by the use of small PVC internal tags that could be inserted into the musculature directly under the exoskeleton (Neal 1969). Tests comparing the recapture rates of shrimp tagged with Petersen tags and

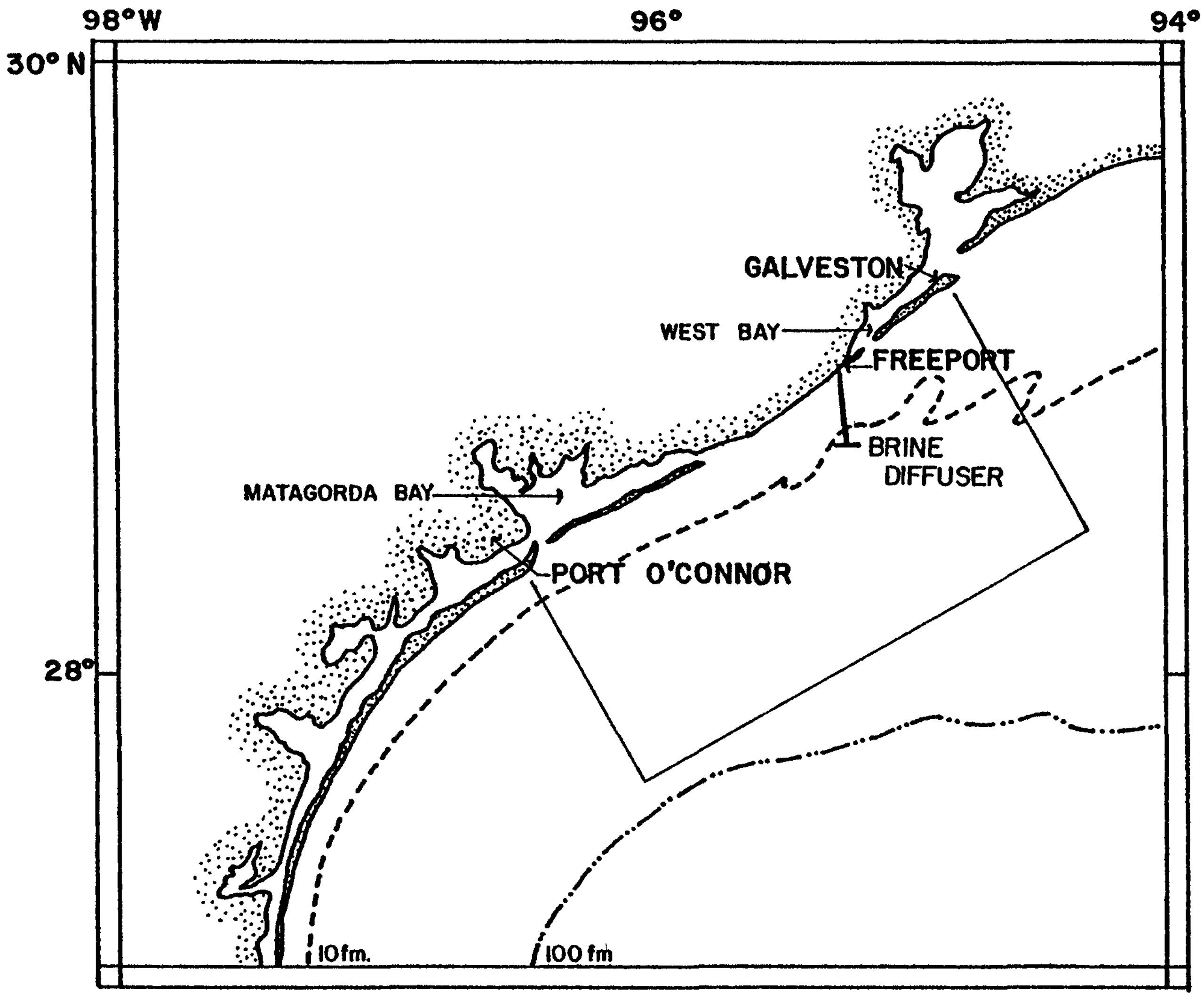



Fig. 1. Bryan Mound brine discharge site. The solid line between Port O'Connor and Galveston shows the area under study.

shrimp marked with stain and internal tags showed significantly higher returns with Petersen tags, so that the use of the Petersen tag was recommended for future mark-release experiments (Welker et al. 1975). Subsequently, a streamer tag was developed and tested by Marullo et al. (1976). The streamer tag manufactured by Floy Tag and Mfg., Inc. has been used in all mark-release studies by National Marine Fisheries Service (NMFS) since 1976 (Dennis Emiliani, pers. comm.). The streamer tag also has been utilized in mark-release experiments by Farmer and Al-Attar (1979), and was used in the present study.

## OBJECTIVES

The objectives of this study were to:

(1) tag and release juvenile and adult brown shrimp (*Penaeus aztecus*) and white shrimp (*Penaeus setiferus*), inshore and offshore, and day and night;

(2) determine mortality due to tagging;

(3) estimate tag loss;

(4) determine effect of tagging on growth;

(5) determine effect of tagging on predation by redfish (*Sciaenops ocellata*);

(6) estimate rates of non-reporting and non-recognition of recaptured tagged shrimp; and

(7) obtain continuous (hourly) bottom temperature measurements at Buccaneer Gas and Oil Field.

## SECTION 2

## SUMMARY

### INSHORE TAGGING

In fall 1979 10,125 juvenile white shrimp (*Penaeus setiferus*) were released in West Bay (Galveston) and 10,107 juvenile white shrimp were released in Matagorda Bay (Port O'Connor).

In spring/summer 1980 10,352 juvenile brown shrimp (*Penaeus aztecus*) were released in West Bay and 10,219 juvenile brown shrimp were released in Matagorda Bay.

### OFFSHORE TAGGING

In fall 1979 20,085 adult white shrimp and 7,928 adult brown shrimp were released offshore in the vicinity of the Bryan Mound diffuser.

In spring/summer 1980 22,222 adult brown shrimp were released offshore in the vicinity of the Bryan Mound diffuser.

### EXPERIMENTAL POND STUDY

Four 0.1 ha ponds at the Texas A&M Mariculture Facility located at Central Power and Lighting's (CP&L) Barney M. Davis Power Plant in Corpus Christi, Texas were utilized to determine shrimp mortality due to tagging, tag loss frequency, growth inhibition and altered predation as a result of tagging.

Pink shrimp (*Penaeus duorarum*) were used in the experimental pond study. Brown or white shrimp were not present in sufficient numbers to permit the study to be performed at the time the Texas A&M Mariculture facilities were available.

Five hundred pink shrimp were placed in two ponds without predators: 100 shrimp marked with streamer tags plus fluorescent pigment, 200 shrimp marked with streamer tags only, 200 unmarked shrimp.

One thousand pink shrimp were placed in two ponds: 250 shrimp marked with orange streamer tags, 250 shrimp marked with black streamer tags, 500 unmarked shrimp. Three redfish (*Sciaenops ocellata*) were used as predators and 509 small fish served as an alternative food source for the fish.

### Ponds without Predators

Statistical analyses were performed using two ponds as replicates.

There was no significant difference (p-value <0.05) in mortality among unmarked shrimp, shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only.

Tag loss was 0.25% among survivors.

Analysis of variance (ANOVA) and analysis of covariance (ANACOVA) were utilized to determine whether there were significant differences in growth (total length, total weight) between unmarked shrimp, shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only. The tests were two-tailed.

Increase in total length and total weight was significantly greater (p-value <0.05) in shrimp marked with streamer tags plus fluorescent pigment than in shrimp marked with streamer tags only. Total length gain (when adjusted for total weight gain) also was significantly greater in shrimp marked with streamer tags plus fluorescent pigment than in shrimp marked with streamer tags only.

Increase in total length (when adjusted for total weight gain) was significantly greater (p-value <0.05) in unmarked than marked shrimp.

### Ponds with Predators

Statistical analyses were performed using two ponds as replicates.

There was no significant difference at the 95% level of confidence in mortality between shrimp marked with orange streamer tags and shrimp marked with black streamer tags. However, the extensive bird predation may have affected the results.

There was no significant difference in mortality between unmarked shrimp and shrimp marked with streamer tags.

Tag loss was 1.4% among survivors.

Shrimp mortality was significantly greater (p-value <0.05) in the pond containing three redfish than in the pond containing two redfish.

Analysis of variance and analysis of covariance were utilized to determine whether there were significant differences in growth (total length, total weight) between unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags. The tests were two-tailed.

Based on interaction plots (ANOVA and ANACOVA), total length gain appeared to be greater in shrimp marked with black streamer tags than in shrimp marked with orange streamer tags. There was no significant difference in weight gain, at the 95% confidence level, between shrimp marked with orange streamer tags and shrimp marked with black streamer tags.

Increase in total length was significantly greater (p-value <0.05) in unmarked shrimp than in marked shrimp. However, there was no significant difference in weight gain between unmarked and marked shrimp.

Comparison of Ponds with and without Predators

Mortality was significantly greater in ponds containing redfish.

Tag loss was greater in ponds containing redfish and small fish.

Growth (total length and total weight) of unmarked shrimp was significantly greater in ponds without predators (two-tailed test).

Predation by Other Animals

Birds and other animals ate approximately 40% of the shrimp in the four ponds.

Approximately 78% of the tagged shrimp eaten by birds were marked with orange streamer tags.

## NON-REPORTING OF RECAPTURED TAGGED SHRIMP

Among the tagged shrimp collected by LGL port agents, 78% were received from shrimpers, 21% from fish house employees and less than 1% from bait dealers.

Random interviews with shrimpers, fish house employees and bait dealers in fall 1979 suggested that the degree of non-reporting of tags by shrimpers was 16%.

Random interviews with shrimpers, fish house employees and bait dealers in fall 1980 revealed 23% non-reporting of tags by shrimpers, 6% non-reporting of tags by fish house employees and 1% non-reporting of tags by bait dealers.

A total of 20 tagged shrimp were "planted" on conveyer belts at various ports along the Texas coast in September-October 1980. Only two of these tagged shrimp were recovered by fish house employees.

## CONTINUOUS TEMPERATURE MONITORING

From 8 November 1979 to the present, 182 days of temperature data have been collected.

## SECTION 3

## METHODS AND MATERIALS

### INSHORE TAGGING

The West Bay tagging operation was conducted at the West Bay Bait Camp near San Luis Pass (29°06'N, 95°07'W), and the Matagorda Bay tagging operation was conducted at the Port O'Connor Fishing Center Bait Camp (28°26'N, 96°25'W).

Juvenile shrimp were purchased at the bait camp and kept in holding tanks with continuously running seawater for a minimum of 4 h and a maximum of 36 h prior to tagging. Temperature and dissolved oxygen measurements were taken periodically to make certain that high water quality was being maintained. Dead shrimp were culled frequently to reduce the stress on the remaining shrimp.

Tagging tables for inshore tagging were constructed according to NMFS specifications (Dennis Emiliani, pers. comm.). Modified vinyl streamer tags (Fig. 2) were provided by the government (see Marullo et al. 1976 for descriptions of the streamer tags). The shrimp were transferred with dip-nets from the holding tank to plastic dish pans containing seawater for tagging. The tagging needle was dipped into a 10% mixture of tetracycline in petroleum jelly to reduce mortality due to infection, and inserted through the articular membrane between the first and second abdominal segments (Fig. 2) to reduce interference with ecdysis (Marullo et al. 1976). The tag was drawn through the shrimp until the lengths extending from each side were equal and the needle detached (Marullo et al. 1976). The tag number, species, sex and tail length (mm) of all shrimp were recorded on release data forms provided by the government. Missing and broken tags also were noted. The word "tank" was printed on the data sheet if the shrimp jumped into the holding tank before measurements were taken. Shrimp with necrotic tissue, softness, disease, etc., were not tagged. The marked shrimp were placed in a separate holding tank with running seawater and held for a minimum of 4 h prior to release. Dead tagged shrimp were culled frequently to reduce stress on the remaining shrimp. Temperature and dissolved oxygen measurements were checked periodically to make certain high water quality was being maintained.

In preparation for release of tagged shrimp, several ice chests were filled with fresh seawater. Approximately 50 tagged shrimp, in good condition, were placed in each ice chest. Moribund or dead shrimp were separated out at this time. Tagged shrimp were released near the sandy bottom in West Bay, and near *Spartina* beds and black mangrove bushes in Matagorda Bay. Half of the shrimp were released at night and half during the day. The time, location (latitide-longitude) and depth

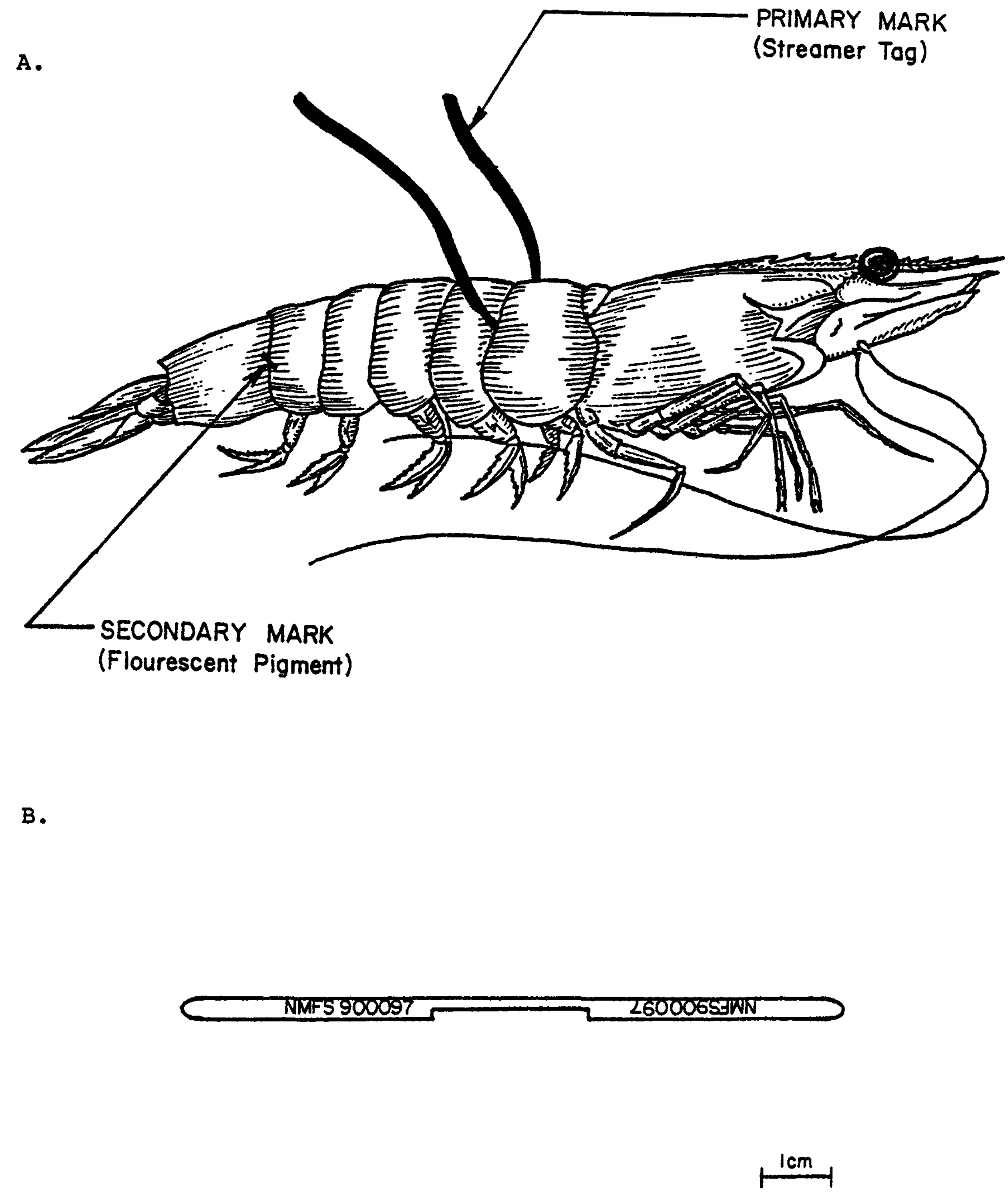



Fig. 2. A. Position of streamer tag and fluorescent pigment in marked shrimp. B. Illustration of streamer tag (actual size).

of release were recorded. Salinity, temperature and dissolved oxygen were recorded at the release site. Salinity was measured with an American Optical Salinity-Refractometer. Temperature and dissolved oxygen were recorded with a Yellow Springs Instrument oxygen meter (Model #54A). Water samples were collected in small jars for turbidity measurements and analyzed in the laboratory using a Hach Turbidimeter (Model #2100a).

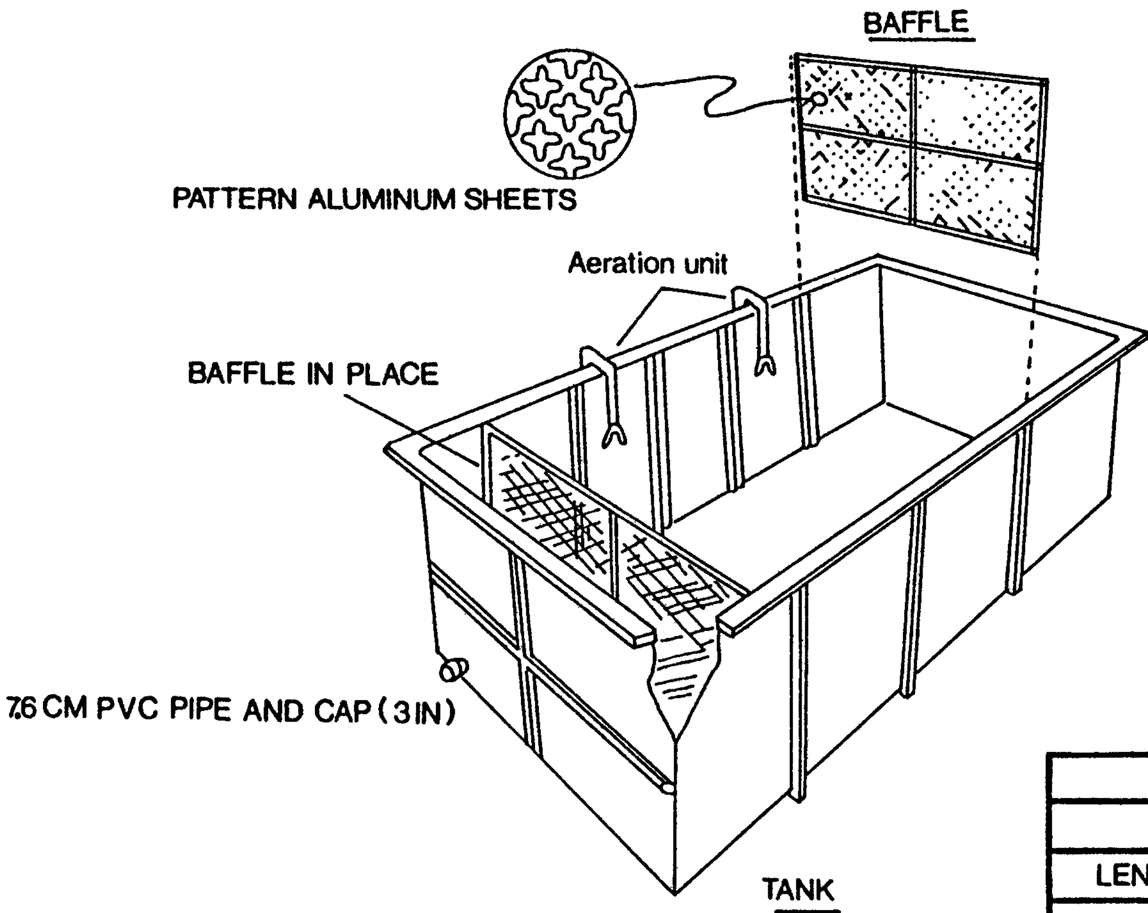
Tags were removed from dead and moribund shrimp and tag numbers recorded. A sample of 200 shrimp was collected each day to determine size distributions of shrimp. Tail length (mm), total length (mm), tail weight (g) and total weight (g) were recorded on data sheets provided by the government.

OFFSHORE TAGGING

The vessel *Tonya and Joe* was used for all offshore operations. Adult shrimp were collected in 15-min trawl tows using a 40' trawl. The live shrimp were immediately placed in a large ice chest filled with fresh seawater and transferred to one of the holding tanks equipped with a circulating seawater aeration system (Fig. 3). The intake of the water pump was attached to the drain of one tank and the outlet led to aspirator aeration units. Two aspirator aeration units were used per tank. Tanks were fitted with five baffle/dividers to decrease surge due to vessel roll and provide additional areas for the shrimp to rest. The holding tanks were filled with fresh seawater and the water level maintained by an adjustable standpipe. Two of the tanks were connected in series with 3" PVC pipe and flexible hose. Connections were secured by band clamps. The third tank was attached to a separate pump.

A maximum of 250 shrimp was placed in each of the four compartments in order of time of collection so that tagging generally could begin soon after trawling was completed. Shrimp were held a minimum of 4 h and a maximum of 36 h before tagging. A removable table top described by Emiliani (1971) was placed over the holding tank for the tagging operation. The procedures followed for holding the shrimp prior to tagging, the tagging operation, and holding the tagged shrimp were the same as those described for inshore tagging.

Prior to release of the shrimp, plastic release canisters were assembled (see Emiliani 1971). Between 50 and 75 shrimp were transferred from the holding tanks into a mesh counter box using a dip net. Moribund or dead shrimp were separated out at this time. Shrimp were loaded in the canister which was then sealed and released at the surface of the water. The cement block attached to the canister forced it to the bottom, and within 5-15 min the shrimp were released at the sea bottom (using a dissolving salt block trigger mechanism--see Emiliani 1971). All releases were made at ¼-½ mi intervals in the vicinity of the Bryan Mound Diffuser (28°43'42"N, 95°14'27"W). The release route was determined by the NMFS field party chief. Loran C stations, latitude-longitude and depth (fm) were recorded at each release site. Temperature, dissolved oxygen and conductivity readings were obtained at the location of the




| TANK DIMENSIONS (INSIDE) | | |
|---|---|---|
| | TOP | BOTTOM |
| LENGTH | 21M (7FT) | 20M(6.8FT) |
| WIDTH | 12M(4FT) | 11M(3.8FT) |
| DEPTH | 08M(2.7FT) | |

Fig. 3. The shrimp holding tank and baffle/dividers (modified from Emiliani, 1971).

first release, middle release and last release using a Hydrolab System 8000. Hydrolab measurements also were taken periodically in the holding tanks to make certain high water quality was being maintained. A sample of 200 shrimp was collected daily for length/weight analysis.

EXPERIMENTAL POND STUDY

Studies to determine the effect of tagging on shrimp mortality, growth and predation were planned for late autumn 1979 at the 0.1 ha ponds at Houston Lighting and Power (HL&P) Cedar Bayou Stream Electric Generating Station. However, the facilities and personnel were not available at that time. It was discovered that the ponds at the Texas A&M Mariculture facility at the CP&L Barney M. Davis Power Plant in Corpus Christi would be available from late February to early April 1980. During these months brown and white shrimp were rare in the bait shrimp catch, whereas pink shrimp (*Penaeus duorarum*) were abundant. Because of the limited availability of the ponds, pink shrimp were substituted for brown or white shrimp.

Two adjacent 0.1 ha earthen ponds (12 and 14), ranging from 0.3-1.0 m in depth were utilized for the tag mortality-tag loss experiment. The methodology of Marullo et al. (1976) was utilized.

Pink shrimp were purchased at Billings Bait Camp in Corpus Christi. Temperature and dissolved oxygen in the holding tanks at the bait camp were recorded with an oxygen meter (Yellow Springs Instruments Model #54A). Salinity was measured with an American Optical Salinity-Refractometer. The shrimp were transferred in seawater to ice chests. Snorky pumps (De Drannek Products) or SCUBA tanks were used to aerate the seawater in the ice chests during transport of the shrimp to the holding tanks at the power plant. Salinity, temperature and dissolved oxygen were checked in the holding tanks prior to transfer and the shrimp were acclimated, when necessary to prevent undue stress. The shrimp were held in circular tanks 2.4 m and 3.7 m in diameter with continuously circulating aerated seawater, for a minimum of 4 h and a maximum of 36 h.

The shrimp were subjected to one of three possible treatments: (1) streamer tag only, (2) streamer tag plus fluorescent pigment (for the determination of tag loss), or (3) unmarked (control). The shrimp were tagged using the method previously described for inshore tagging. A mixture of 1 g fluorescent pigment (Neon Red-Day Glo Fluorescent Pigment, Switzer Bros., Inc.) in 9 g petroleum jelly was injected into the tissue between the 5th and 6th abdominal segments (Fig. 2) using a 1 cc Tuberculin syringe and Luer-lok 27 gauge, ¼" needle (Dennis Emiliani, pers. comm.). Sufficient stain was injected to form a minute dot of color. The sex, tag number (where applicable), tail length (mm), total length (mm), total weight (g) and presence of pigment (where applicable), were recorded for each shrimp. Weight was recorded to the nearest 0.1 g on an electronic top-loading balance (Ainsworth Division). Each of the three groups of shrimp was kept in a separate 1.8 m or 2.4 m holding tank for a minimum of 4 h.

In preparation for release, ice chests were filled with pond water. The shrimp were counted as they were transferred to the ice chests. Dead and moribund shrimp were removed at this time. A total of 500 shrimp were placed in each of two ponds (12 and 14): 200 shrimp with streamer tags; 100 shrimp with streamer tags plus fluorescent pigment; and 200 controls (unmarked). Three lbs of experimental Marine Ration 20 (Ralston Purina Co.)were distributed to each pond daily. The feeding schedule was determined by the average weight of the shrimp and the number of shrimp in each pond (David Hutchins, pers. comm.). Salinity, temperature and dissolved oxygen were recorded daily at the shallow end, and at the surface and bottom of the deep end of the ponds by the staff of the Texas A&M Shrimp Mariculture Facility. The perimeter of the ponds also was searched daily for loose tags, and the tag number and date of recovery recorded.

The two ponds were drained after 30 days. Most of the shrimp were caught in a filter bag placed over the drainpipe. The mud bottom of the ponds also was closely examined for shrimp. The recovered shrimp were separated into three groups by treatment. All unmarked shrimp were examined for tag loss by looking for fluorescent pigment with ultra-violet light and by closely examining the abdominal area at the site of tag insertion. The sex, tail length (mm), total length (mm), and total weight (g) were recorded for all recovered shrimp. Growth and survival among the three treatments were determined.

A second experiment was conducted at the 0.1 ha ponds to determine the effect of streamer tags on predation by redfish (*Sciaenops ocellata*). One thousand pink shrimp were placed in each of the two ponds ( 11 and 13): 250 shrimp with orange streamer tags, 250 shrimp with black streamer tags, and 500 unmarked shrimp. The different colors were used to determine whether tag color had any effect on predation by redfish. Orange and black were chosen since they were being used in the mark-release experiments in the field. Twelve redfish, approximately 350 mm in length, were purchased and three in the best condition, were placed in each of the two ponds. Total lengths (mm) of the redfish were recorded. In addition, 509 small fish (approximately 60% mullet and 40% cyprinidonts) were placed in each of the two ponds as an alternative food source for the redfish. The small fish were captured with a cast net. Salinity, temperature and dissolved oxygen of the ponds were recorded daily; the perimeter of the ponds also was searched for tags. The ponds were drained after 30 days. All recovered shrimp were weighed and measured. Growth and survival were determined for each treatment. Total length of the redfish was recorded and gut contents were analyzed for the presence of shrimp and tags.

Data Analysis

Chi-square contingency tests were utilized to determine whether significant differences in survival existed among treatments. The G-test (Sokal and Rohlf 1969) also was performed on the data. The two tests gave similar results for all the parameters tested. In ponds 12 and 14 the treatments consisted of (1) unmarked shrimp (controls), (2) shrimp marked with streamer tags plus fluorescent pigment, and (3) shrimp marked with streamer tags only. In pond 11 and 13 the treatments consisted of (1) unmarked shrimp (controls), (2) shrimp marked with orange streamer tags, and (3) shrimp marked with black streamer tags.

Factorial analysis of variance (ANOVA) and factorial analysis of covariance (ANACOVA) were performed to determine if significant differences in growth existed among the treatments. The "General Linear Models Procedure" of Statistical Analysis Systems (SAS) (1979) was utilized. In order to compare unmarked shrimp with marked shrimp all the data were corrected for the initial group means within each pond-treatment. However, when tagged shrimp only were compared (e.g. streamer tag plus fluorescent pigment *vs.* streamer tag only) the uncorrected data (i.e. actual length and weight gain) were used.

The design for the factorial analysis of variance of growth of the treatment and unmarked survivors in ponds 12 and 14 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 673 | Total number survivors in ponds 12 and 14 |
| Pond | 1 | 12 x 14 |
| Treatment | 2 | Unmarked x streamer tag plus pigment x streamer tag only |
| Pond x Treatment | 2 | (2 x 1) |
| Residual | 668 | (673 - 5) |

The design for the factorial analysis of covariance of growth of the treated and unmarked survivors in ponds 12 and 14 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 673 | Total number survivors in ponds 12 and 14 |
| Weight | 1 | Covariate |
| Pond | 1 | 12 x 14 |
| Treatment | 2 | Unmarked x streamer tag plus pigment x streamer tag only |
| Pond x Treatment | 2 | (2 x 1) |
| Residual | 667 | (673 - 6) |

The design for the factorial analysis of variance of growth of the treated survivors in ponds 12 and 14 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 396 | Number of treated survivors in ponds 12 and 14 |
| Pond | 1 | 12 x 14 |
| Treatment | 1 | Streamer tag plus pigment x streamer tag only |
| Pond x Treatment | 1 | (1 x 1) |
| Residual | 393 | (396 - 3) |

The design for the factorial analysis of covariance of growth of the treated survivors in ponds 12 and 14 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 396 | Number of treated survivors in ponds 12 and 14 |
| Weight | 1 | Covariate |
| Pond | 1 | 12 x 14 |
| Treatment | 1 | Streamer tag plus pigment x streamer tag only |
| Pond x Treatment | 1 | (1 x 1) |
| Residual | 392 | (396 - 4) |

The design for the factorial analysis of variance of growth of the treated and unmarked survivors in ponds 11 and 13 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 676 | Total number of survivors in ponds 11 and 13 |
| Pond | 1 | 11 x 13 |
| Treatment | 2 | Unmarked x orange streamer tag x black streamer tag |
| Pond x Treatment | 2 | (2 x 1) |
| Residual | 671 | (676 - 5) |

The design for the factorial analysis of covariance of growth of the treated and unmarked survivors in ponds 11 and 13 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 676 | Total number of survivors in ponds 11 and 13 |
| Weight | 1 | Covariate |
| Pond | 1 | 11 x 13 |
| Treatment | 2 | Unmarked x orange streamer tag x black streamer tag |
| Pond x Treatment | 2 | (2 x 1) |
| Residual | 670 | (676 - 6) |

The design for the factorial analysis of variance of growth of the treated survivors in ponds 11 and 13 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 341 | Number of treated survivors in ponds 11 and 13 |
| Pond | 1 | 11 x 13 |
| Treatment | 1 | Orange streamer tag x black streamer tag |
| Pond x Treatment | 1 | (1 x 1) |
| Residual | 338 | (341 - 3) |

The design for the factorial analysis of covariance of growth of the treated survivors in ponds 11 and 13 is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 341 | Number of treated survivors in ponds 11 and 13 |
| Weight | 1 | Covariate |
| Pond | 1 | 11 x 13 |
| Treatment | 1 | Orange streamer tag x black streamer tag |
| Pond x Treatment | 1 | (1 x 1) |
| Residual | 337 | (341 - 4) |

The experimental design for the factorial analysis of variance of growth of unmarked shrimp in ponds with redfish predators (11 and 13) and ponds without redfish predators (12 and 14) is:

| Source | Degrees of Freedom | Explanation |
|---|---|---|
| Total | 611 | Total number of unmarked survivors in ponds 11,12,13,14 |
| Treatment | 1 | Unmarked survivors in ponds 12-14 combined x unmarked survivors in ponds 11-13 combined |
| Residual | 610 | (611 - 1) |

NON-REPORTING OF RECAPTURED TAGGED SHRIMP

To estimate degree of non-reporting of recaptured tagged shrimp by shrimpers, three methods were used. First, all tagged shrimp returned to LGL port agents at each port (Galveston, Port Bolivar, Kemah, Freeport, Palacios, Port Lavaca, Port O'Connor, Rockport-Fulton and Aransas Pass) were categorized according to point of discovery (shrimper, fish house [includes unloading dock, packing plant, etc.] and bait dealer). The second method involved random interviews with shrimpers, fish house employees and bait dealers at each of the above ports after completion of the fall 1979 tagging operation and spring/summer 1980 tagging operation. Three individuals in each category were interviewed, where possible. At the time of the 1979 interviews most bait stands were closed for the winter season and only a small number of shrimp boats were operating, making it difficult to find subjects to question. Each person was asked the same questions. In the 1979 survey the questions asked were: (1) "Are you familiar with the tagging program?" and (2) "What percent of the tagged shrimp recovered are not reported by shrimpers?" In the 1980 survey question #2 was revised. Shrimpers were asked "What percent of tagged shrimp recovered in the trawls are not reported by shrimpers?" Fish house employees were asked "What percent of the tagged shrimp found in the fish house are not reported by fish house employees?" Bait dealers were asked "What percent of tagged shrimp recovered by bait dealers are not reported?" Each of the individuals questioned also was asked his opinion of the tagging program.

An additional method for determining non-reporting of tags was initiated after the completion of the summer 1980 tagging effort. Tagged shrimp were "planted" on conveyer belts as shrimp were being unloaded from vessels. This procedure is similar to that described by Klima (1974). The number of shrimp "planted" at each port is as follows: five at Brownsville, five at Aransas Pass and ten at Freeport. A record of the tag numbers of the "planted" shrimp was given to Mr. Neal Baxter of NMFS so that the principal investigator would be notified if any of the 20 tagged shrimp were recovered.

## CONTINUOUS BOTTOM TEMPERATURE MEASUREMENTS

Continuous bottom temperature measurements were taken at Buccaneer Gas and Oil Field at a depth of 12 fm. A Hydrolab System 8000 water quality analyzer with a temperature sensor and internal memory was utilized. Measurements were taken at hourly intervals. The instrument was serviced monthly, weather permitting. Collection of the data began on 8 November 1979 and will continue for the duration of the study.

SECTION 4

# RESULTS AND DISCUSSION

## INSHORE AND OFFSHORE SHRIMP TAGGING

The expected numbers and species of tagged shrimp to be released, location and month of release are shown in Table 1. The actual numbers of white shrimp (*Penaeus setiferus*) and brown shrimp (*Penaeus aztecus*) released and dates of the inshore fall 1979 and spring/summer 1980 tagging effort are shown in Table 2. A total of 10,125 juvenile white shrimp was released in West Bay in fall 1979. A total of 10,107 juvenile white shrimp was released in Matagorda Bay in fall 1979. The average mortality of white shrimp tagged inshore was 13% prior to release.

A total of 10,352 juvenile brown shrimp was released in West Bay in spring/summer 1980. A total of 10,219 juvenile brown shrimp was released in Matagorda Bay in spring/summer 1980. The average mortality of tagged brown shrimp prior to release was 12%. The short term tagging mortality was similar in the two species.

The numbers of white shrimp and brown shrimp released offshore in the vicinity of the Bryan Mound diffuser are shown in Table 3. A total of 20,085 adult white shrimp was released in fall 1979. Attempts also were made to release 10,000 adult brown shrimp. However, the insufficient supply of brown shrimp in the northwestern Gulf of Mexico in late autumn resulted in the release of only 7,928 adult brown shrimp in fall 1979. The additional 2,072 brown shrimp were released during the 1980 tagging effort. The average mortality of the tagged shrimp prior to release was 3%.

A total of 22,222 adult brown shrimp was released in the vicinity of the Bryan Mound Diffuser in spring/summer 1980. The average mortality of the tagged shrimp prior to release was 5%. The increase in short-term tagging mortality in the summer was probably attributable to the higher seawater temperature.

Table 4 shows the total number of completed data forms submitted by LGL for the fall 1979 and spring/summer 1980 tagging operations inshore and offshore. Table 5 shows the number of shrimp used for length/weight measurements. It was not always possible to obtain the required 200 shrimp/day. The major problem was lack of shrimp, but freezer malfunction and damaged shrimp (broken telson or rostrum in freshly molted individuals) also resulted in a loss of measurable shrimp.

During the fall 1979 and spring/summer 1980 offshore and inshore tagging effort, temperature, salinity and dissolved oxygen were frequently measured in the holding tanks to ensure high water quality. In addition to these periodic measurements, temperature, salinity (inshore), conductivity (offshore) and dissolved oxygen were recorded at the time of release in the holding tanks and at the release site. Water samples also were collected for turbidity measurements. Table 6 shows the numbers of samples of hydrological data collected inshore and offshore in 1979 and 1980. Tables 7, 8 and 9 are summaries of the depth, temperature, salinity, dissolved oxygen and turbidity of the seawater at the release site at Matagorda Bay, West Bay and Bryan Mound diffuser, respectively, at the time of the first release of tagged shrimp each day. Figures 4-11 illustrate the daily release routes during one of the offshore trips (22-29 July 1980), and the points at which seawater was analyzed. Further information on the location and depth of all shrimp releases during the study period can be obtained from Mr. Neal Baxter (NMFS, Galveston, Tx). Additional hydrological data for the holding tanks and release sites are on file at NMFS (NSTL Station, Mississippi, Attention: Mr. Hillman Holley).

Recapture information from LGL tagged shrimp releases was coded and prepared for computer analysis by the staff of Mr. Neal Baxter (NMFS, Galveston, Tx). Table 10 shows the percent recovery of brown and white shrimp marked and released by LGL in 1979 and 1980. Figures 12 and 13 illustrate the location of recaptures of white shrimp and brown shrimp, respectively, released offshore in the vicinity of the Bryan Mound Diffuser in fall 1979. The data in these figures are based on recaptures up to 18 April 1980.

## EXPERIMENTAL POND STUDY

### Hydrology

Daily measurements of water temperature, salinity and dissolved oxygen in the four 0.1 ha ponds at the Barney M. Davis Power Plant used in the tag mortality, tag loss and predation study are shown in Tables 11-14. Water chemistry was similar in ponds 12 and 14, used as replicates in the tag mortality-tag loss study. Variations in water temperature between the two ponds were less than 1.0 C (Fig. 14). Ponds 11 and 13, replicates in the predation mortality experiment, showed somewhat greater variations in water temperature. Temperature differences as much as 2.0 C existed between the two ponds (Fig. 15). Water temperature was generally lower in pond 11 because less heated water flowed into this pond (David Hutchins, pers. comm.).

### Tagging Mortality-Tag Loss

#### Survival

The percent survival of pink shrimp (*Penaeus duorarum*) after 30 days in ponds 12 and 14 is shown in Table 15 and Fig. 16. In pond 12 survival was somewhat higher in the unmarked shrimp (controls) than in the marked

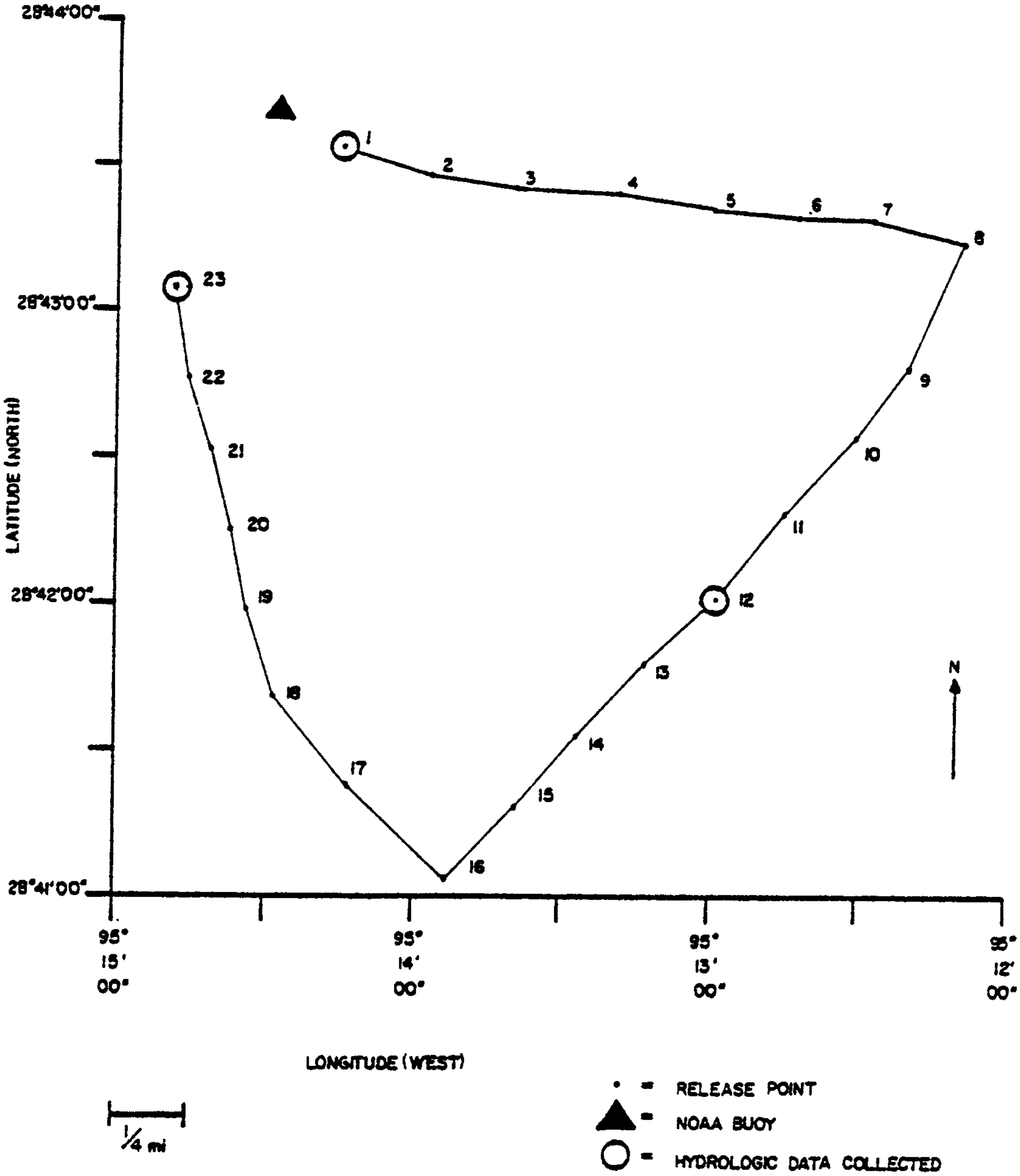



Fig. 4. Location of tagged shrimp releases on 22 July 1980.

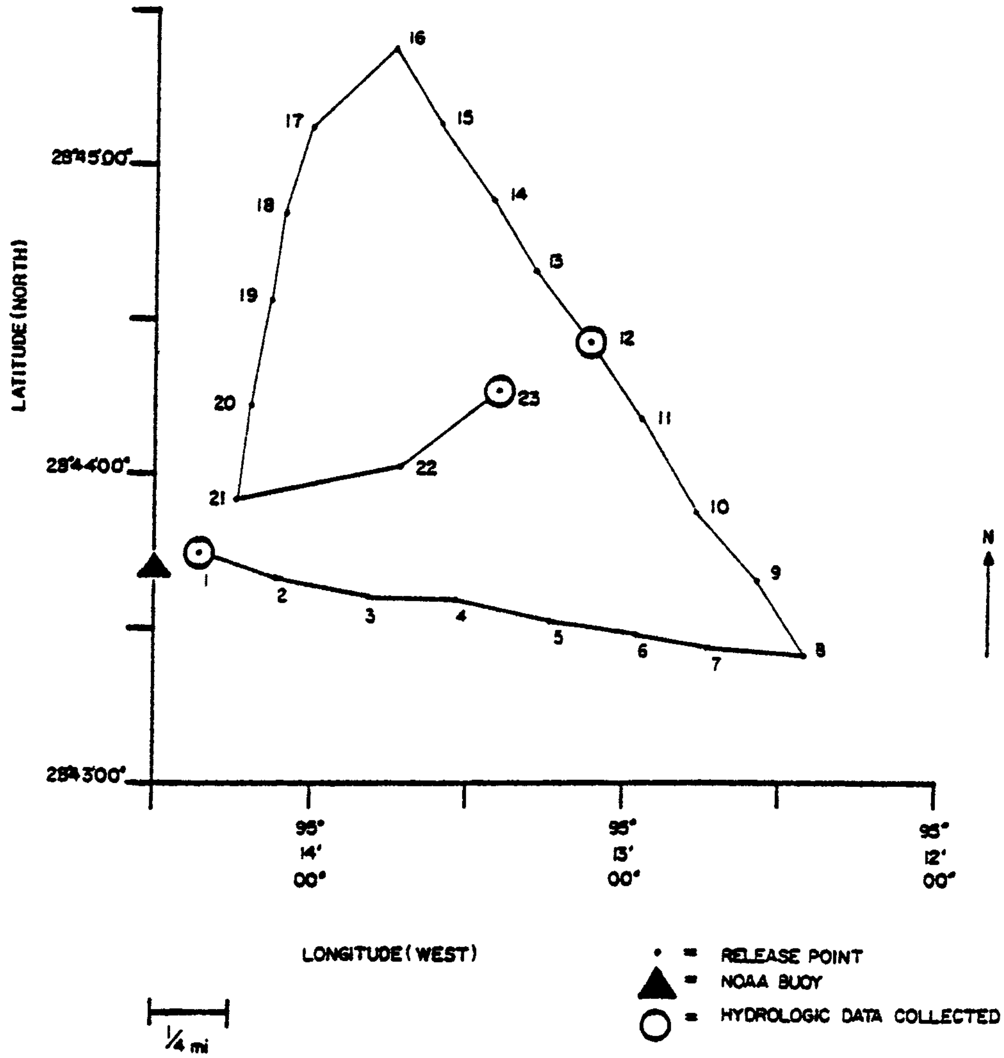



Fig. 5. Location of tagged shrimp releases on 23 July 1980.

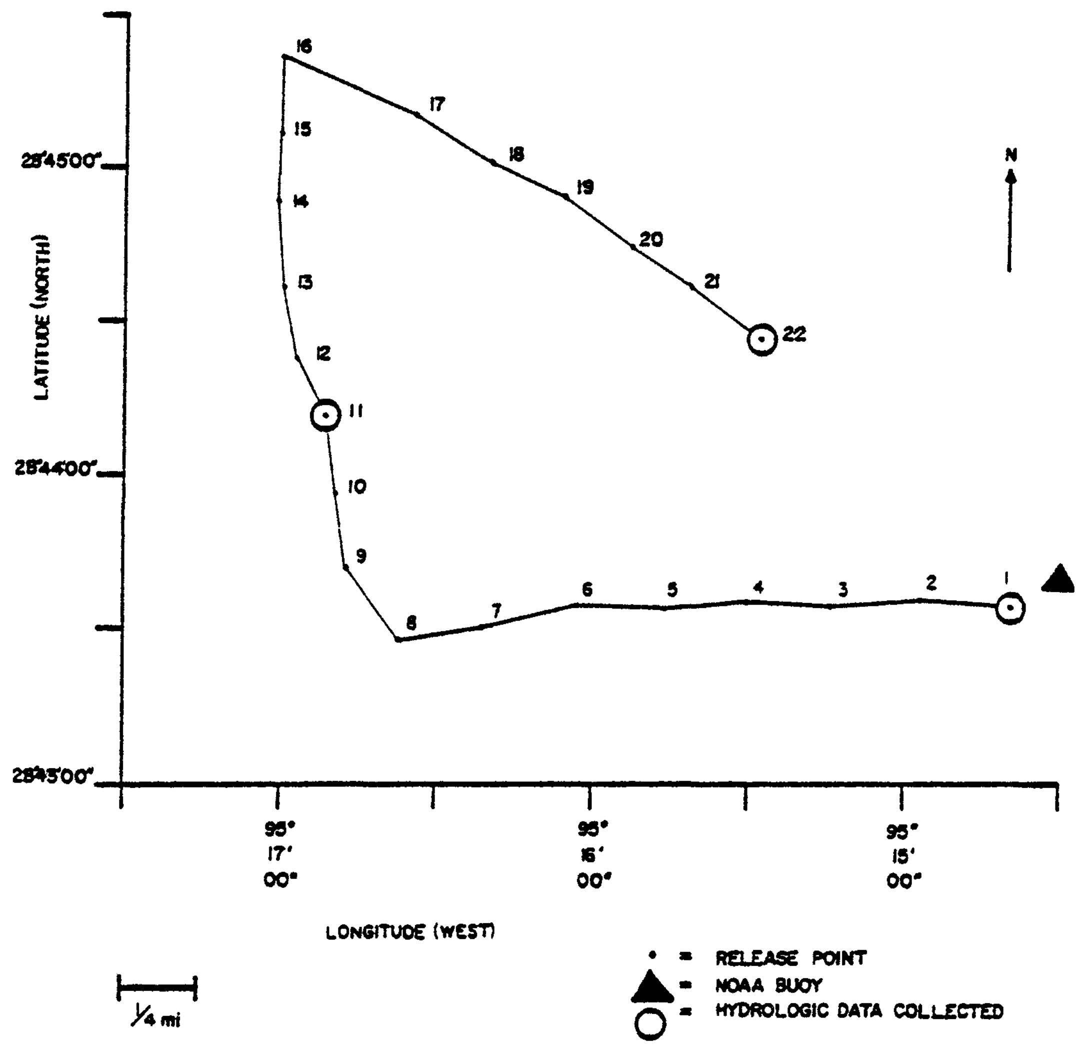



Fig. 6. Location of tagged shrimp releases on 24 July 1980.

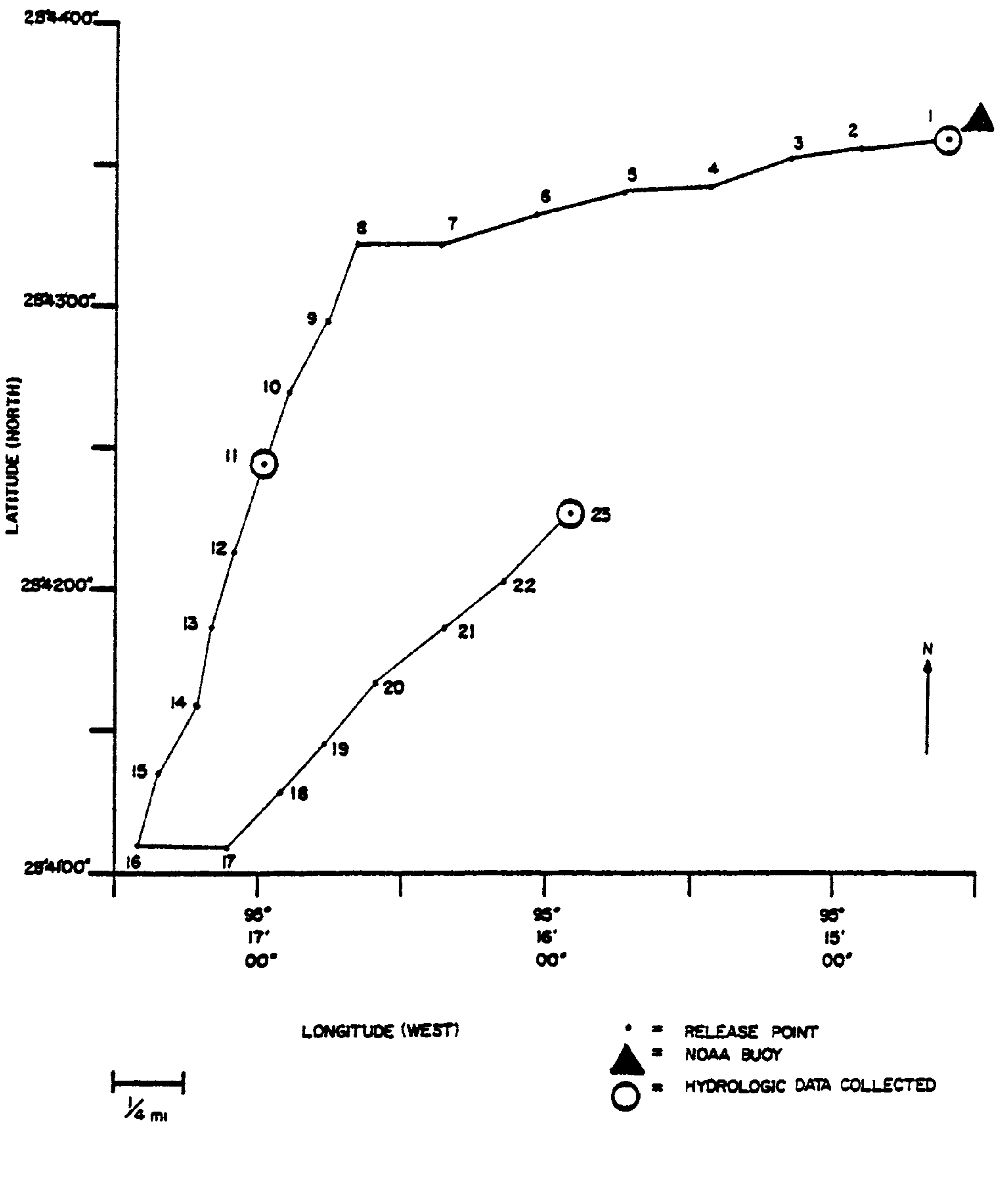



Fig. 7. Location of tagged shrimp releases on 25 July 1980.

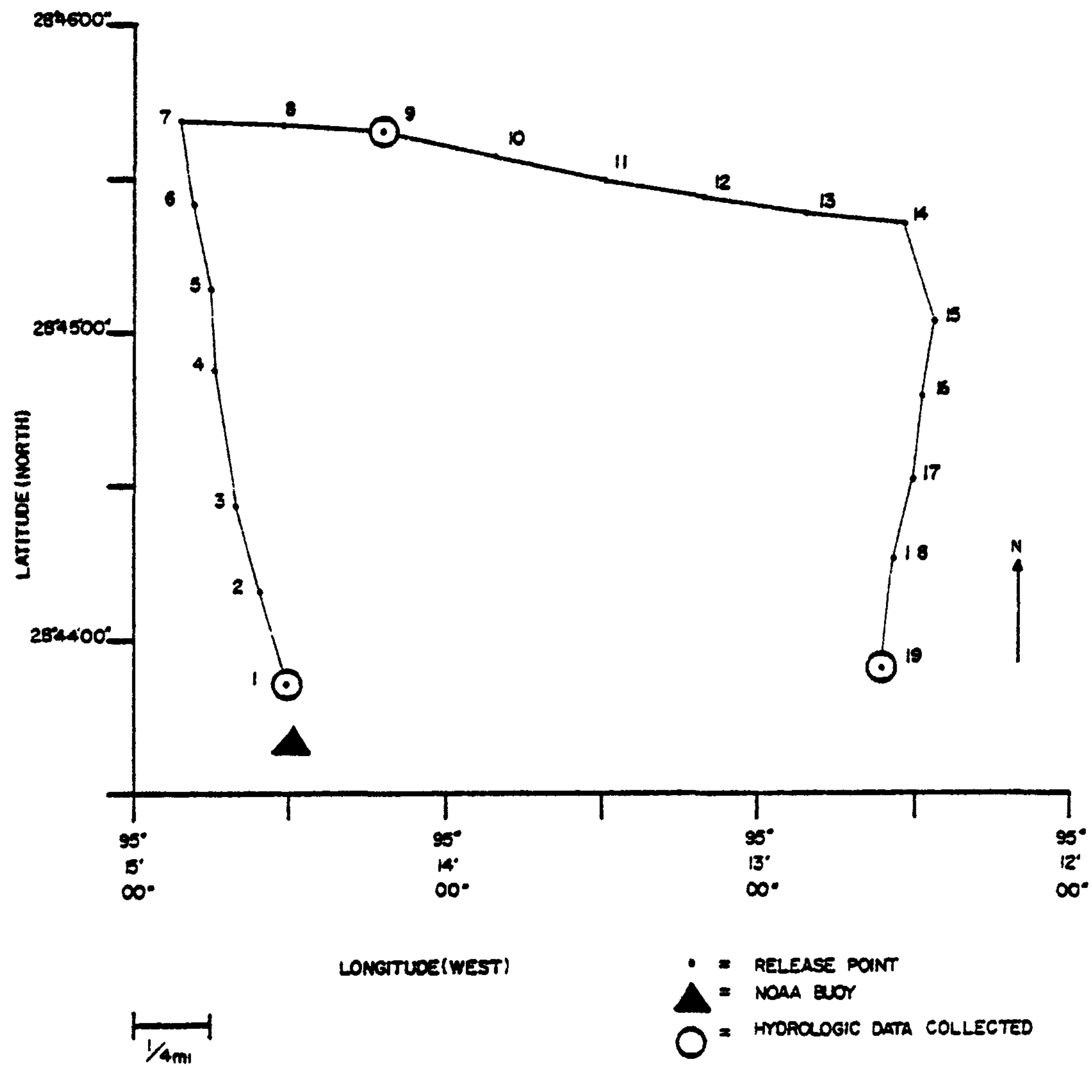



Fig. 8. Location of tagged shrimp releases on 26 July 1980.

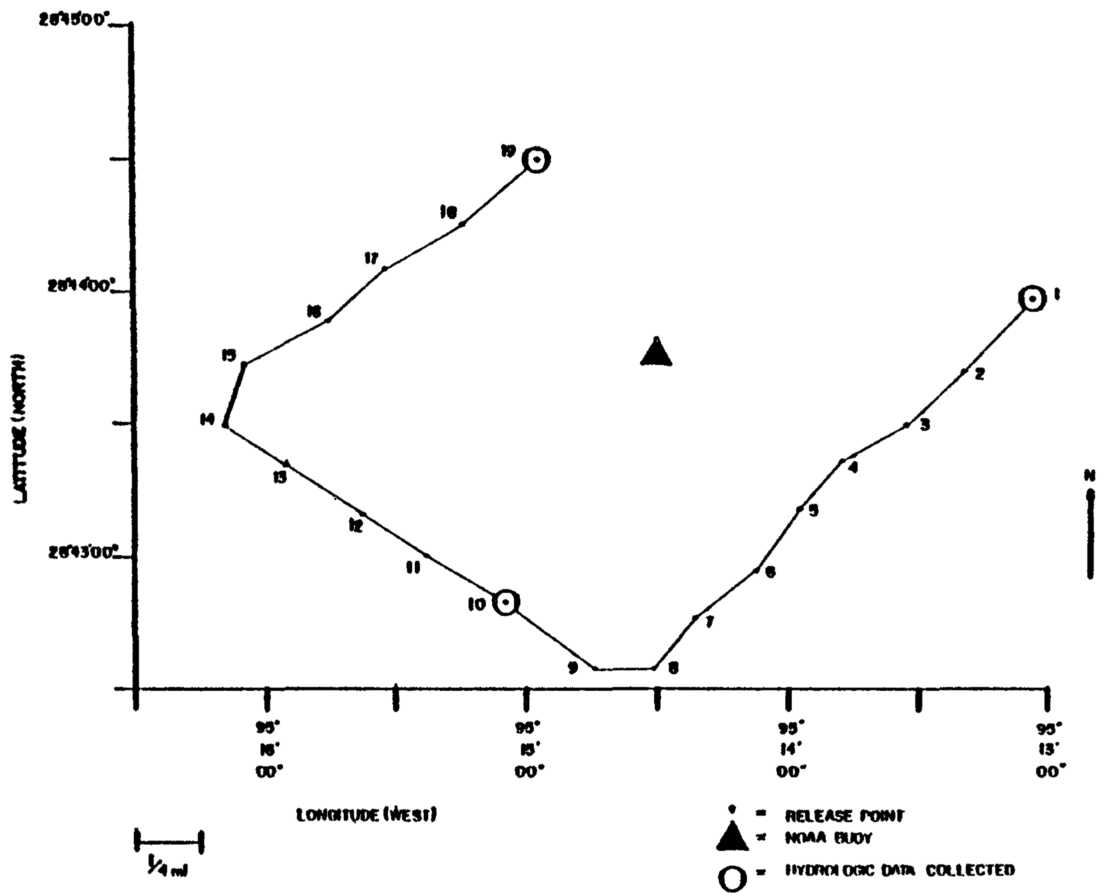



Fig. 9. Location of tagged shrimp releases on 27 July 1980.

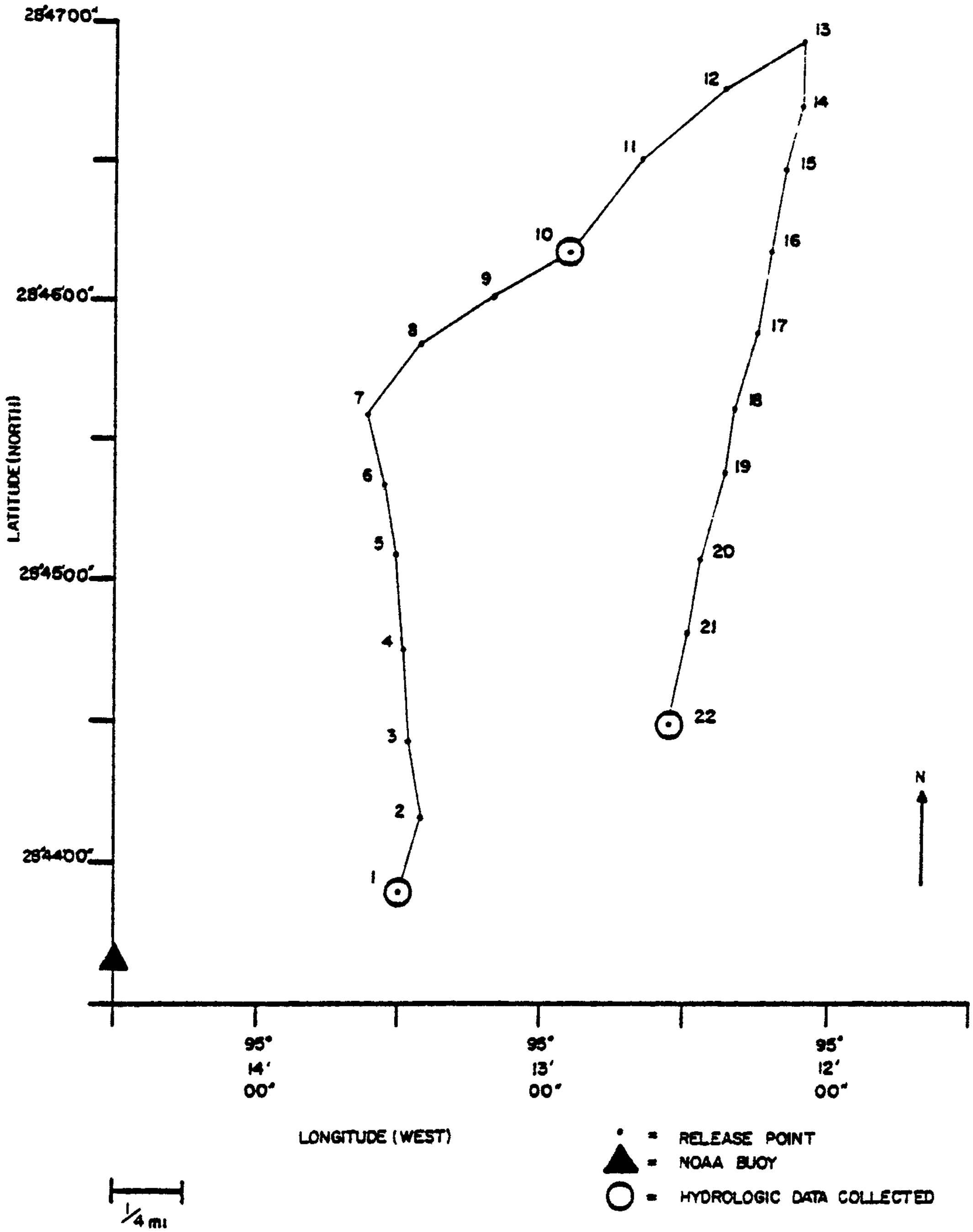



Fig. 10. Location of tagged shrimp releases on 28 July 1980.

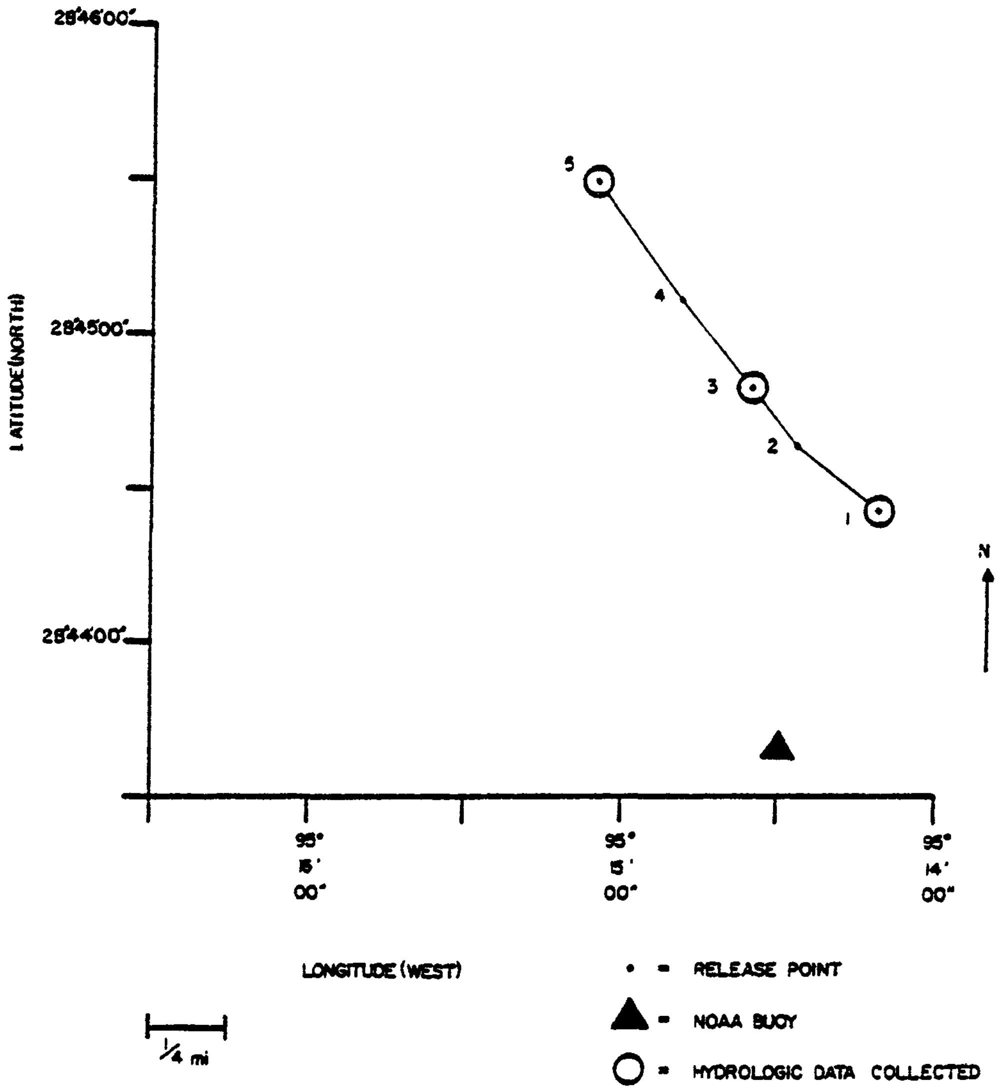



Fig. 11. Location of tagged shrimp releases on 29 July 1980.

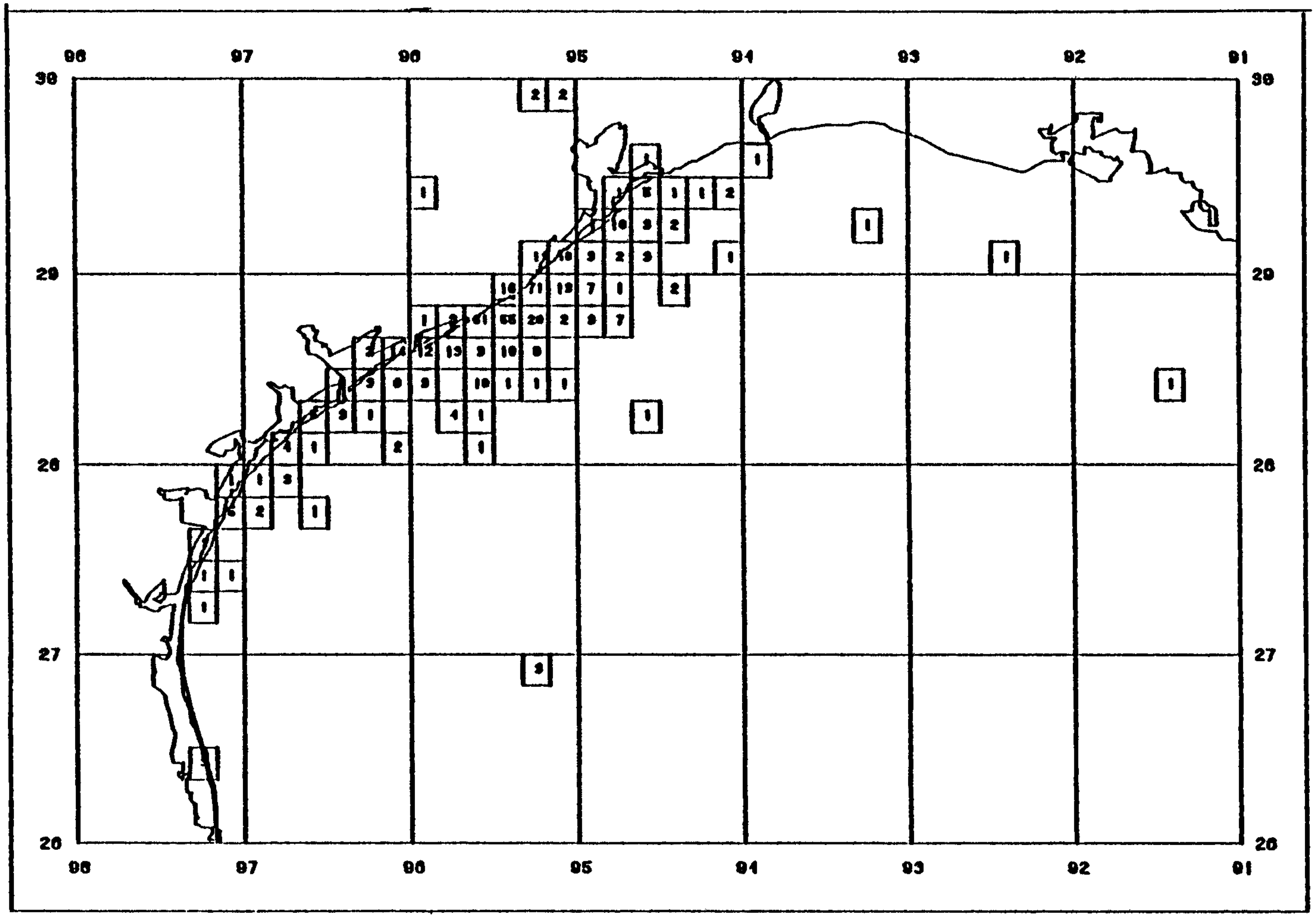



Fig. 12. Map of Texas coast showing number and location of recapture of white shrimp (*Penaeus setiferus*) released offshore in the vicinity of the Bryan Mound diffuser site in fall 1979. (Courtesy of Mr. Neal Baxter, NMFS, Galveston, Texas.)

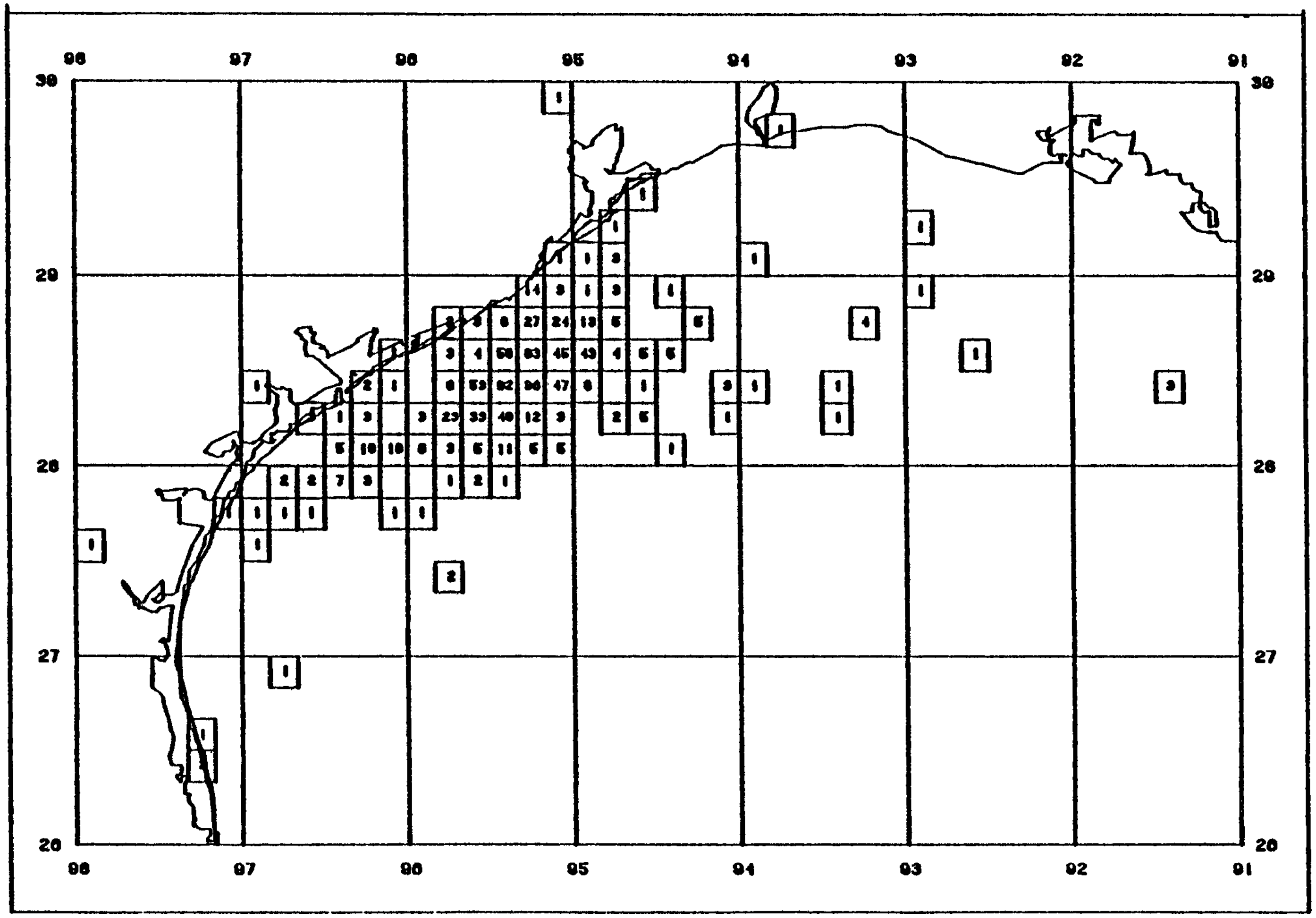



Fig. 13. Map of Texas coast showing number and location of recapture of brown shrimp (*Penaeus aztecus*) released offshore in the vicinity of the Bryan Mound diffuser site in fall 1979. (Courtesy of Mr. Neal Baxter, NMFS, Galveston, Texas.)

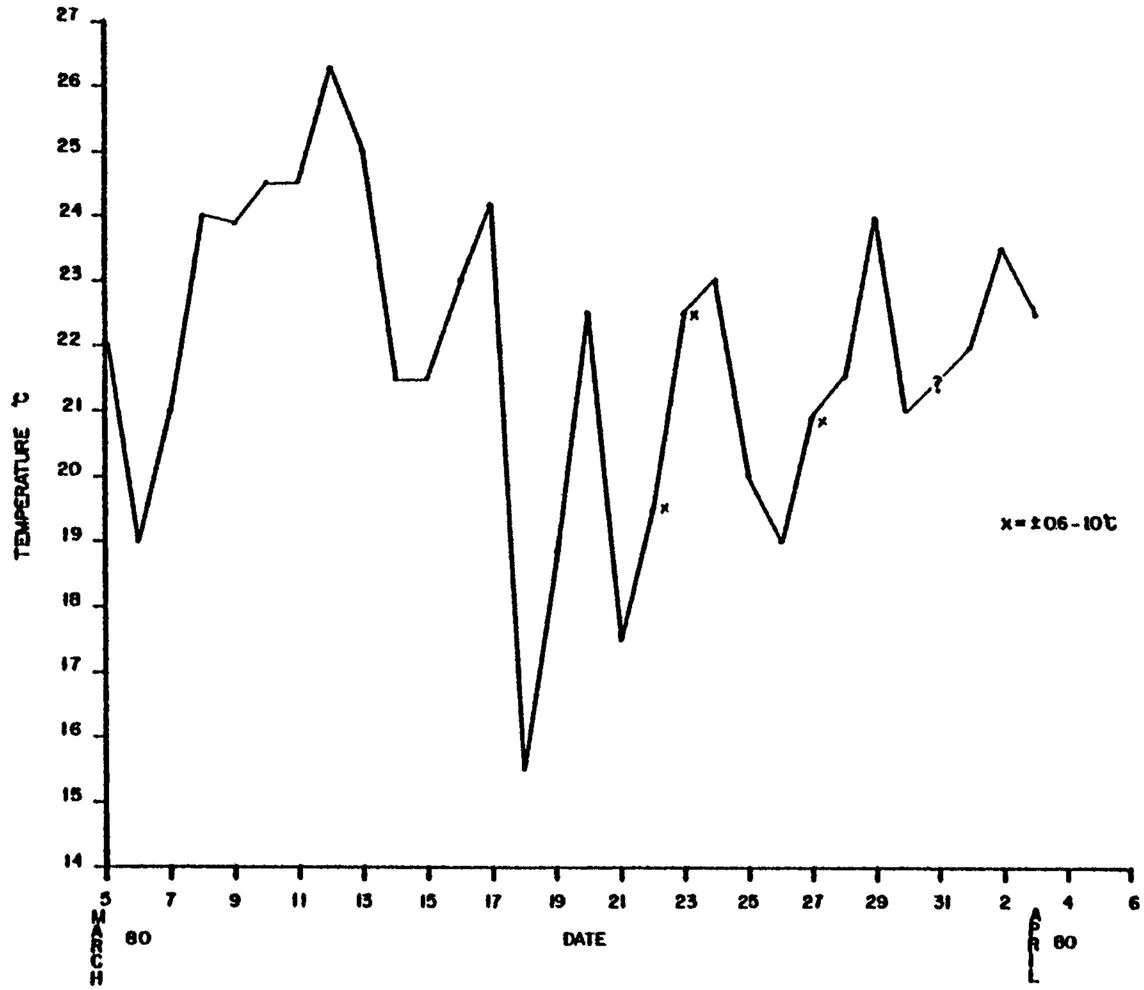



Fig. 14. Temperature (C) in pond 12 during the 30-day tag mortality-tag loss study. The "x" indicates temperature differences between pond 12 and pond 14.

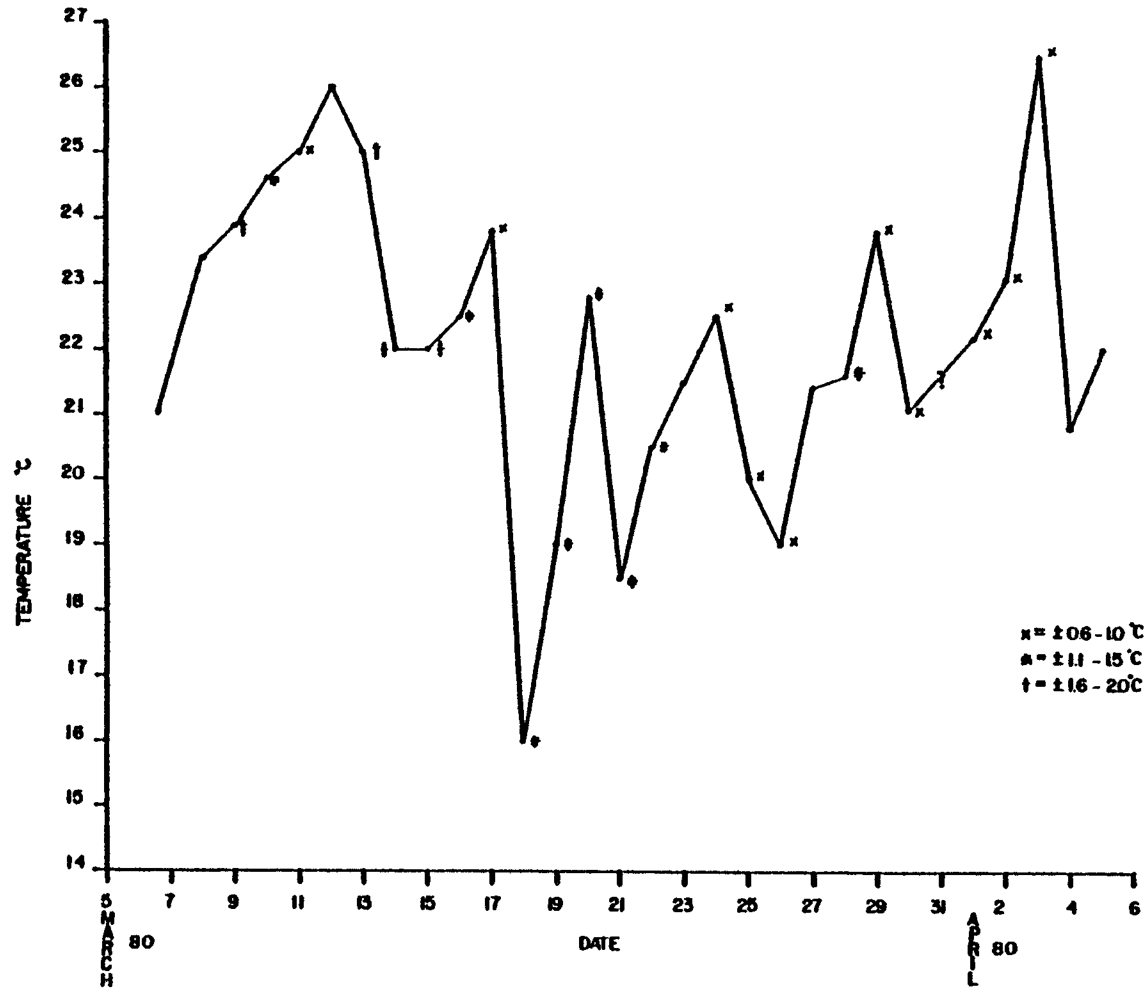



Fig. 15 Temperature (C) in pond 13 during the 30-day predation mortality study. The symbols (x,*,†) indicate temperature differences between pond 11 and pond 13.

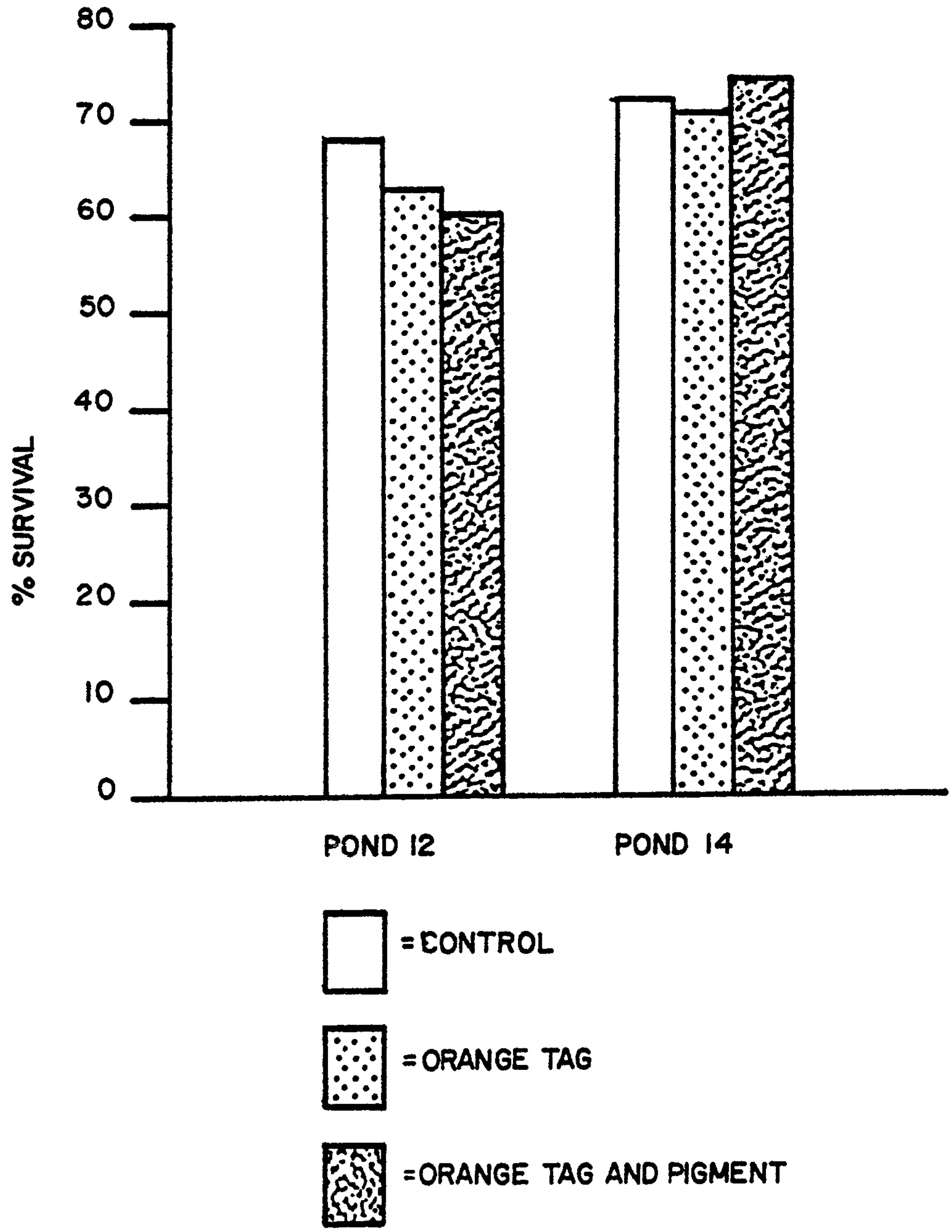



Fig. 16. Percent survival of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds.

shrimp. Survival was similar between shrimp marked with streamer tags and those marked with streamer tags plus fluorescent pigment. Results of chi-square contingency tests and G-tests (Table 16) revealed no significant differences in survival among the three groups at a 95% level of confidence. In pond 14 there also was no significant difference in survival among unmarked shrimp, shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only. Results of chi-square contingency tests at the 95% confidence level revealed that survival is significantly greater in pond 14 than in pond 12.

Similar survival between marked and unmarked pink shrimp suggests that marking shrimp with streamer tags or fluorescent pigment does not significantly alter their mortality. Hattori and Fukama (1972) reported that survival was not significantly different between tagged and untagged *Penaeus japonicus*. Marullo et al. (1976) stated that mortality in marked white shrimp (*Penaeus setiferus*) did not differ significantly from the controls. Knudsen et al. (1977) noted no significant difference in survival between brown shrimp (*Penaeus aztecus*) marked with fluorescent pigment and unmarked controls. Since the results were similar when different species of shrimp were used it is believed that the species of shrimp tested is not a factor.

A total of 21 tags were found at the edge of ponds 12 and 14 during the 30-day experiment. Six of these tags were shriveled up and in clumps of tags indicating bird predation (see p. 62 for discussion of bird predation). The remaining 16 tags were the result of natural mortality of the shrimp or tag loss. Estimates of natural mortality rates have been reported in the literature using mark-recapture data and commercial fishery statistics. Lindner (1959) estimated that natural mortality of white shrimp in the Gulf of Mexico was between 20-46% per month. Klima (1964) reported that natural mortality of brown shrimp was 60% per month between April and June. In a later study Klima (1974) was unable to obtain reliable estimates of natural mortality in shrimp. Kutkuhn (1966) determined a weekly natural mortality rate of 0.42 in juvenile pink shrimp approximately 90 mm in total length in September. This is equivalent to a monthly rate of approximately 81% ($N_t=N_oe^{-rt}$, where $N_o=1.0$; $r=0.42$; $t=4$ weeks; and $N_t=0.19$) assuming the weekly rate may be used as an instantaneous decay constant. Kutkuhn (1966) stated, however, that estimates of natural mortality should be applied with great caution to other fisheries or to other age groups at different seasons. Berry (1969) reported that most mortality in pink shrimp was attributable to fishing mortality; natural mortality was relatively low. Tag loss was reported to be low in shrimp marked with streamer tags (Marullo et al. 1976). In the present study only one of the surviving shrimp showed evidence of tag loss (Table 17). No tag loss occurred in shrimp marked with streamer tags plus fluorescent pigment. Slightly higher tag loss was observed in ponds 11 and 13 containing redfish predators.

Growth

A summary of mean total length (mm) and mean total weight (g) of pink shrimp in ponds 12 and 14 at the beginning and end of the 30-day experiment is shown in Table 18. The mean total length, standard deviation, two standard errors of the mean, and size range of unmarked shrimp (controls), shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only in pond 12 are shown in Fig. 17. The term "total start" in the figure refers to the mean length at the start of the experiment of all shrimp in a particular group (e.g. 200 shrimp marked with streamer tag only). The term "survivor start" refers to the mean length at the start of the experiment of those shrimp that were recovered at the termination of the study (e.g. 123 shrimp marked with streamer tag only). Figure 17 illustrates that the mean total length of the "total start" is similar to the mean of the "survivor start". The similarity of these two means suggests that "survivor start" population is representative of the "total start" population. The mean total length was similar among the three treatments at the start of the experiment. At the termination of the experiment the mean total length of the three groups also was similar, indicating a similar growth rate. Figure 18 illustrates the same parameters for the shrimp in pond 14. The means also were similar among the three treatments in this pond.

The mean total weight (g), standard deviation, two standard errors of the mean, and range of weight of unmarked shrimp, shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only in pond 12 and pond 14 are shown in Figs. 19 and 20, respectively. In pond 12 the mean total weight was similar among the three treatments at the start of the experiment. The mean total weight after 30 days also was similar among unmarked shrimp, shrimp marked with streamer tag plus fluorescent pigment and shrimp marked with streamer tags only. In pond 14 the mean total weight at the end of the experiment was greater in the unmarked than marked shrimp.

Comparisons of differences in growth of marked and unmarked shrimp after 30 days are illustrated in Fig. 21 (total length) and Fig. 22 (total weight). In pond 12 increase in total length (Fig. 21) was similar among the three treatments, whereas in pond 14 there was a greater change in total length in the unmarked than in the marked shrimp. The increase in total weight (Fig. 22) was greater in the marked shrimp in pond 12, whereas in pond 14 the unmarked shrimp showed the greatest change in weight.

Analysis of variance was used to determine whether significant differences existed in the growth (total length, total weight) of unmarked shrimp, shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only (Table 19A). The data were corrected for the initial group mean within each pond-treatment combination so that the growth of unmarked shrimp could be compared with that of marked shrimp. Because of the pond x treatment interaction (p-value $<0.05$) nothing conclusive could be said about the difference in increase in total length between ponds or between treatments. The interaction plot (Fig. 23A) did not help in the interpretation of the data. Analysis of variance performed on increase in total weight also showed a significant

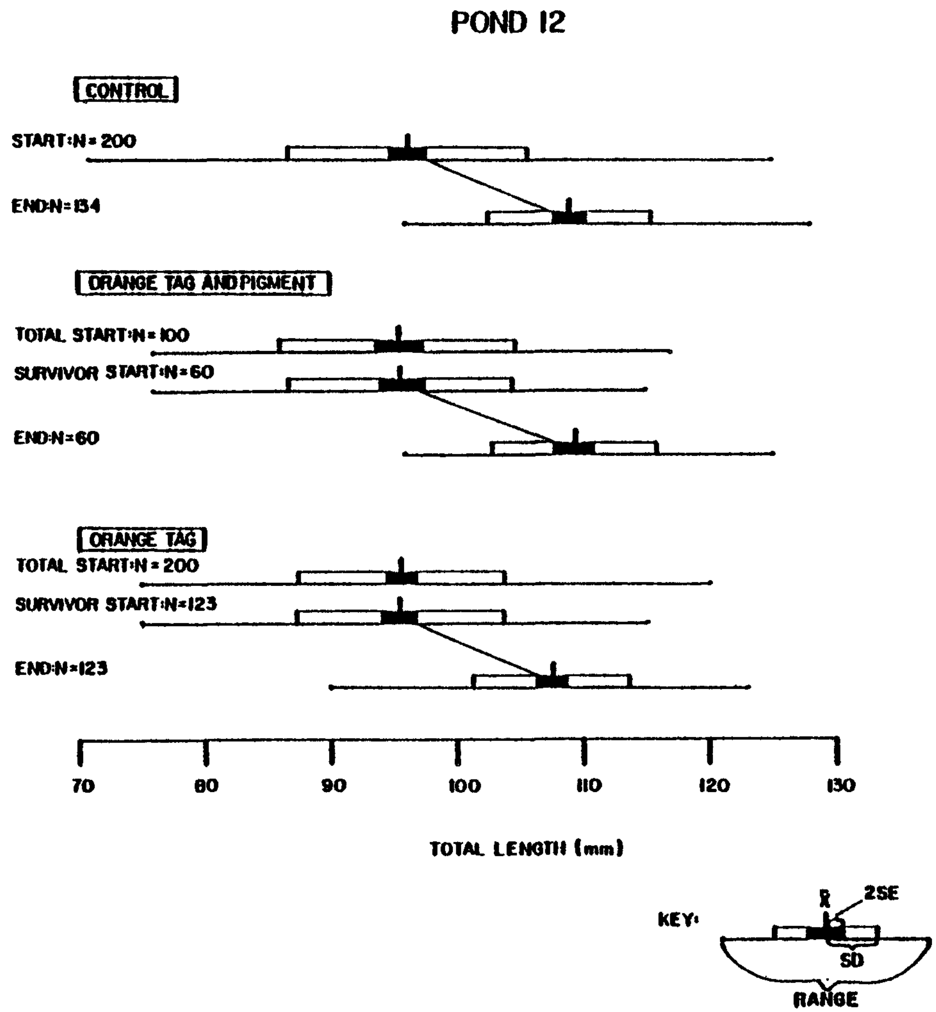



Fig. 17. Mean total length (mm) of pink shrimp (*Penaeus duorarum*) in pond 12 at the start and end of the 30-day experiment.

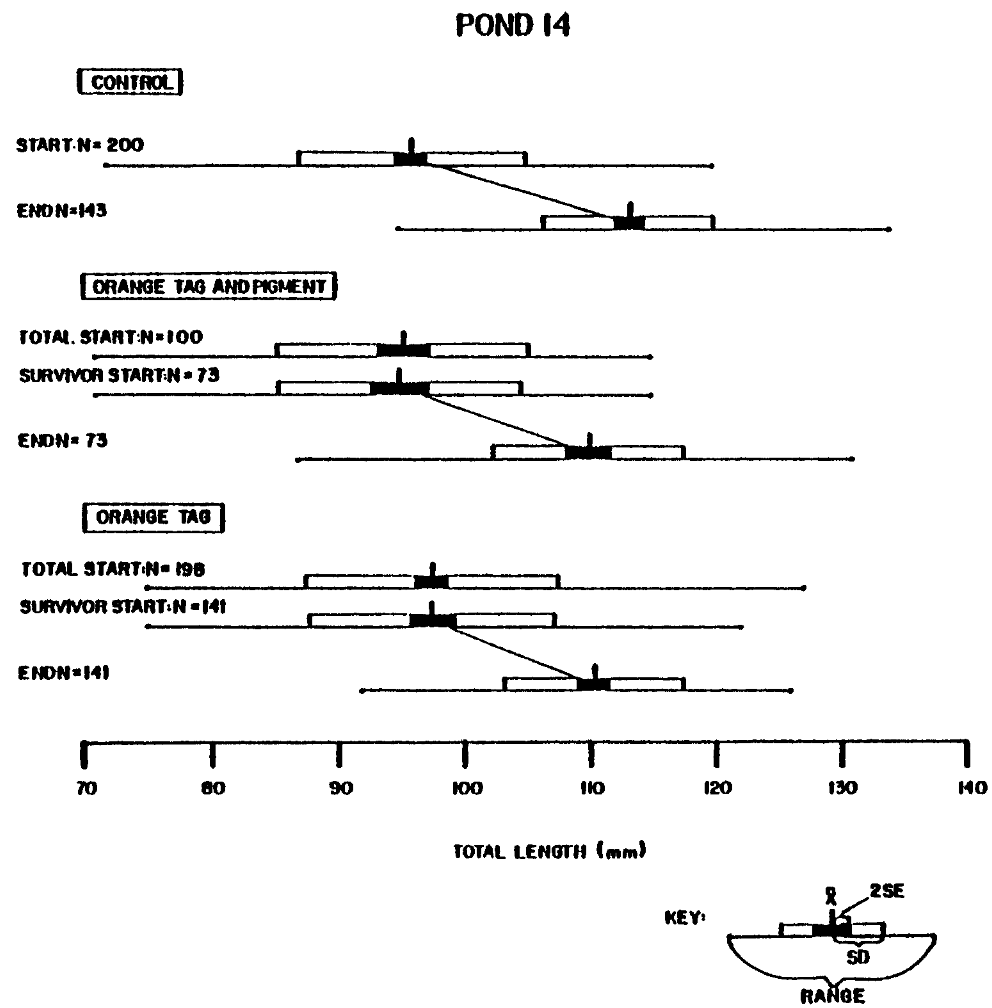



Fig. 18. Mean total length (mm) of pink shrimp (*Penaeus duorarum*) in pond 14 at the start and end of the 30-day experiment.

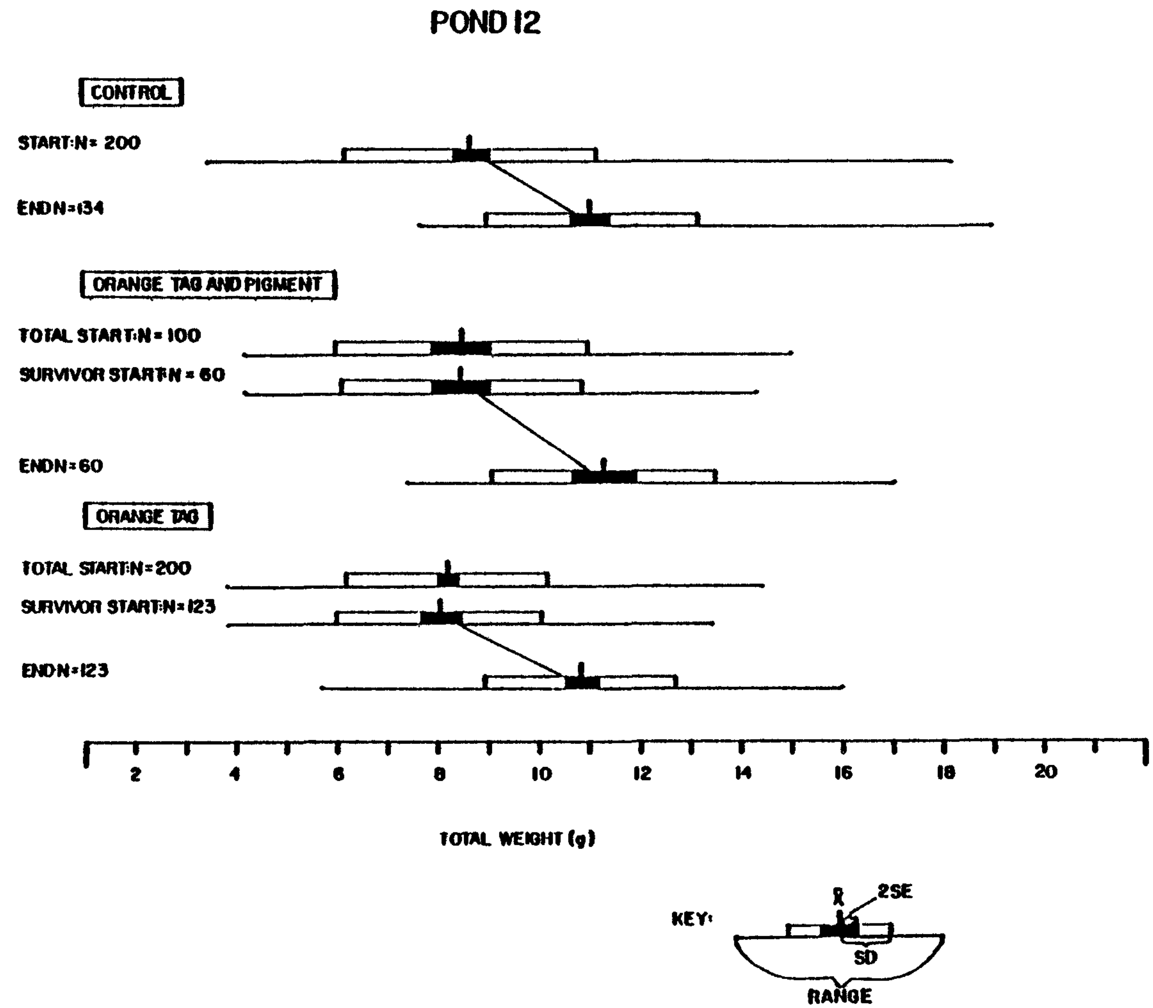



Fig. 19. Mean total weight (g) of pink shrimp (*Penaeus duorarum*) in pond 12 at the start and end of the 30-day experiment.

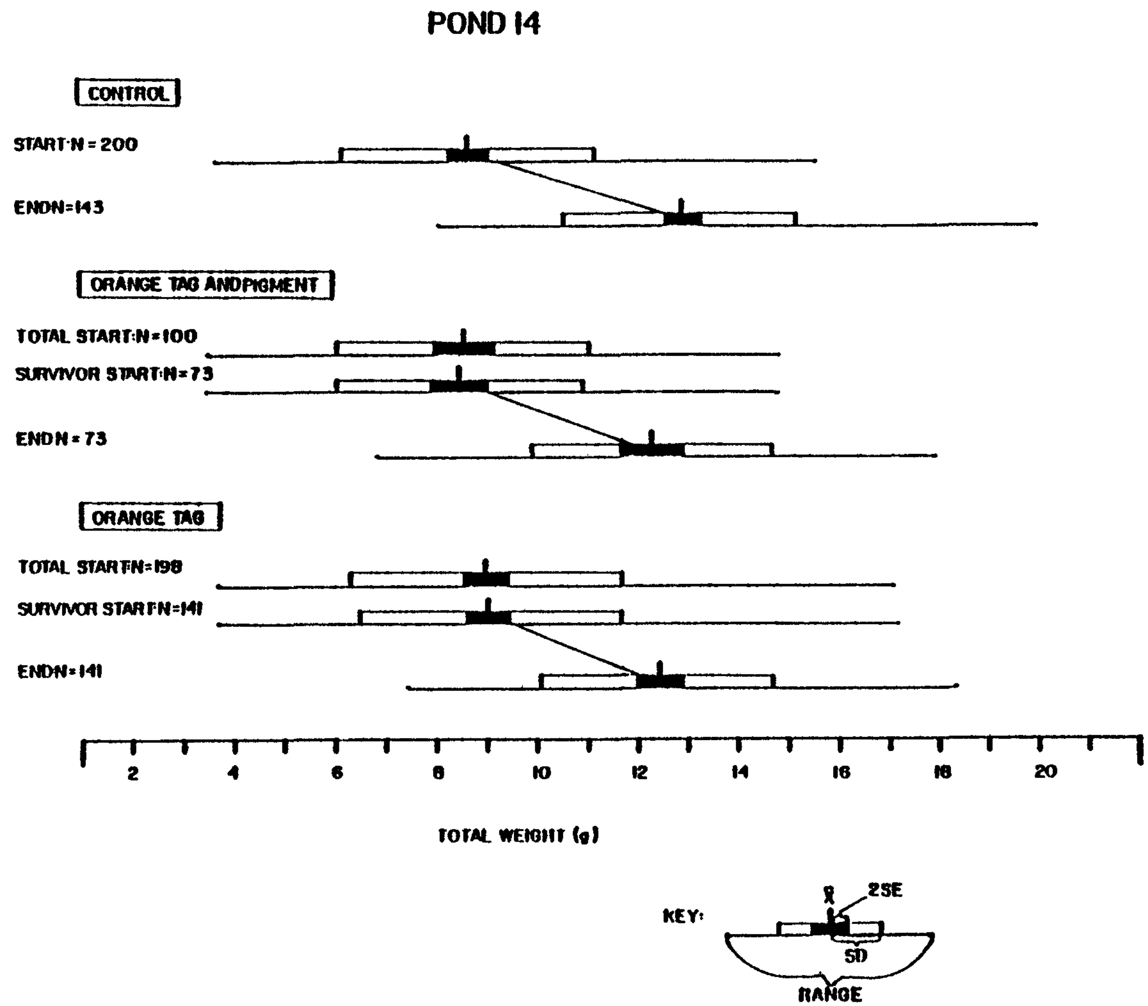



Fig. 20. Mean total weight (g) of pink shrimp (*Penaeus duorarum*) in pond 14 at the start and end of the 30-day experiment.

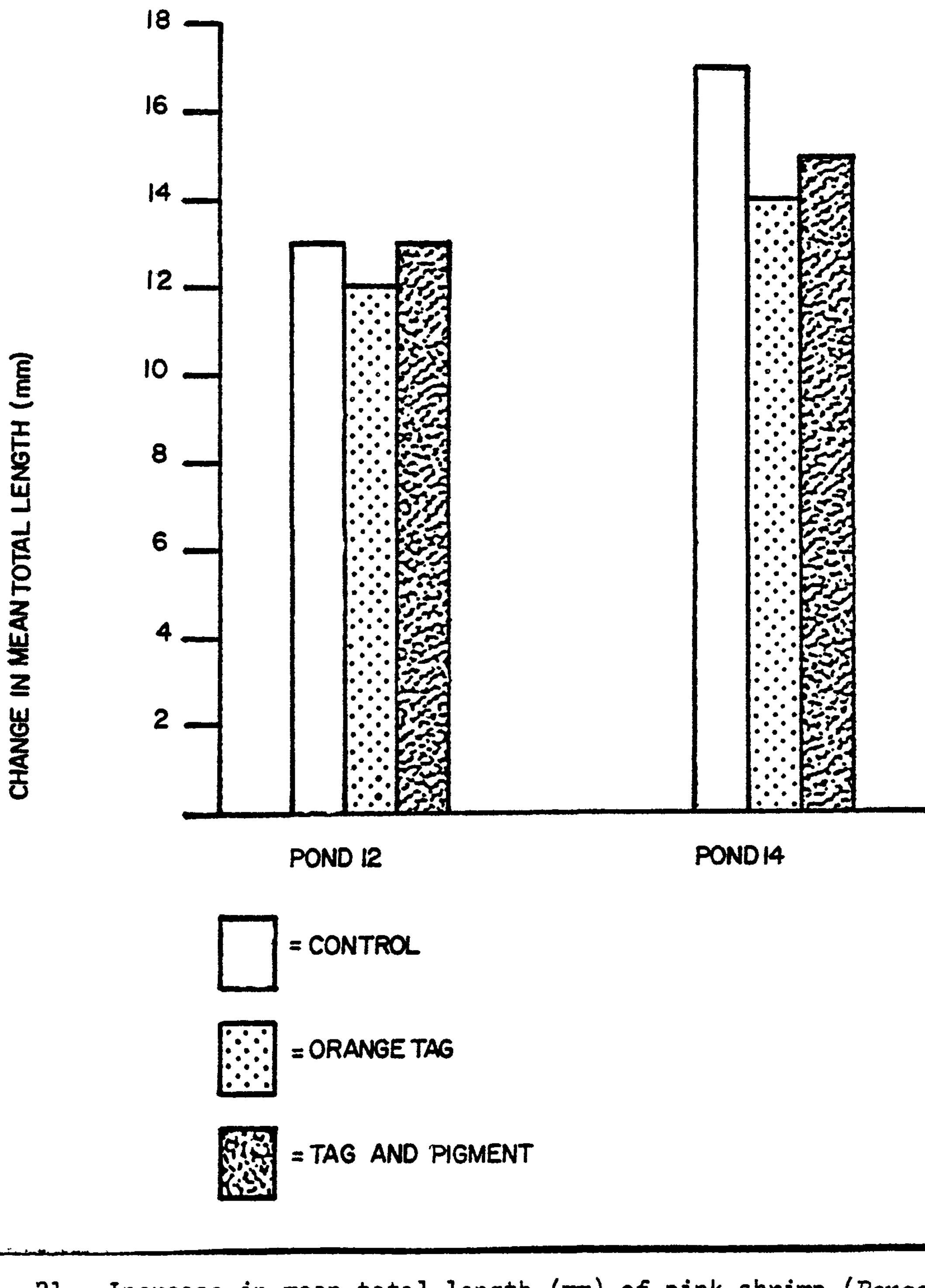



Fig. 21. Increase in mean total length (mm) of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds.

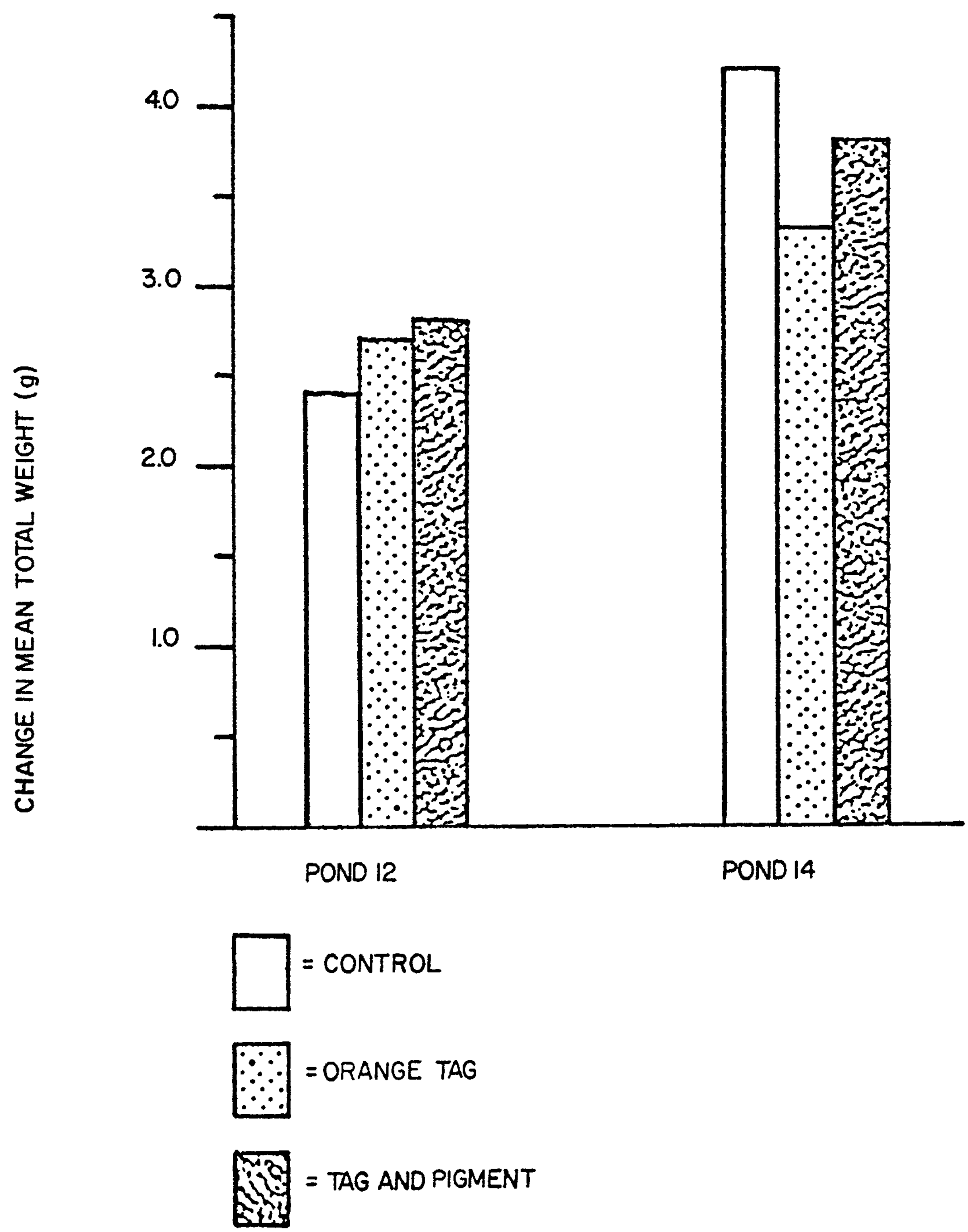



Fig. 22. Increase in mean total weight (g) of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds.

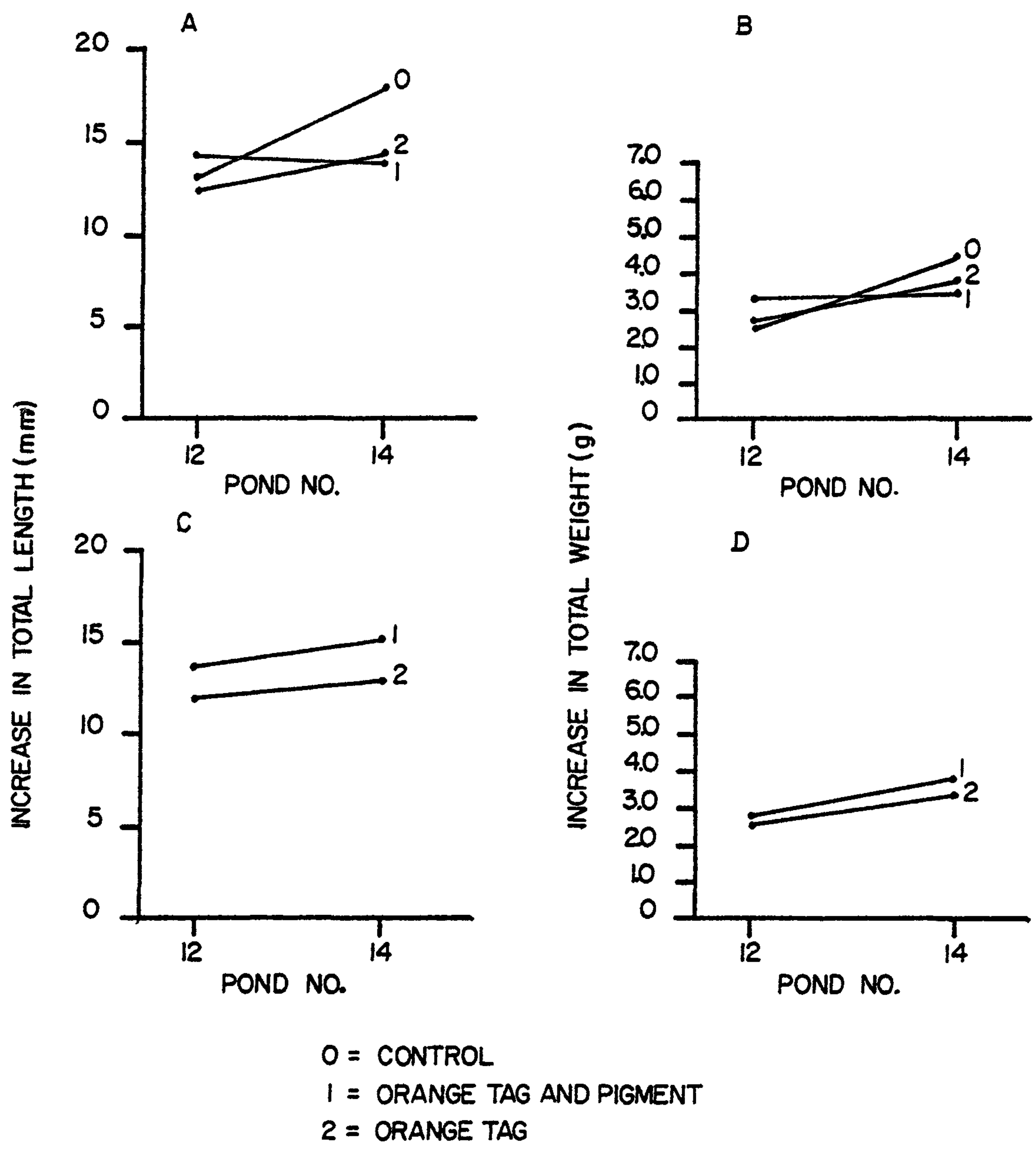



Fig. 23. Analysis of variance interaction plots for total length gain (A & C) and total weight gain (B & D). A-B: data corrected for initial means; C-D: uncorrected data.

pond x treatment interaction. A plot of the interaction (Fig. 23B) did not clarify the results.

Analysis of variance was performed on differences in growth (total length, total weight) between shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only using data uncorrected for the initial group means (Table 20A). The results showed no pond x treatment interaction. There was a significant difference in growth (total length and total weight) between the two treatments at the 95% confidence level. The interaction plots for total length gain (Fig. 23C) and total weight gain (Fig. 23D) revealed that increases in total length and weight were greater in shrimp marked with streamer tags plus fluorescent pigment than in shrimp marked with streamer tags only. Results of ANOVA also revealed that the weight gain in pond 14 was significantly greater than in pond 12 (p-value <0.05). The differences between these two ponds are puzzling since the shrimp in both ponds received the same amount of food. The small differences in water quality between the two ponds (Tables 11 and 12) probably cannot account for differences in weight increase between the two adjacent ponds.

Comparison of the interaction plot for total length gain corrected for the initial mean (Fig. 23A) with the plot of total length using the uncorrected data (Fig. 23C) illustrates different slopes for treatments 1 and 2. The same observations were made when the interaction plot for total weight gain corrected for the initial mean (Fig. 23B) was compared with the interaction plot of the uncorrected data (Fig. 23D).

In order to determine whether the slope differences were attributable to some unknown effect of correction of the means, an analysis of covariance was performed on total length gain using total weight gain as the covariate. The hypotheses of parallelism were tested for each analysis of covariance performed to make certain that the covariate was not affected by the factors tested (i.e. treatment, pond). The hypotheses of parallelism for the covariate (weight gain) were not rejected at the 95% level of confidence. A logarithmic transformation of total length gain and total weight gain was considered for linearizing the data before ANACOVA. Since the plots of the untransformed data showed a clearly linear relationship between the two variables, the logarithmic transformation was determined to be inappropriate.

Analysis of covariance was performed on data corrected for initial group means to determine whether there were significant differences in length gain (adjusted for weight gain) among unmarked shrimp, shrimp marked with streamer tags plus pigment and shrimp marked with streamer tags only (Table 19B). The results revealed no significant pond x treatment interaction at the 95% level of confidence. There were significant differences in increase in total length (adjusted for total weight) between ponds 12 and 14. There also were significant differences (p-value <0.05) between treatments. Duncan's New Multiple Range Test revealed that the increase in total length (adjusted for total weight gain) was significantly greater (p-value ≤0.05) in unmarked shrimp than in marked shrimp. The interaction plot illustrates this relationship (Fig. 24A).

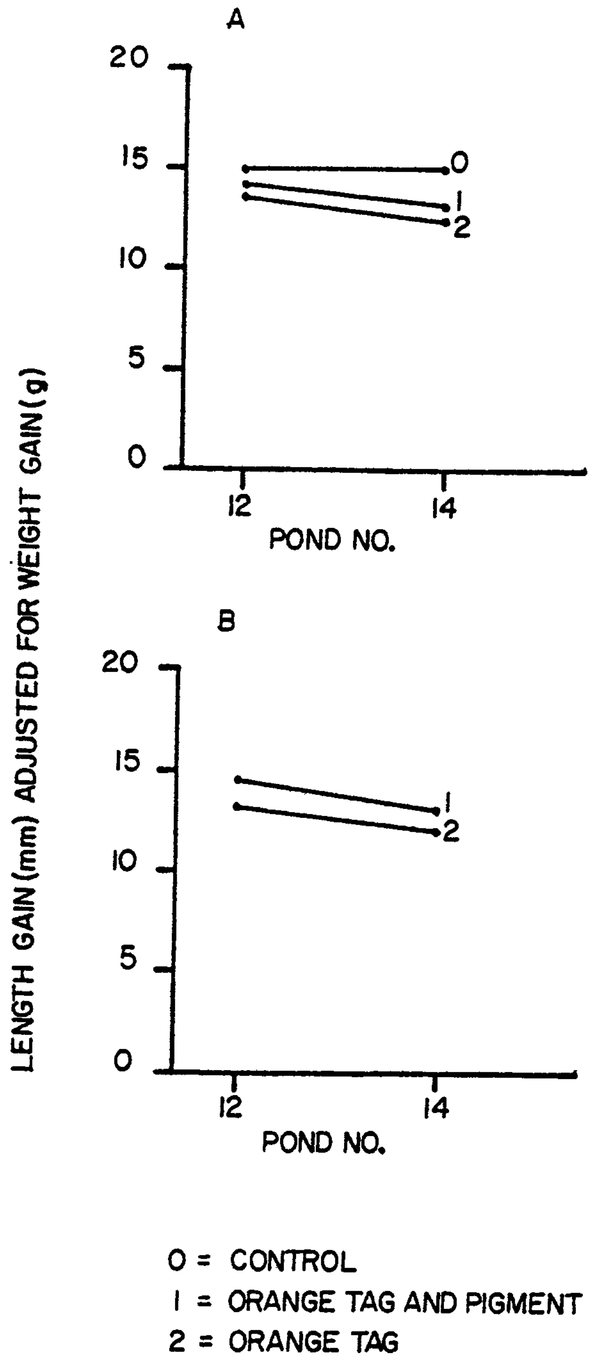



Fig. 24. Analysis of variance interaction plots for length gain adjusted for weight gain. A: data corrected for initial mean; B: uncorrected data.

Analysis of covariance also was performed on the uncorrected data (Table 20B). There was no significant pond x treatment interaction at the 95% confidence level. The length gain was significantly different between ponds 12 and 14. The increase in total length (adjusted for weight gain) was significantly greater (P-value <0.05) in shrimp marked with streamer tags plus fluorescent pigment than in shrimp marked with streamer tags only. The interaction plot (Fig. 24B) illustrates this relationship. In contrast to the ANOVA interaction plots, the ANOCOVA interaction plots for length gain adjusted for weight gain show similar trends for treatments across ponds regardless of whether data corrected for the means (Fig. 24A) or uncorrected data (Fig. 24B) was utilized.

In the present study there was a significant difference in increase in total length and total weight between shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only. Welker et al. (1975), on the other hand reported no significant difference in growth rate between shrimp marked with biological stains and shrimp marked with Petersen tags.

Pink shrimp, an average total length of 96 mm at the beginning of this experiment in early March 1980, grew to a mean total length of 110 mm after 30 days in the 0.1 ha ponds; the growth rate was approximately 0.5 mm/day. Kutkuhn (1966) reported that in September juvenile pink shrimp grew 3.4 mm/week (0.5 mm/day). Lindner and Anderson (1957) showed a growth of 5 mm/month (0.2 mm/day) in white shrimp released in late February. Klima (1964) reported an increase of 21 mm in four weeks (0.8 mm/day) for white shrimp released in September. Klima (1974) noted a somewhat greater growth rate in white shrimp released in August (29 mm in four weeks or 1.0 mm/day) indicating the influence of temperature on shrimp growth. Knudsen et al. (1977) reported a growth rate of 0.53-0.87 mm/day in juvenile brown shrimp released in May-June 1975.

In the present study juvenile pink shrimp weighed an average of 8.6 g at the start of the experiment and 11.8 g at the termination of the study. The weight increase averaged 0.1 g/day. Kutkuhn (1966) reported an increase of 1.5 g/week (0.2 g/day) in juvenile pink shrimp in September. Klima (1964) noted a weight increase of 6.3 g in white shrimp four weeks after release in September (0.2 g/day). The greater increase in weight recorded by Klima (1964) and Kutkuhn (1966) can be attributed to the higher seawater temperatures at the time of their studies.

## Predation Mortality-Growth

### Survival

The percent survival of unmarked shrimp and shrimp marked with streamer tags after 30 days in 0.1 ha ponds containing redfish (*Sciaenops ocellata*) as predators is shown in Table 21. Results of the chi-square contingency tests and G-tests (Table 22) revealed no significant differences in survival at the 95% level of confidence between shrimp marked with streamer tags and unmarked controls in pond 11 and pond 13, suggesting that streamer tags did not affect predation. Costello and Allen

(1962), on the other hand, reported greater predation in tagged pink shrimp than unmarked shrimp after a 10-day exposure to mangrove snapper, red grouper and black grouper. Survival of unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags is shown in Table 23 and Fig. 25. In pond 11 survival was greater in shrimp marked with black streamer tags, whereas in pond 13 survival was greater in shrimp marked with orange streamer tags. Results of chi-square contingency tests revealed no significant differences in survival at the 95% confidence level between shrimp marked with orange streamer tags and those marked with black streamer tags in either pond 11 or pond 13. It appears that color of the streamer tag does not affect predation by redfish. However, extensive predation of the shrimp by birds may have influenced the results.

Comparison of survival of shrimp between pond 11 and pond 13, based on chi-square tests, shows significantly lower survival in pond 13 at the 95% confidence level. This is attributable in part to the number of redfish in each pond. At the interaction of the experiment three redfish were placed in each pond, but only two redfish survived in pond 11. The higher feeding rate of the redfish in pond 13 also accounts for the higher shrimp mortality in that pond. More than three times as many tags were recovered in pond 13 than pond 11. The difference in food consumption by the redfish in the two ponds may be partially attributable to the warmer water temperatures in pond 13 (up to 2.0 C higher). The differences in the state of health of the redfish in the two ponds account for the higher predation mortality in pond 13. The small increase in length of the redfish in pond 11 and their poor general appearance (Table 24) indicate that they were diseased (Bob Colura, pers. comm.). The high mortality among the small fish (mullet and cyprinidonts) in pond 11 also is indicative of fish disease. A total of 509 small fish was placed in each of ponds 11 and 13. At the termination of the experiment, 375 fish were recovered from pond 13, whereas only 187 fish were retrieved from pond 11. Since there were more redfish in pond 13, greater predation of the small fish would have been expected in that pond. Diseases in fish frequently are caused by ciliate protozoans (e.g. *Cryptocaryon irritans*); these diseases spread rapidly and can destroy the fish population in one pond, but not affect those in neighboring ponds (Bob Colura, pers. comm.).

Growth

A summary of mean total length (mm) and mean total weight (g) of pink shrimp in ponds 11 and 13 at the beginning and end of the 30-day experiment is shown in Table 25. The mean total length (mm), standard deviation, two standard errors of the mean, and size range of unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags in ponds 11 and 13 are shown in Figs. 26 and 27, respectively. The means at the start of the experiment were similar among the three treatments. The mean total length of the tagged survivors measured at the start of the experiment was similar to the means of the total number of marked shrimp originally placed in each pond. The similarity of the two "starting" means suggests that predation was random among the different size groups.

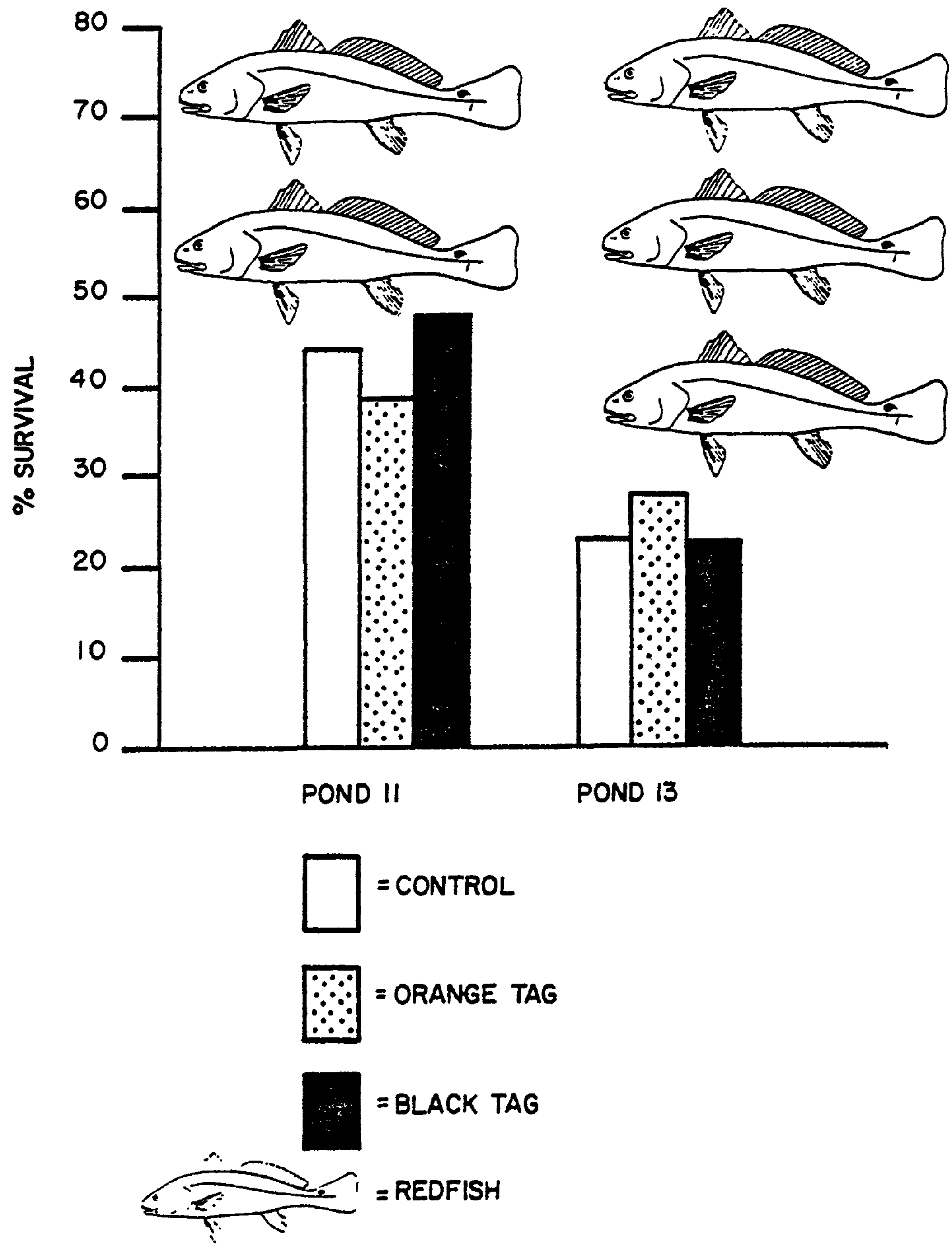



Fig. 25. Percent survival of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds containing redfish predators.

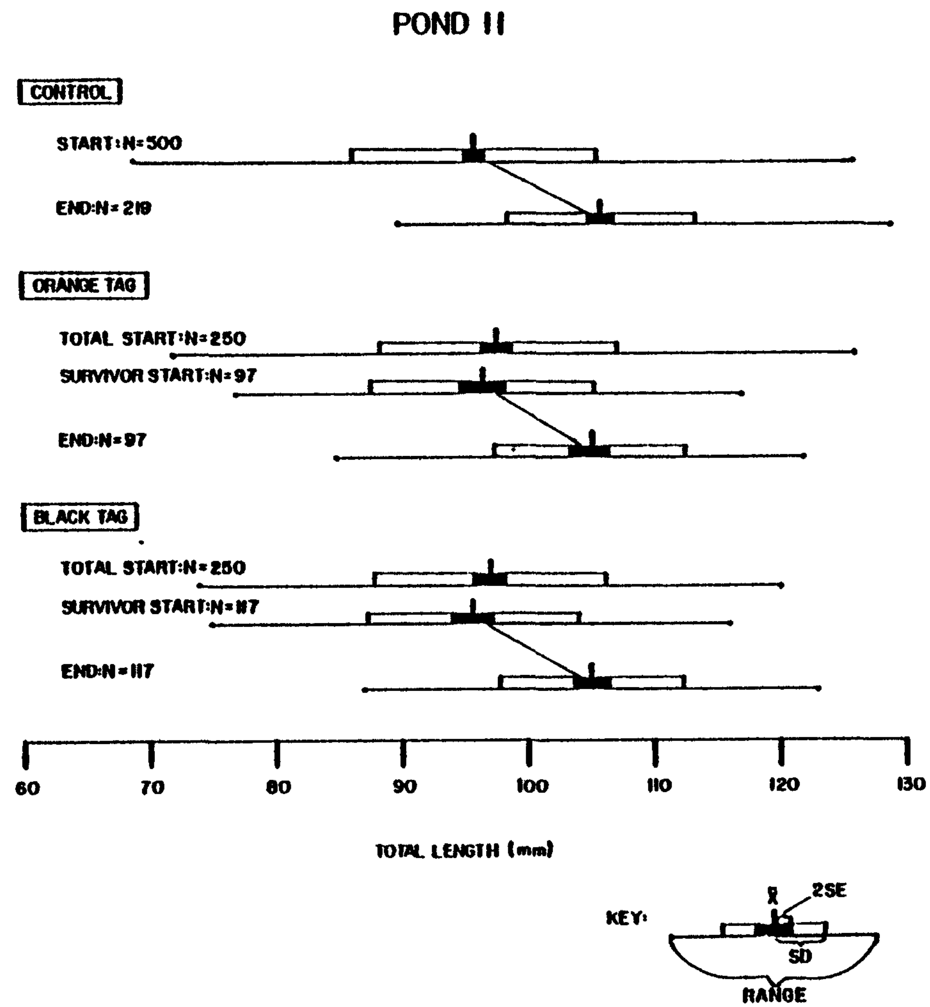



Fig. 26. Mean total length (mm) of pink shrimp (*Penaeus duorarum*) in pond 11 at the start and end of the 30-day experiment.

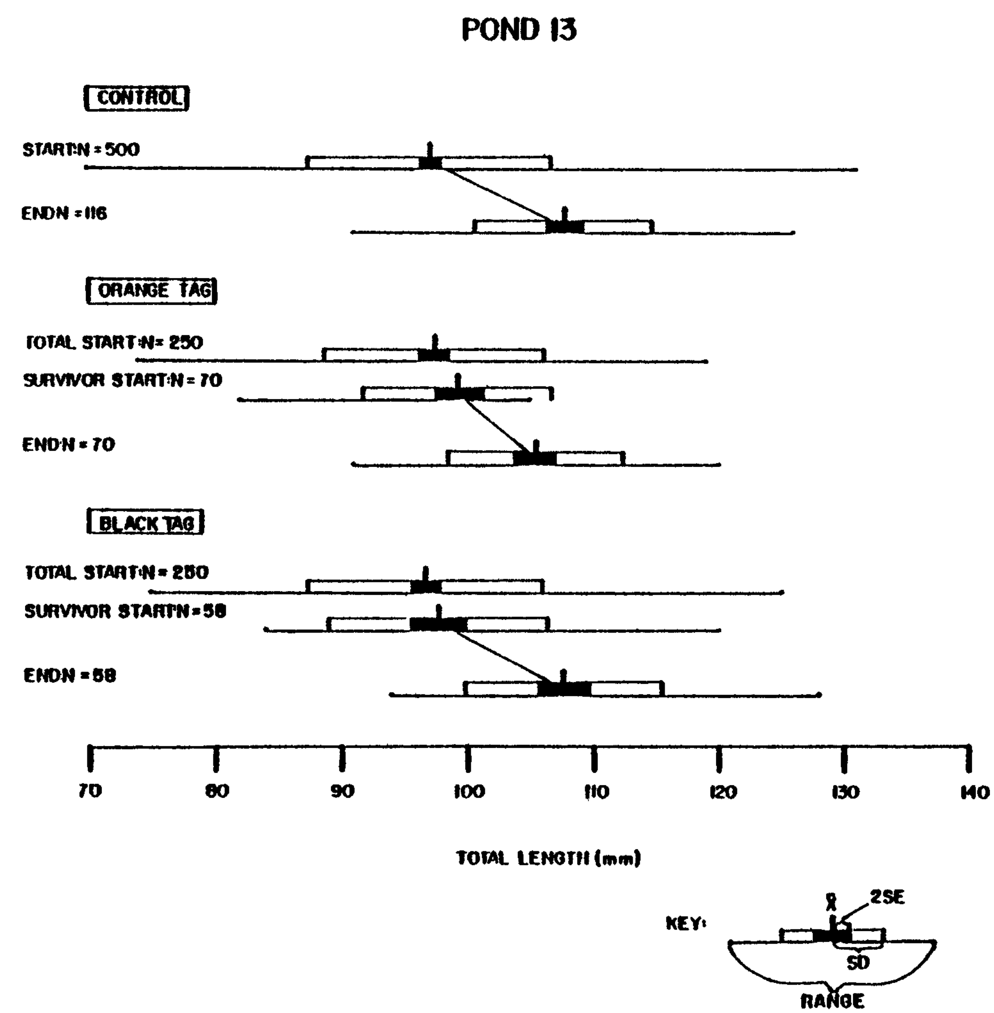



Fig. 27. Mean total length (mm) of pink shrimp *(Penaeus duorarum)* in pond 13 at the start and end of the 30-day experiment.

The mean total weight (g), standard deviation, two standard errors of the mean, and range of weight of unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags in ponds 11 and 13 are shown in Figs. 28 and 29, respectively. The mean total weight of the tagged survivors at the start of the experiment was similar to the mean total weight of the 250 orange tagged shrimp and 250 black tagged shrimp originally placed in the two ponds. Similarity between the two "starting" means suggests that predation was random among shrimp of differing weight classes.

Comparison of difference in growth of marked and unmarked shrimp after 30 days is illustrated in Fig. 30 (total length) and Fig. 31 (total weight). Increase in length was greater in the controls than in the marked shrimp in ponds 11 and 13. Increase in weight was similar among the three treatments in both ponds.

Analysis of variance was used to determine whether significant differences existed in the growth (total length, total weight) of unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags (Table 26A). The data were corrected for the initial group mean within each pond-treatment combination so that growth of the unmarked shrimp could be compared with that of the marked shrimp. The results showed no treatment x pond interaction. The length gain was not significantly different between ponds. There was a significant difference in increase in total length at the 95% confidence level. Duncan's New Multiple Range Test revealed that the increase in total length was significantly greater (p-value $\leq 0.05$) in the unmarked shrimp than in the marked shrimp. The interaction plot (Fig. 32A) illustrates the relationship among the three treatments. Analysis of variance of the increases in total weight showed no pond x treatment interaction and no significant differences (p-value $<0.05$) in weight gain among unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags. The interaction plot (Fig. 32B) illustrates the results.

The significant difference in increase in length between marked and unmarked individuals suggests that ecdysis might be inhibited by marking shrimp with streamer tags. As a consequence the marked shrimp might remain in a proecdysis stage, characterized by an increase in wet weight (Highnam and Hill 1977). The weight gain is the result of accumulation of food reserves and a rise in blood calcium (Barnes 1980). Thus, the increase in weight during proecdysis could explain the non-significant differences in weight gain between marked and unmarked shrimp during the short term of the study.

Analysis of variance was performed on differences in growth (total length, total weight) between shrimp marked with orange streamer tags and shrimp marked with black streamer tags using the uncorrected data (Table 27A). The analysis of total length gain revealed a significant pond x treatment interaction (p-value $<0.05$), so that nothing conclusive could be said about the differences between ponds or between treatments. However, the interaction plot (Fig. 32C) illustrates that total length gain was apparently greater in shrimp marked with black streamer tags

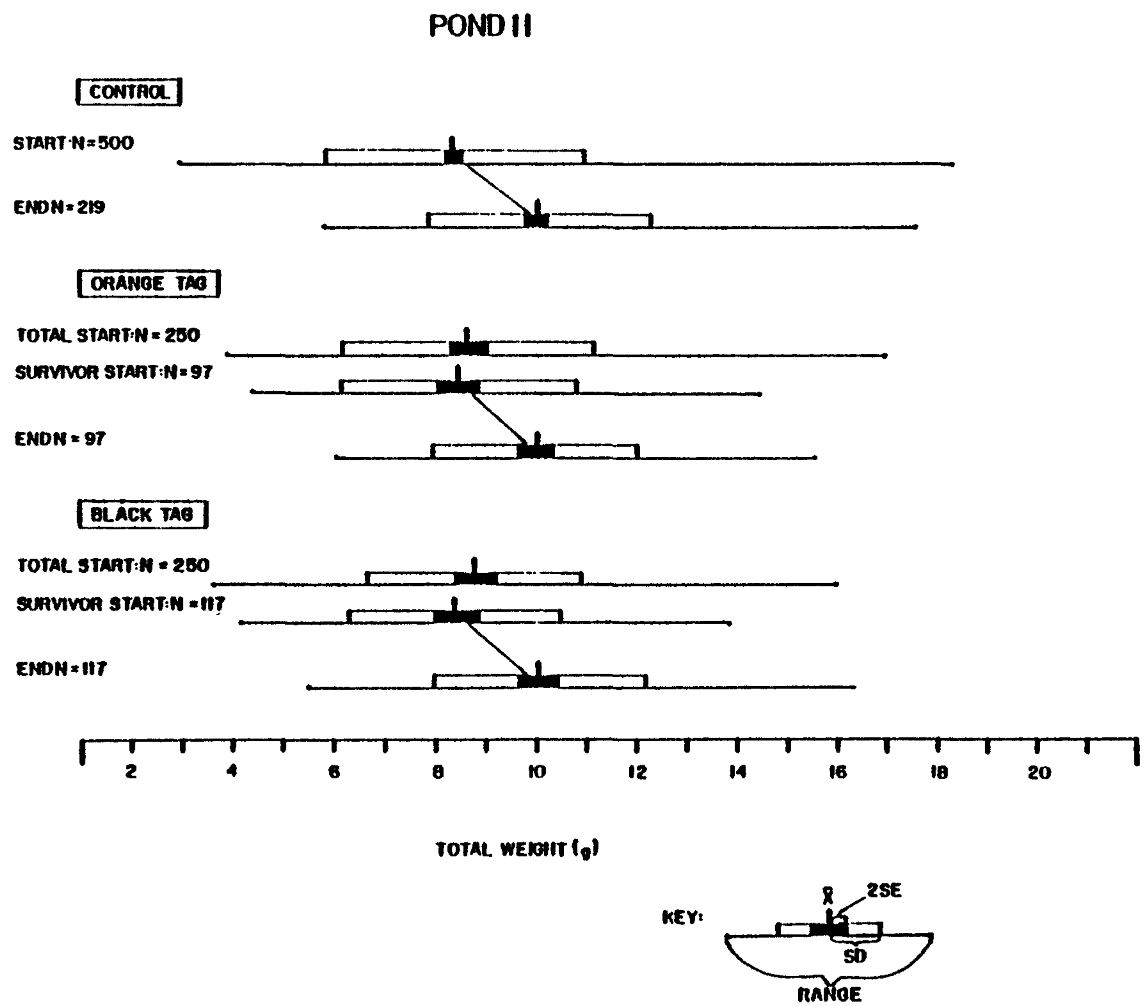



Fig. 28. Mean total weight (g) of pink shrimp (*Penaeus duorarum*) in pond 11 at the start and end of the 30-day experiment.

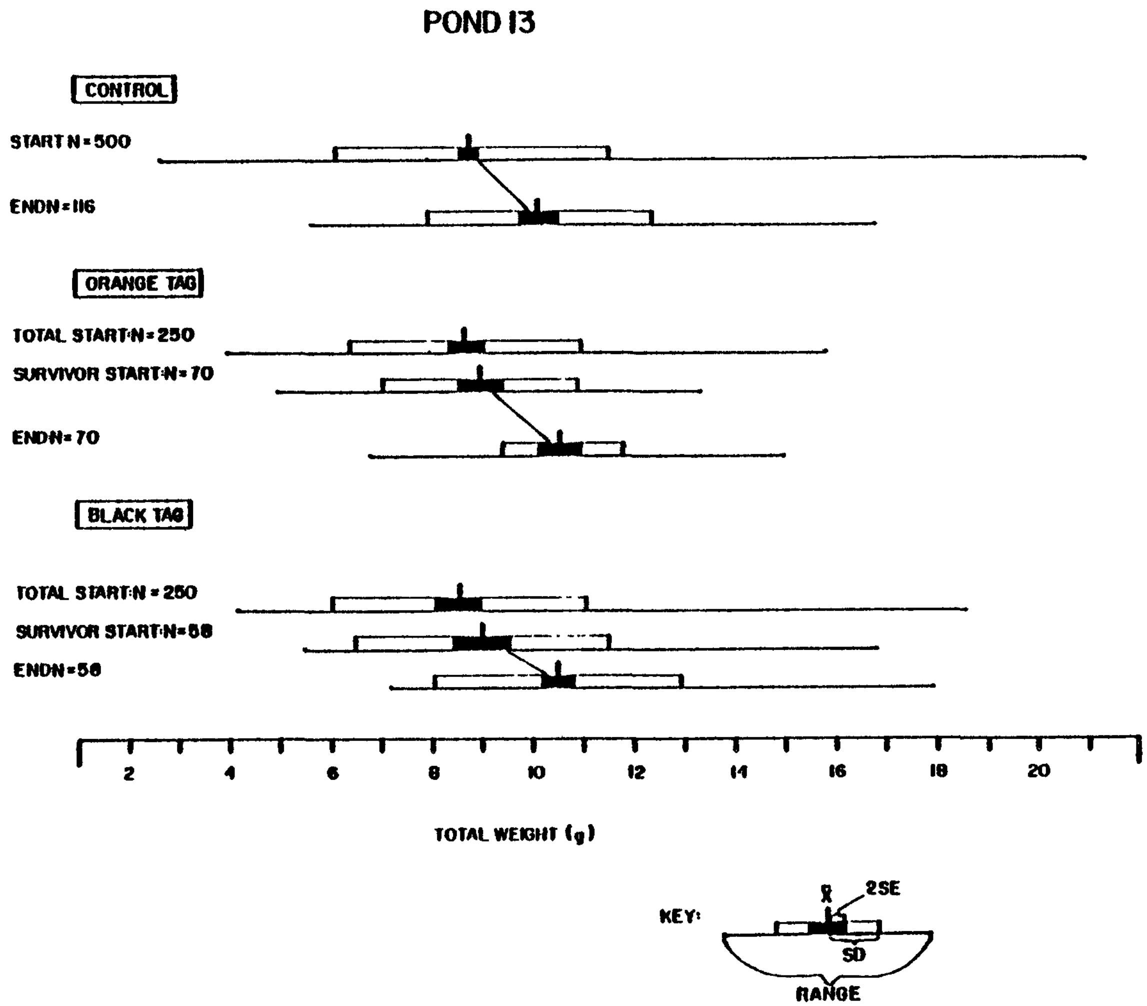



Fig. 29. Mean total weight (g) of pink shrimp (*Penaeus duorarum*) in pond 13 at the start and end of the 30-day experiment.

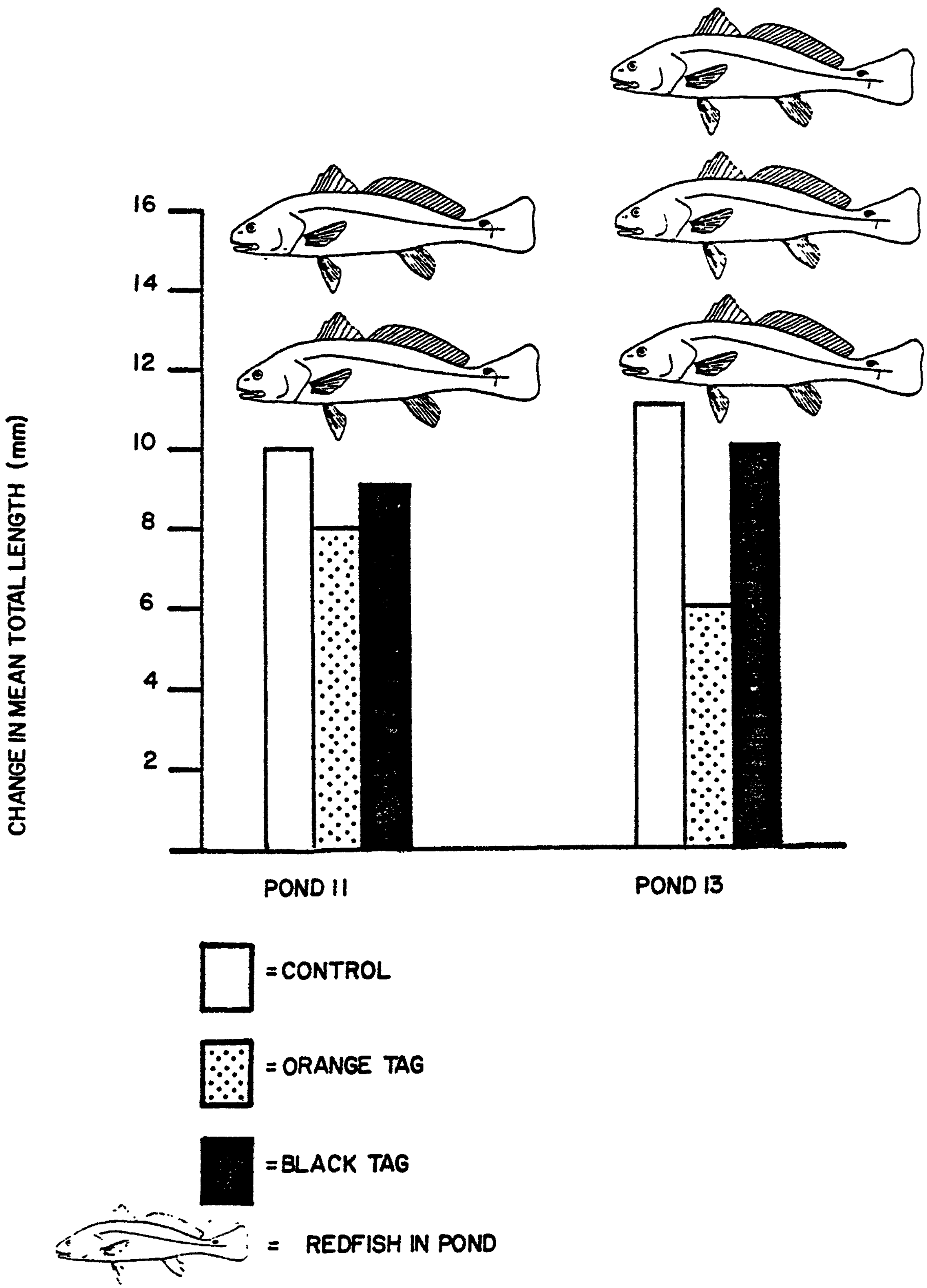



Fig. 30. Increase in mean total length (mm) of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds containing redfish predators.

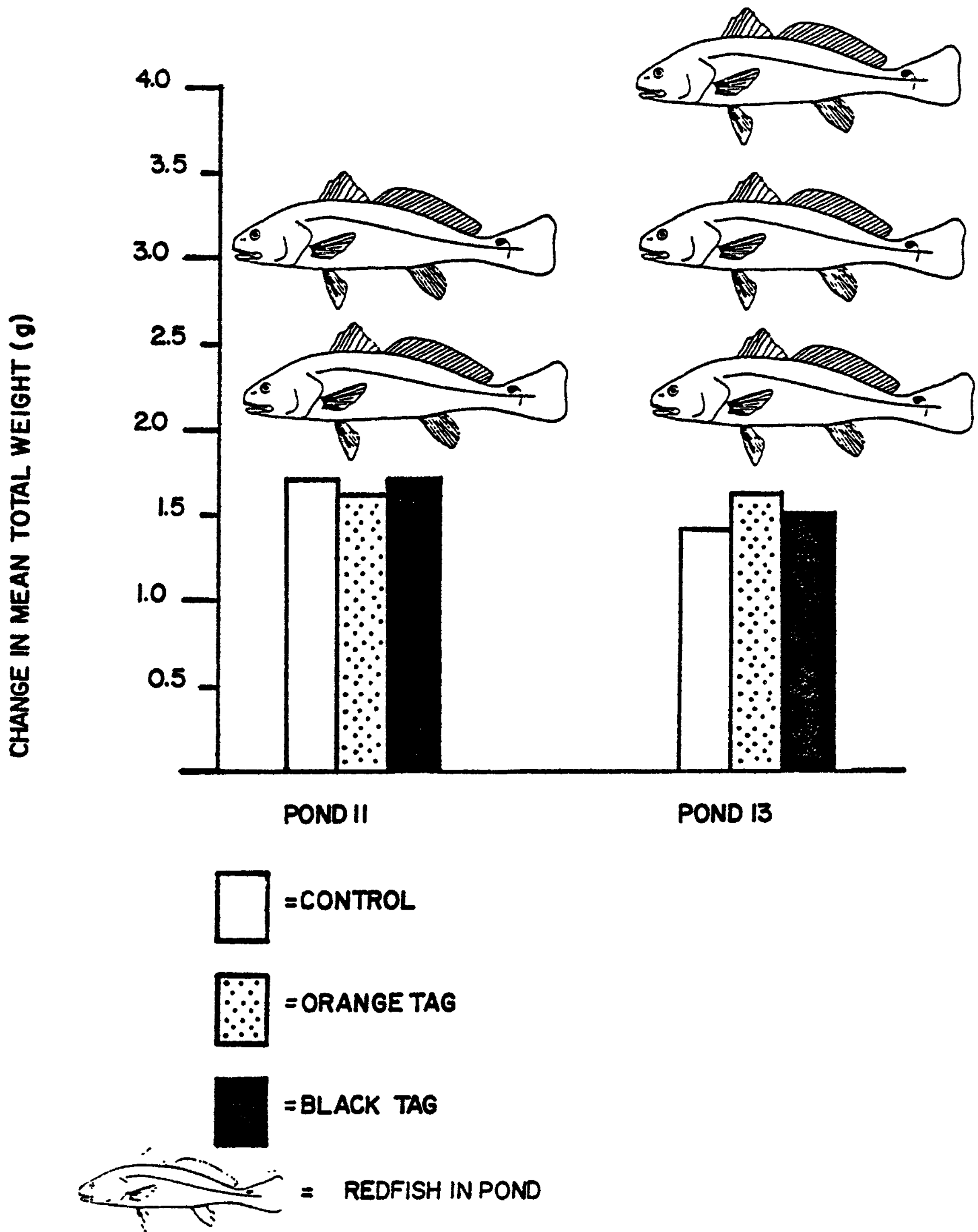



Fig. 31. Increase in mean total weight (g) of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds containing redfish predators.

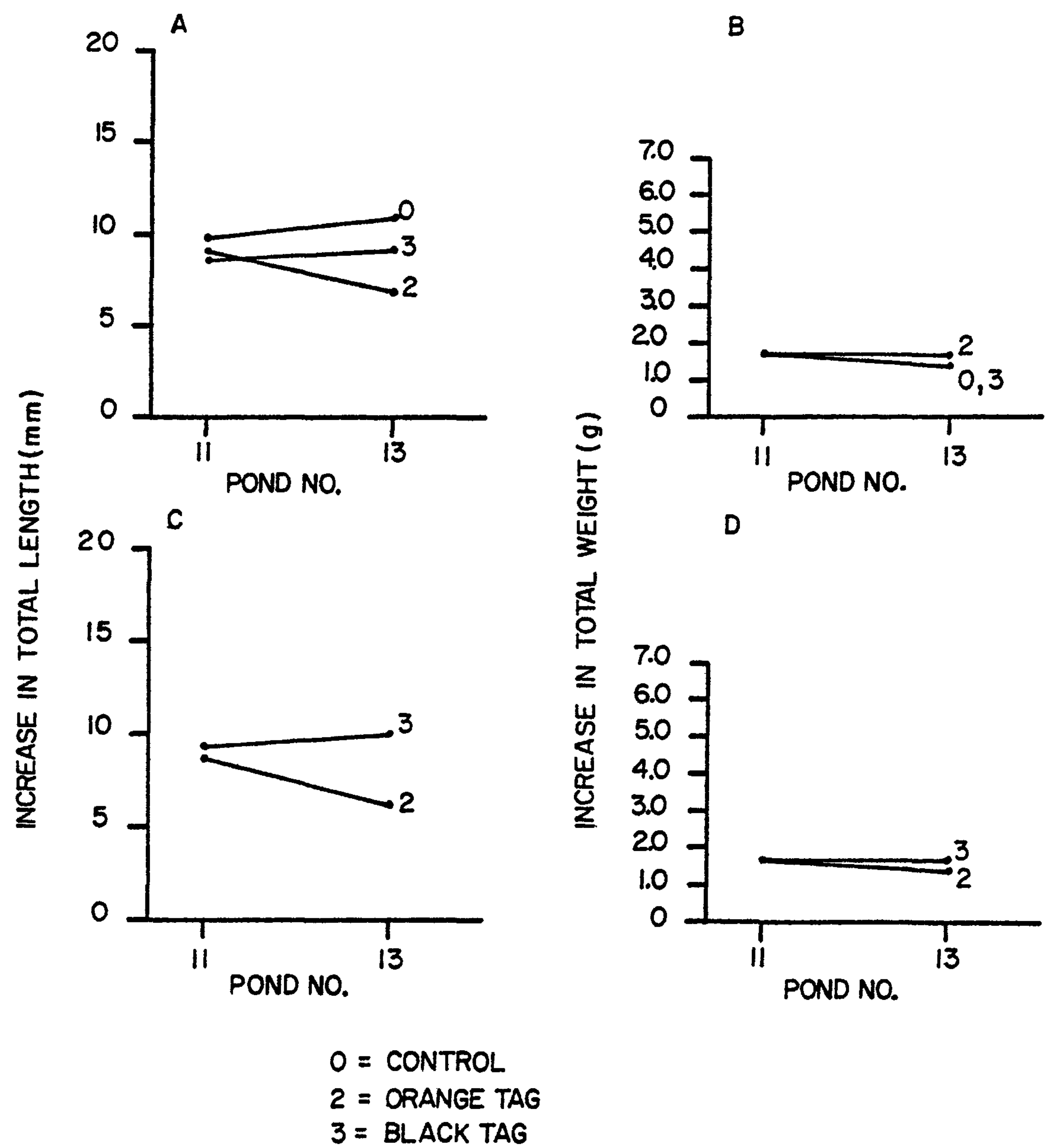



Fig. 32. Analysis of variance interaction plots for total length gain (A & C) and total weight gain (B & D). A-B: data corrected for initial means; C-D: uncorrected data.

than in shrimp marked with orange streamer tags in both pond 11 and pond 13. These observations are puzzling since survival was greater in shrimp marked with orange streamer tags than in those marked with black streamer tags (see Table 23). Analysis of variance of the total weight gain showed no pond x treatment interaction and no significant differences (p-value <0.05) in weight gain between shrimp marked with orange streamer tags and shrimp marked with black streamer tags. The interaction plot (Fig. 32D) revealed little difference in weight gain between the two treatments and ponds.

Comparison of the interaction plot for total length corrected for the initial mean (Fig. 32A) with the plot of the uncorrected data (Fig. 32C) showed that the slopes of treatments 2 and 3 (2=shrimp marked with orange tags; 3=shrimp marked with black tags) appeared to be the same. The interaction plots (Figs. 32B and 32D) showed similar results for total weight gain. However, the presence of a significant pond x treatment interaction (p-value <0.05) in one ANOVA and not in the other is puzzling. In order to determine whether the difference was attributable to the correction of the initial means, an ANOCOVA was performed on increase in total length using total weight gain as the covariate. The hypotheses of parallelism were tested for each ANOCOVA performed to make certain that the covariate was not affected by the factors tested (i.e. treatment, pond). The hypotheses of parallelism for the covariate (weight gain) were not rejected at the 95% level of confidence. A logarithmic transformation of the total length gain and total weight gain was considered. Since the plots of the raw data showed a linear relationship between the two variables, the log transformation was determined to be inappropriate.

Analysis of covariance was performed on the data corrected for the initial group means to determine whether there were significant differences in length gain (adjusted for weight gain) among unmarked shrimp, shrimp marked with orange streamer tags and shrimp marked with black streamer tags (Table 26B). The results revealed a significant pond x treatment interaction at the 95% level of confidence, so that nothing conclusive could be said about increase in total length (adjusted for total weight gain) between treatments and between ponds. However, the interaction plot (Fig. 33A) tends to indicate that the unmarked shrimp had a uniformly greater total length gain (adjusted for total weight gain) than the marked shrimp. Analysis of covariance also was performed on the uncorrected data (Table 27B). Because of the pond x treatment interaction (p-value <0.05) nothing conclusive could be said about the difference between ponds and treatments. The plot of the interaction (Fig. 33B) suggests that the length gain (adjusted for weight gain) was greater in shrimp marked with black streamer tags than that in shrimp marked with orange streamer tags. The results of the covariate analysis seem to be more consistent with respect to the interaction term than the ANOVA's without the covariate.

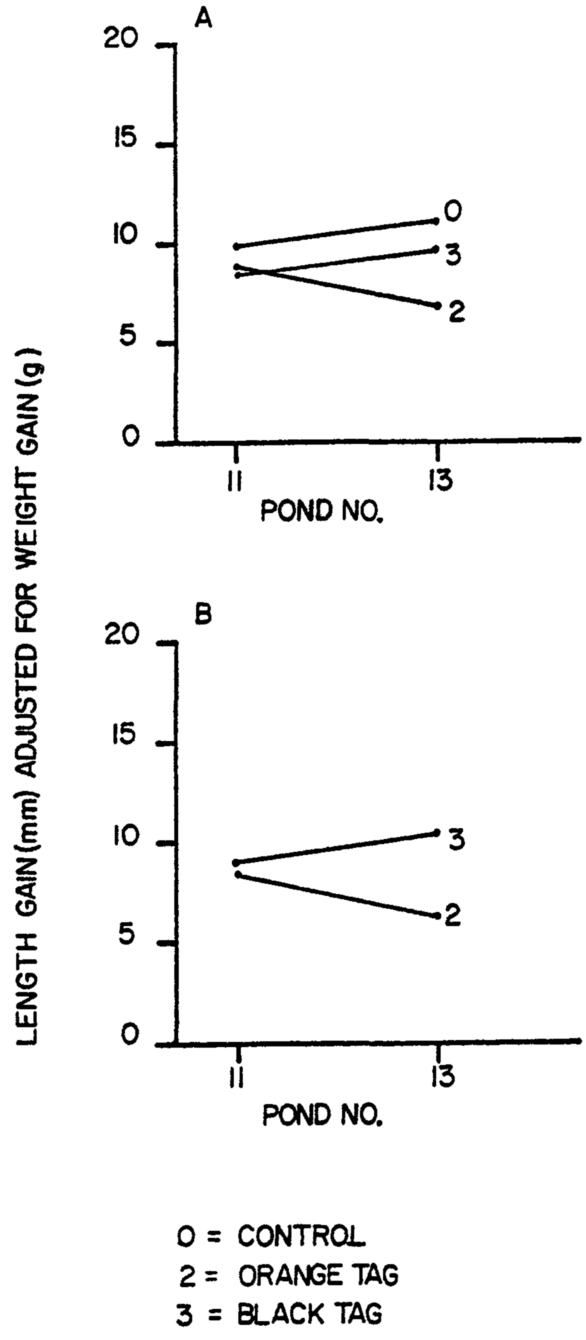



Fig. 33. Analysis of covariance interaction plots for length gain adjusted for weight gain. A: data corrected for initial means; B: uncorrected data.

Comparison of Ponds

Growth, mortality and tag loss in shrimp were compared between ponds without redfish predators (12 and 14) and ponds containing redfish (11 and 13). Mortality of pink shrimp was lowest in ponds without redfish and small fish (Fig. 34). Shrimp mortality in pond 13, containing three healthy redfish, was almost twice as high as in pond 11, with two diseased redfish. There was no significant difference in mortality between marked shrimp and unmarked shrimp in ponds with or without redfish.

Tag loss was greater in the presence of predators (Table 17). In ponds without predators tag loss was 0.25%, whereas in ponds with predators tag loss was 1.4%. The greater tag loss in ponds with predators may be the result of attempted capture of the shrimp by the fish. However, there is no evidence to substantiate this belief.

Growth of shrimp in ponds containing predators (11 and 13) and ponds without predators (12 and 14) was compared. The mean total length (mm), standard deviation, two standard errors of the mean, and size range of all shrimp placed in each pond are shown in Fig. 35. The mean total weight (g), standard deviation, two standard errors of the mean, and range of weight of all shrimp placed in each pond is shown in Fig. 36. The mean total length and total weight of shrimp in each pond was similar at the start of the experiment. Growth was greater in the ponds without predators (Fig. 37). To determine whether the differences in growth between ponds containing redfish predators and ponds without predators was significant, ANOVA was performed. Unmarked controls were used in this test since there were differences in the treatments of the shrimp in ponds with predators (11 and 13) and ponds without predators (12 and 14). Shrimp in ponds 11 and 13 were marked with orange streamer tags and black streamer tags. On the other hand, shrimp in ponds 12 and 14 were marked with orange streamer tags plus fluorescent pigment and orange streamer tags only. Results of ANOVA on differences in growth of unmarked shrimp between ponds containing redfish and ponds without redfish are shown in Table 28. Increase in total length and total weight of unmarked shrimp was significantly greater, at the 95% confidence level, in ponds without predators than in ponds containing two or three redfish and 509 small fish.

The lower growth rate of shrimp in the ponds containing redfish may be attributed to two factors. The presence of redfish may have inhibited feeding in shrimp thereby reducing growth. Competition for food also may account for the lower growth rate of the shrimp in ponds 11 and 13. Three lbs of food were distributed to each pond daily. This amount was expected to be threefold greater than required for optimal growth of the 1000 shrimp initially placed in pond 11 and pond 13 (David Hutchins, pers. comm.). However, birds probably ate 15% of the food as soon as it was distributed (David Hutchins, pers. comm.). The 509 small fish (mullet, cyprinidonts) also ate a substantial amount of the food because they were noticeably larger at the termination of the experiment. Thus, it is possible that insufficient food supply effectively reduced the growth rate of the shrimp.

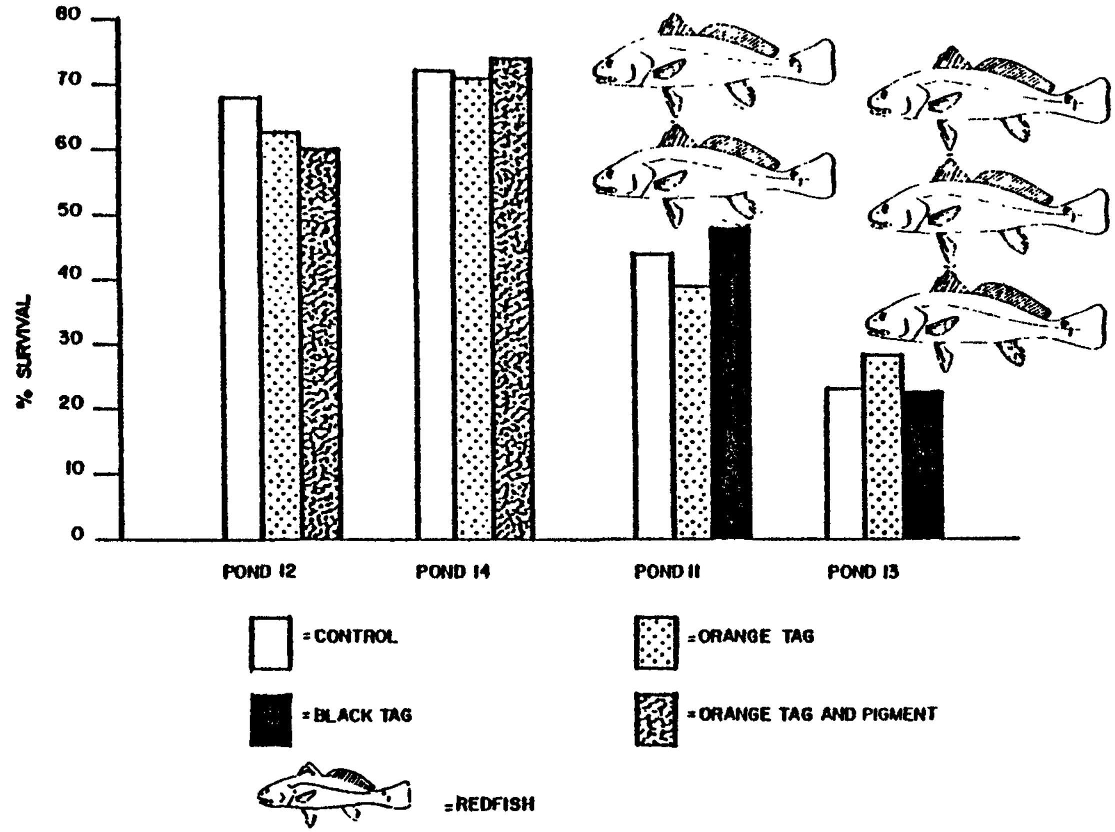



Fig. 34. Comparison of survival of pink shrimp (*Penaeus duorarum*) after 30 days in ponds with and without redfish.

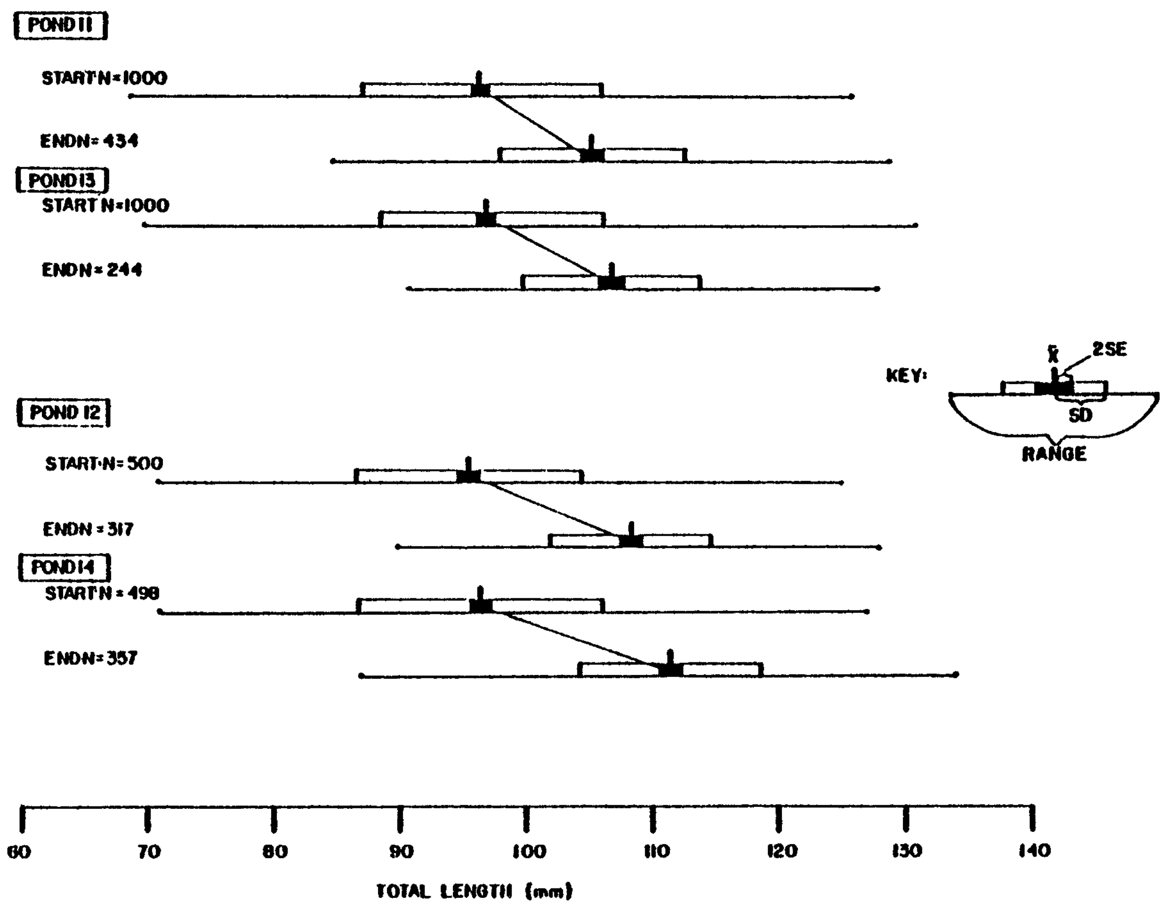



Fig. 35. Mean total length (mm) of pink shrimp (*Penaeus duorarum*) in ponds 11, 12, 13 and 14 at the start and end of the 30-day experiment.

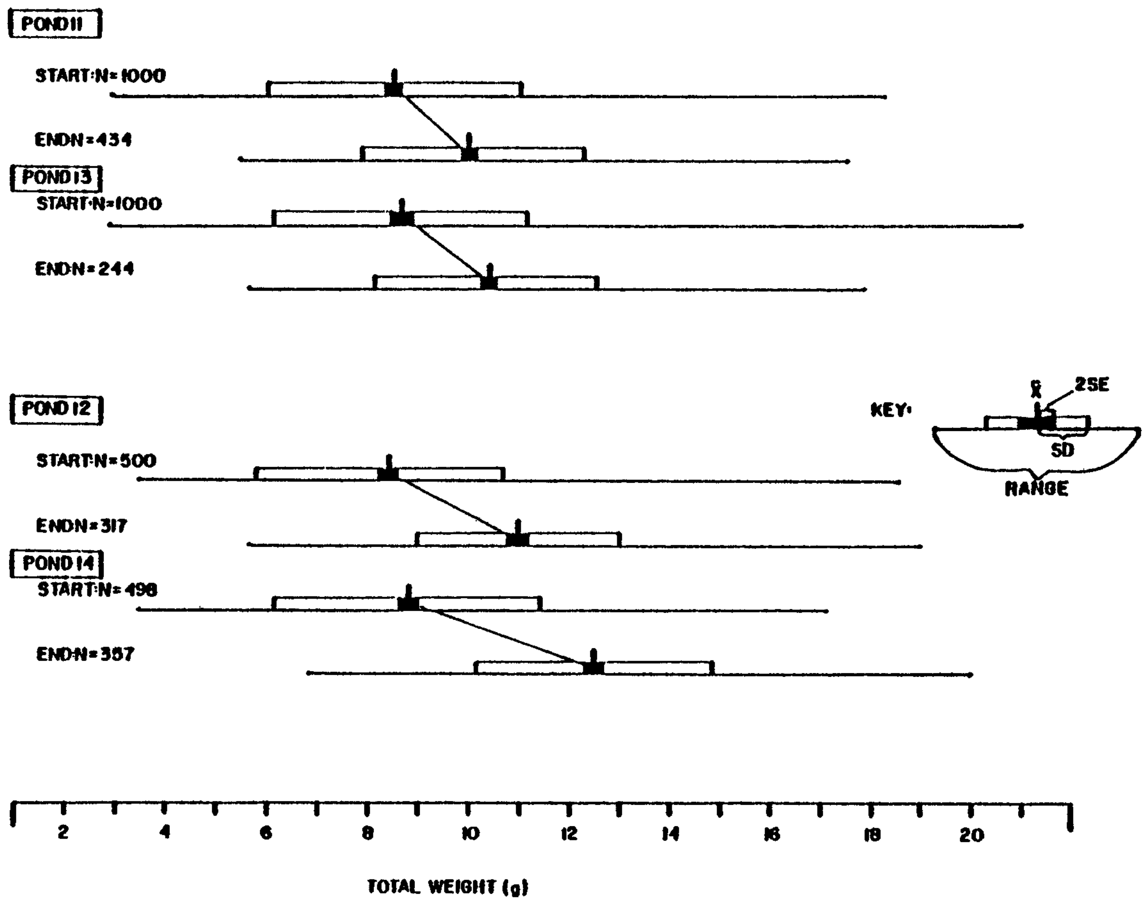



Fig. 36. Mean total weight (g) of pink shrimp (*Penaeus duorarum*) in ponds 11, 12, 13 and 14 at the start and end of the 30-day experiment.

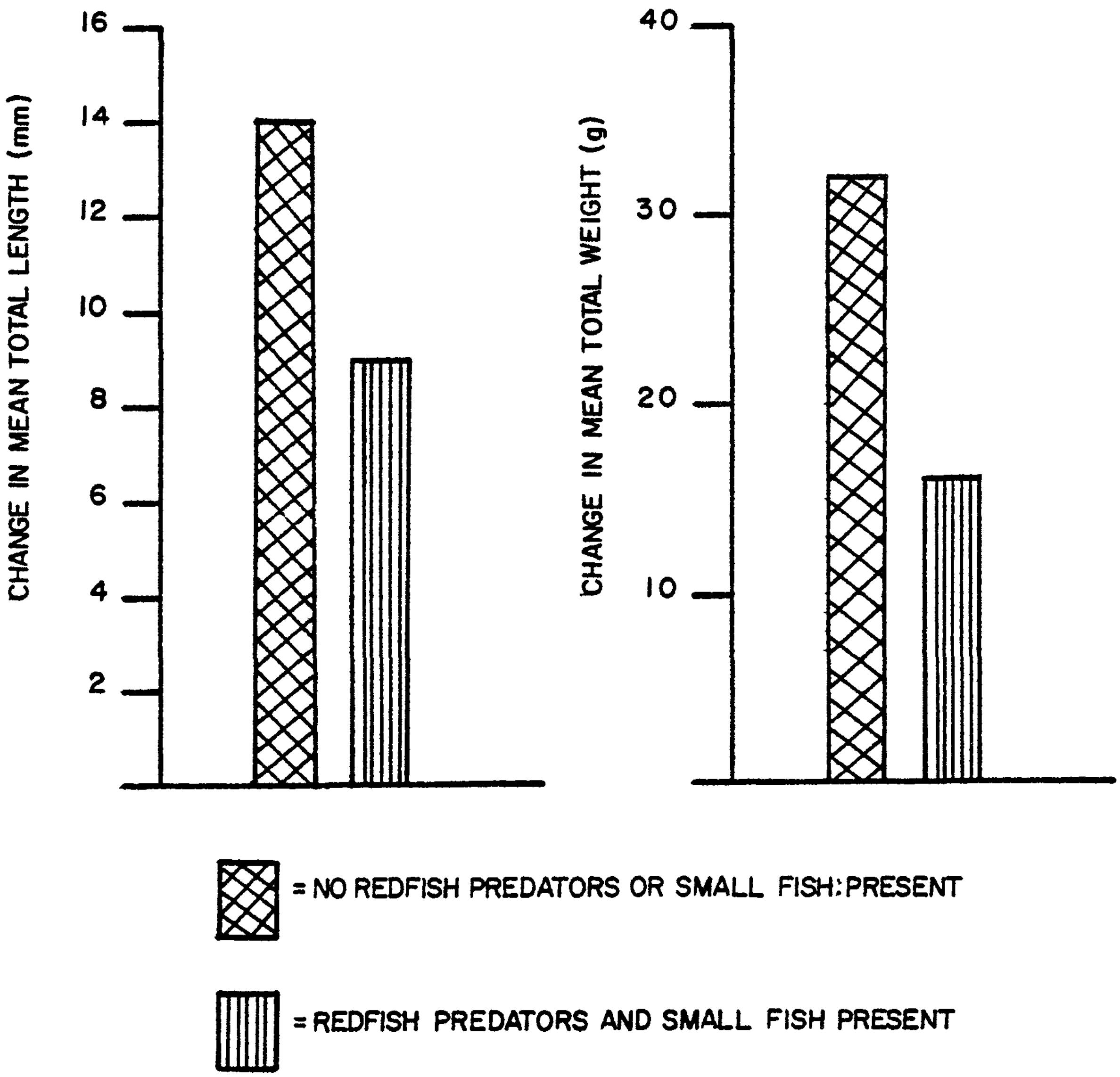



Fig. 37. Comparison of increase in total length (m) and total weight (g) of pink shrimp (*Penaeus duorarum*) after 30 days in ponds with and without redfish.

Predation by Other Animals

Almost 40% of the streamer tags were never recovered from the 0.1 ha ponds (Table 29). These tags are listed as "missing" in Tables 15 and 23. It is presumed that most of the missing tagged shrimp were eaten by birds. The Louisiana heron (*Hydranassa tricolor*), great blue heron (*Ardea herodias*), night heron (*Nycticorax nycticorax*), laughing gull (*Larus atricilla*), herring gull (*Larus argentatus*), terns (Sterninae), egrets (Ardeidae), scaup (*Aythya* spp.) and willet (*Catoptrophorus semipalmatus*) were among the birds observed at the ponds; they are known to feed on shrimp. Racoon tracks were seen at the edge of the ponds. A few crabs also were recovered from the ponds at the termination of the experiment.

There were several indicators of bird predation: (1) The tags were recovered in wrinkled clumps with as many as 12 tags per clump, and the tag numbers often were illegible. The grinding action of the avian gizzard could result in erasure of the tag numbers and wrinkling of the tags. Streamer tags that were removed from the redfish digestive tract at the termination of the experiment were not wrinkled and all the numbers were legible. Experiments performed to determine the damage to streamer tags after passage through the redfish digestive tract revealed that the tags remained in good condition (Terry Cody, pers. comm.); (2) Often tags recovered in a single clump originated from different ponds. For example, in one clump containing nine tags recovered at the edge of pond 11, one tag each came from ponds 11, 12 and 13, two tags were from pond 14 and the remainder were illegible; (3) Some of the clumps of tags were recovered on the levees between ponds or in ponds not used in the experiment; (4) Parts of a beetle exoskeleton were intertwined with a clump of tags; and (5) at the termination of the experiment a live tagged shrimp from one pond was recovered in another pond. It is presumed that a bird captured the shrimp but accidently dropped it into the other pond.

The avian predators showed a distinct color preference for shrimp marked with orange streamer tags. In ponds 11 and 13, 50% of the shrimp were marked with orange streamer tags and 50% were marked with black streamer tags. Of the 18 legible wrinkled tags recovered from these two ponds 14 (78%) were orange, whereas only 4 (22%) were black.

NON-REPORTING OF RECAPTURED TAGGED SHRIMP

The number of tags returned to LGL port agents by shrimpers, fish house employees and bait dealers from September 1979 to October 1980 is shown in Table 30. During this 14-month period, 78%, 21% and 1% of the tagged shrimp collected by LGL port agents were returned by shrimpers, fish house employees and bait dealers, respectively. These results suggest that 22% of the tagged shrimp recovered are not reported by shrimpers. The degree of non-reporting of tags is higher than the above data indicate since many tagged shrimp seen by fish house employees as the catch is being unloaded are returned to the captain of the vessel. At Port Lavaca many tagged shrimp are recovered by employees at the packing plants (Table 30). Most of these tagged shrimp originate from the Freeport unloading docks, indicating a large percent of tags are not reported by Freeport shrimpers. The tag returns by shrimpers at Rockport-Fulton and Aransas Pass are an overestimate, since tags recovered by non-shrimpers at these two ports are collected by the TIMS port agents. Tags returned by NMFS port agents were not included in the results shown in Table 30. since NMFS does not categorize their returns according to point of discovery (i.e. shrimper, fish house employee, bait dealer) (Neal Baxter, pers. comm.).

Non-reporting of tags also was estimated from random interviews with shrimpers, fish house employees and bait dealers after the completion of the fall 1979 tagging effort, and again after the summer 1980 tagging effort. The first series of random interviews were conducted in December 1979. By this time most bait stands were closed for the season and many boats remained at the docks, thereby reducing the number of shrimpers, fish house employees and bait dealers available for interviews. All groups were asked their estimate of percent non-reporting of tags among shrimpers. The average percent of non-reporting of tags by shrimpers using uncorrected data was 20%. Transformation of the averages by arcsin transformation ($\Theta = \arcsin\sqrt{p}$, where p is the percent) and then converting them back to the original scale revealed that 16% of the tags recovered were not reported by shrimpers (Table 31).

Random interviews also were conducted in September 1980 to determine the degree of non-reporting of tags by shrimpers, fish house employees, and bait dealers. Non-reporting of tags was estimated to be 27% among shrimpers, 10% among fish house employees and 3% among bait dealers (Table 31). Arcsin transformations of the averages revealed that 23%, 6% and 1% of the tags were not reported by shrimpers, fish house employees and bait dealers, respectively. Several reasons were given for non-reporting of recaptured tagged shrimp (Table 33). Many of the individuals interviewed were skeptical of the fishing contest and believed that they had no chance of winning. They would have preferred a monetary reward for each tagged shrimp returned. Some people complained that they never received letters of acknowledgement for returned tagged shrimp. Many deckhands who handled the shrimp ignored the tags or pulled them out and discarded them. They often were unaware of the tagging program and its significance, or did not want to take the time to record the recapture information. Shrimpers also have been reported to keep the tagged shrimp as souvenirs. Some of the complaints are exaggerated and often contradictory. For example, some shrimpers reported that black tags were difficult to see at night; others said that there was no difficulty in recognizing black tags on the well-lit decks at night.

The problem of non-reporting of tags was discussed by Paulik (1961), Klima (1964, 1974) and Kutkuhn (1966). Paulik (1961) noted that recovery programs that depended on voluntary tag reporting by sports fishermen appeared to be subject to particularly high levels of non-response error. He reported that Mullan (1959) found a 60% non-response for mandible tags on trout while Stroud and Bitzer (1955) estimated a 25% non-response for strap and cheek tags on warm water species of fish.

Klima (1964) believed that the failure of shrimpers to report tags was of minor importance. Kutkuhn (1966) reported that the chances of detecting marked shrimp were good to excellent because of the extensive publicity preceding and during the experiment, and the $2.00 reward offered for the return of any marked shrimp.

After the completion of the summer 1980 tagging effort an additional method for determining degree of non-reporting of tags was initiated. Shrimp marked with black streamer tags were "planted" on conveyers as the shrimp were being unloaded from vessels. The ports at which the tagged shrimp were "planted", date, number of shrimp used and number recovered are shown in Table 34. Tag recovery was expected within one month after the shrimp had been "planted" (Neal Baxter, pers. comm.). However, by the end of November 1980 only two of the 20 tagged shrimp "plants" had been recovered. The two tagged shrimp recovered at Aransas Pass were noticed within minutes after their placement on the conveyer belt. The results of this experiment do not agree with the data presented by Klima (1974). In Klima's study (1974) one to four marked shrimp were placed in the hold as the catch was being unloaded at various shrimp plants in Seabrook and Galveston, Texas. The degree of non-reporting of tags was 18% (Klima 1974). In the present study, non-reporting of tags was 90%. Differences in the results between the two studies could be attributed to differences in number of samples, marking method and ports used in the experiment. Klima's (1974) sample consisted of 71 shrimp, whereas in the present study 20 shrimp were used. The ports of Galveston and Seabrook were sampled by Klima (1974), whereas Brownsville, Aransas Pass and Freeport were sampled in the present study. Random interviews at various ports along the Texas coast in 1979 and 1980 (see Tables 31 and 32) indicate that the degree of non-reporting of tagged shrimp varies among ports. Klima (1974) used shrimp marked with biological stains, whereas in the present study black streamer tags were utilized.

## CONTINUOUS TEMPERATURE MONITORING

Continuous bottom temperature measurements collected to date were obtained at BGOF. Since the data was first collected on 8 November 1979, many problems have developed with the two Hydrolab System 8000 units. Table 35 describes the problems associated with the data gathering. The data collected to date are available at NMFS (NSTL Station, Mississippi). The measurements of bottom water temperature at BGOF will be extended beyond the original cutoff date of 1 January 1981 until 518 days of temperature records have been collected.

## SECTION 5

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**TABLES**

Table 1. Species, release location, month and expected number of tagged shrimp to be released for the Bryan Mound disposal site study.

| | White (*P. setiferus*) | | | Brown (*P. aztecus*) | | | |
|---|---|---|---|---|---|---|---|
| | Inshore | | Offshore | Inshore | | Offshore | Grand |
| Date | Galveston | Matagorda | Diffuser | Galveston | Matagorda | Diffuser | Total |
| Aug 1979 | 5,000 | 5,000 | 10,000 | | | 10,000 | 30,000 |
| Sept 1979 | 5,000 | 5,000 | 10,000 | | | | 20,000 |
| May 1980 | | | | 5,000 | 5,000 | | 10,000 |
| June 1980 | | | | 5,000 | 5,000 | 10,000 | 20,000 |
| July 1980 | | | | | | 10,000 | 10,000 |
| TOTALS | 10,000 | 10,000 | 20,000 | 10,000 | 10,000 | 30,000 | 90,000 |

Table 2. Number of white shrimp (*Penaeus setiferus*) and brown shrimp (*Penaeus aztecus*) released in West Bay and Matagorda Bay in fall 1979 and spring/summer 1980.

*Penaeus setiferus*

| Location | Dates From | Dates To | No. Shrimp Tagged | No. Tagged Shrimp Released | No. Releases Required |
|---|---|---|---|---|---|
| West Bay | 5 Sept | 9 Sept 79 | 3,392 | 2,382 | 5,000 |
| West Bay | 10 Oct | 14 Oct 79 | 5,900 | 5,312 | 5,000 |
| West Bay | 5 Nov | 6 Nov 79 | 2,599 | 2,431 | |
| TOTALS | | | 11,891 | 10,125 | 10,000 |
| Matagorda Bay | 26 Sept | 1 Oct 79 | 5,000 | 4,371 | 5,000 |
| Matagorda Bay | 29 Oct | 1 Nov 79 | 6,499 | 5,736 | 5,000 |
| TOTALS | | | 11,499 | 10,107 | 10,000 |

*Penaeus aztecus*

| Location | Dates From | Dates To | No. Shrimp Tagged | No. Tagged Shrimp Released | No. Releases Required |
|---|---|---|---|---|---|
| West Bay | 1 June | 4 June 80 | 5,576 | 5,153 | 5,000 |
| West Bay | 15 July<br>21 July | 18 July 80<br>23 July 80 | 6,341 | 5,199 | 5,000 |
| TOTALS | | | 11,917 | 10,352 | 10,000 |
| Matagorda Bay | 27 May | 30 May 80 | 5,606 | 5,115 | 5,000 |
| Matagorda Bay | 8 July | 11 July 80 | 5,931 | 5,104 | 5,000 |
| TOTALS | | | 11,537 | 10,219 | 10,000 |

Table 3. Number of white shrimp (*Penaeus setiferus*) and brown shrimp (*P. aztecus*) released offshore in the vicinity of the Bryan Mound Diffuser in fall 1979 and summer 1980.

***Penaeus setiferus***

| Location | Dates From | Dates To | No. Shrimp Tagged | No. Tagged Shrimp Released | No. Releases Required |
|---|---|---|---|---|---|
| Offshore | 8 Sept | 11 Sept 79 | 2,458 | 2,291 | |
| | 24 Sept | 3 Oct 79 | 8,140 | 7,768 | 10,000 |
| | 14 Nov | 19 Nov 79 | 10,248 | 10,026 | 20,000 |
| TOTALS | | | 20,846 | 20,085 | 20,000 |

***Penaeus aztecus***

| Location | Dates From | Dates To | No. Shrimp Tagged | No. Tagged Shrimp Released | No. Releases Required |
|---|---|---|---|---|---|
| Offshore | 8 Sept | 11 Sept 79 | 473 | 464 | |
| | 24 Sept | 3 Oct 79 | 1,034 | 1,026 | |
| | 13 Oct | 20 Oct 79 | 5,654 | 5,551 | |
| | 26 Nov | 27 Nov 79 | 900 | 887 | 10,000 |
| | 17 June | 27 June 80 | 12,609 | 11,677 | 10,000 |
| | 22 July | 29 July 90 | 10,864 | 10,545 | 10,000 |
| TOTALS | | | 31,534 | 30,150 | 30,000 |

Table 4. Forms completed and submitted by LGL for the fall 1979 and spring/summer 1980 shrimp tagging effort.

| Season | Trip No. | Release Summary Forms | Daily Release Form | Tagged Shrimp Release Data Form | Daily Tagging Mortality Form | Length-Weight Sample Form |
|---|---|---|---|---|---|---|
| Fall 1979 | I-1 | 1 | 5 | 20 | 9 | 6 |
| " | I-2 | 1 | 4 | 25 | 5 | 6 |
| " | I-3 | 1 | 5 | 31 | 5 | 5 |
| " | I-4 | 1 | 4 | 33 | 5 | 4 |
| " | I-5 | 1 | 2 | 13 | 2 | 2 |
| " | 0-1 | 1 | 4 | 16 | 4 | 8 |
| " | 0-2 | 1 | 13 | 50 | 11 | 10 |
| " | 0-3 | 1 | 8 | 33 | 8 | 8 |
| " | 0-4 | 1 | 11 | 53 | 6 | 6 |
| " | 0-5 | 1 | 1 | 5 | 1 | 1 |
| Spring/Summer 1980 | I-1 | 1 | 4 | 30 | 5 | 5 |
| " | I-2 | 1 | 4 | 29 | 4 | 4 |
| " | I-3 | 1 | 4 | 31 | 6 | 4 |
| " | I-4 | 1 | 7 | 34 | 11 | 7 |
| " | 0-1 | 1 | 11 | 67 | 12 | 11 |
| " | 0-2 | 1 | 13 | 56 | 8 | 8 |
| TOTALS | | 16 | 100 | 526 | 102 | 95 |

Table 5. Number of shrimp used for length-weight measurements for daily shrimp tagging effort.

| Trip No. | Date | Number of Shrimp Measured | Notes |
|---|---|---|---|
| I-1 | 05 Sept 79 | 200 | |
| | 06 Sept 79 | 21 | Insufficient shrimp supply |
| | 07 Sept 79 | 200 | |
| | 08 Sept 79 | 200 | |
| | 09 Sept 79 | 29 | Insufficient shrimp supply |
| I-2 | 26 Sept 79 | 165 | Insufficient shrimp supply |
| | 27 Sept 79 | 110 | " |
| | 28 Sept 79 | 133 | " |
| | 01 Oct 79 | 200 | |
| I-3 | 10 Oct 79 | 200 | |
| | 11 Oct 79 | 153 | Insufficient shrimp supply |
| | 12 Oct 79 | 96 | " |
| | 13 Oct 79 | 200 | |
| | 14 Oct 79 | 78 | Insufficient shrimp supply |
| I-4 | 29 Oct 79 | 189 | Insufficient shrimp supply |
| | 30 Oct 79 | 200 | |
| | 31 Oct 79 | 200 | |
| | 01 Nov 79 | 200 | |
| I-5 | 05 Nov 79 | 200 | |
| | 06 Nov 79 | 200 | |
| 0-1 | 08 Sept 79 | 200 | |
| | 09 Sept 79 | 200 | |
| | 10 Sept 79 | 200 | |
| | 11 Sept 79 | 200 | |
| 0-2 | 24 Sept 79 | 155 | Ship freezer broke down; many shrimp damaged |
| | 25 Sept 79 | 32 | " |
| | 26 Sept 79 | 12 | " |
| | 27 Sept 79 | 62 | " |
| | 28 Sept 79 | 51 | " |
| | 30 Sept 79 | 55 | " |
| | 01 Oct 79 | 105 | " |
| | 02 Oct 79 | 195 | " |
| | 03 Oct 79 | 200 | |
| 0-3 | 13 Oct 79 | 179 | Insufficient shrimp supply |
| | 14 Oct 79 | 200 | |
| | 15 Oct 79 | 166 | Insufficient shrimp supply |
| | 16 Oct 79 | 188 | " |
| | 17 Oct 79 | 200 | |
| | 18 Oct 79 | 200 | |
| | 19 Oct 79 | 81 | Insufficient shrimp supply |
| | 20 Oct 79 | 200 | |

....cont'd

Table 5 (cont'd)

| Trip No. | Date | Number of Shrimp Measured | Notes |
|---|---|---|---|
| 0-4 | 14 Nov 79 | 200 | |
| | 15 Nov 79 | 200 | |
| | 16 Nov 79 | 189 | Insufficient shrimp supply |
| | 17 Nov 79 | 122 | " |
| | 18 Nov 79 | 200 | |
| | 19 Nov 79 | 200 | |
| 0-5 | 27 Nov 79 | 149 | Insufficient shrimp supply |
| I-6 | 27 May 80 | 200 | |
| | 28 May 80 | 200 | |
| | 29 May 80 | 200 | |
| | 20 May 80 | 200 | |
| I-7 | 01 June 80 | 200 | |
| | 02 June 80 | 200 | |
| | 03 June 80 | 200 | |
| | 04 June 80 | 200 | |
| I-8 | 08 July 80 | 200 | |
| | 09 July 80 | 200 | |
| | 10 July 80 | 150 | Insufficient shrimp supply |
| | 11 July 80 | 200 | |
| I-9 | 15 July 80 | 56 | Insufficient shrimp supply |
| | 16 July 80 | 200 | |
| | 17 July 80 | 163 | Insufficient shrimp supply |
| | 18 July 80 | 200 | |
| | 21 July 80 | 34 | Insufficient shrimp supply |
| | 22 July 80 | 110 | " |
| | 23 July 80 | 117 | " |
| 0-6 | 17 June 80 | 159 | fresh molting, broken rostrum/telson |
| | 18 June 80 | 195 | " |
| | 19 June 80 | 193 | " |
| | 20 June 80 | 143 | " |
| | 21 June 80 | 160 | " |
| | 22 June 80 | 157 | " |
| | 23 June 80 | 169 | " |
| | 24 June 80 | 195 | " |
| | 25 June 80 | 182 | " |
| | 26 June 80 | 200 | |
| | 27 June 80 | 200 | |

....cont'd

Table 5 (cont'd)

| Trip No. | Date | Number of Shrimp Measured | Notes |
|---|---|---|---|
| 0-7 | 22 July 80 | 200 | |
| | 23 July 80 | 200 | |
| | 24 July 80 | 200 | |
| | 25 July 80 | 188 | fresh molting, broken rostrum/telson |
| | 26 July 80 | 200 | |
| | 27 July 80 | 200 | |
| | 28 July 80 | 200 | |
| | 29 July 80 | 200 | |

Table 6. Number of samples of hydrological data collected at time of tagged shrimp release.

INSHORE TAGGING - 1979

| Sample Type | No. Samples Collected Tank | No. Samples Collected Release Site | No. Samples Required Tank | No. Samples Required Release Site |
|---|---|---|---|---|
| Temperature | 20 | 20 | 20 | 20 |
| Salinity | 20 | 20 | 20 | 20 |
| Dissolved Oxygen | 20 | 20 | 0 | 0 |
| Turbidity | 0 | 20 | 0 | 20 |

OFFSHORE TAGGING - 1979

| Sample Type | No. Samples Collected Tank | No. Samples Collected Surface | No. Samples Collected Release Site | No. Samples Required Tank | No. Samples Required Surface | No. Samples Required Release Site |
|---|---|---|---|---|---|---|
| Temperature | 29 | 29 | 87 | 29 | 29 | 87 |
| Conductivity | 29 | 29 | 87 | 29 | 29 | 87 |
| Dissolved Oxygen | 29 | 25 | 75 | 0 | 0 | 0 |
| Turbidity | 0 | 0 | 87 | 0 | 0 | 87 |

INSHORE TAGGING - 1980

| Sample Type | No. Samples Collected Tank | No. Samples Collected Release Site | No. Samples Required Tank | No. Samples Required Release Site |
|---|---|---|---|---|
| Temperature | 29 | 29 | 29 | 29 |
| Salinity | 29 | 29 | 29 | 29 |
| Dissolved Oxygen | 29 | 29 | 0 | 0 |
| Turbidity | 0 | 29 | 0 | 29 |

OFFSHORE TAGGING - 1980

| Sample Type | No. Samples Collected Tank | No. Samples Collected Surface | No. Samples Collected Release Site | No. Samples Required Tank | No. Samples Required Surface | No. Samples Required Release Site |
|---|---|---|---|---|---|---|
| Temperature | 19 | 19 | 57 | 19 | 19 | 57 |
| Conductivity | 19 | 19 | 57 | 19 | 19 | 57 |
| Dissolved Oxygen | 14 | 14 | 42 | 0 | 0 | 0 |
| Turbidity | 0 | 0 | 57 | 0 | 0 | 57 |

Table 7. Temperature, salinity, dissolved oxygen and turbidity of bottom water in Matagorda Bay at the time of the first release of tagged shrimp.

| | Location of Release | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | (°lat 'N) | (°long 'W) | Depth (fathoms) | Temperature (°C) | Salinity (ppt) | Dissolved Oxygen (ppm) | Turbidity (NTU) |
| 26 Sept 79 | 28° 26' | 96° 24' | 1.2 | 26.0 | 12 | 6.8 | 11.0 |
| 27 Sept 79 | " | " | 1.5 | 27.0 | 14 | 6.2 | 13.0 |
| 28 Sept 79 | " | " | 0.5 | 27.5 | 15 | 5.5 | 8.3 |
| 01 Oct 79 | " | " | 0.5 | 27.0 | 15 | 5.2 | 62.0 |
| 29 Oct 79 | " | " | 0.7 | 26.0 | 30 | 8.0 | 2.1 |
| 30 Oct 79 | " | " | 0.5 | 26.0 | 28 | 7.8 | 3.0 |
| 31 Oct 79 | " | " | 0.2 | 22.5 | 23 | 8.6 | 2.1 |
| 01 Nov 79 | " | " | 0.3 | 21.0 | 22 | 8.7 | 2.8 |
| 27 May 80 | 28° 26' | 96° 24' | 0.5 | 30.0 | 15 | 6.6 | 6.1 |
| 28 May 80 | " | " | 0.1 | 28.5 | 9 | 7.0 | 5.5 |
| 29 May 80 | " | " | 0.4 | 29.0 | 8 | 7.0 | 9.2 |
| 30 May 80 | " | " | 0.5 | 30.0 | 9 | 6.7 | 2.0 |
| 08 July 80 | " | " | 0.3 | 32.0 | 35 | 5.8 | 27.0 |
| 09 July 80 | " | " | 0.3 | 32.0 | 34 | 5.7 | 22.5 |
| 10 July 80 | " | " | 0.5 | 32.5 | 34 | 5.6 | 8.0 |
| 11 July 80 | " | " | 0.3 | 34.0 | 34 | 5.7 | 12.0 |

Table 8. Temperature, salinity, dissolved oxygen and turbidity of the bottom water in West Bay (Galveston) at the time of the first release of tagged shrimp.

| Date | Location of Release (°lat 'N) | Location of Release (°long 'W) | Depth (fathoms) | Temperature (°C) | Salinity (ppt) | Dissolved Oxygen (ppm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| 05 Sept 79 | 29° 06' | 95° 07' | 0.3 | 28.0 | 20 | 5.1 | 5.1 |
| 06 Sept 79 | " | " | 0.3 | 29.5 | -† | 6.4 | 3.9 |
| 07 Sept 79 | " | " | 0.3 | 29.5 | 16 | 6.3 | 2.6 |
| 08 Sept 79 | " | " | 0.3 | 29.0 | 14 | 6.0 | 3.5 |
| 09 Sept 79 | " | " | 0.3 | 29.0 | 15 | 6.2 | -† |
| 10 Oct 79 | " | " | 0.8 | 23.0 | 30 | 7.8 | 5.9 |
| 11 Oct 79 | " | " | 0.5 | 24.5 | 34 | 8.8 | 3.0 |
| 12 Oct 79 | " | " | 0.5 | 30.0 | 32 | 9.6 | 2.6 |
| 13 Oct 79 | " | " | 0.5 | 27.0 | 34 | 8.5 | 2.2 |
| 14 Oct 79 | " | " | 0.5 | 24.5 | 28 | 8.7 | 3.5 |
| 05 Nov 79 | " | " | 0.3 | 19.0 | 24 | 8.7 | 1.0 |
| 06 Nov 79 | " | " | 0.5 | 20.5 | 24 | 8.9 | 1.5 |
| 01 June 80 | " | " | 0.1 | 30.0 | 7 | 7.0 | 1.0 |
| 02 June 80 | " | " | 0.1 | 31.5 | 9 | 6.4 | 12.0 |
| 03 June 80 | " | " | 0.6 | 31.0 | 9 | 6.6 | 1.0 |
| 04 June 80 | " | " | 0.2 | 29.0 | 9 | 6.9 | 1.4 |
| 15 July 80 | " | " | 0.5 | 30.0 | 35 | 6.6 | 25.0 |
| 16 July 80 | " | " | 0.5 | 30.5 | 36 | 6.2 | 39.0 |
| 16 July 80 | " | " | 0.3 | 28.0 | 35 | 6.4 | 20.0 |
| 17 July 80 | " | " | 0.7 | 29.0 | 36 | 6.0 | 15.0 |
| 17 July 80 | " | " | 0.4 | 28.0 | 35 | 5.6 | 12.0 |
| 18 July 80 | " | " | 0.3 | 32.0 | 34 | 6.0 | 32.0 |
| 18 July 80 | " | " | 0.2 | 30.0 | 36 | 6.4 | 17.0 |
| 21 July 80 | " | " | 0.5 | 29.0 | 34 | 6.5 | 27.0 |
| 22 July 80 | " | " | 0.5 | 29.0 | 35 | 6.4 | 44.0 |
| 22 July 80 | " | " | 0.3 | 28.0 | 33 | 6.6 | 20.0 |
| 23 July 80 | " | " | 0.3 | 32.0 | 36 | 6.1 | 62.0 |
| 23 July 80 | " | " | 0.3 | 30.0 | 32 | 8.1 | 72.0 |

†missing data

Table 9. Temperature, salinity, dissolved oxygen and turbidity of bottom water at the Bryan Mound diffuser site at time of first release of tagged shrimp.

| Date | Location of Release (°lat 'N) | Location of Release (°long 'W) | Depth (fathoms) | Temperature (°C) | Salinity (ppt) | Dissolved Oxygen (ppm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| 08 Sept 79 | 28° 45' | 95° 16' | 11.0 | 29.1 | 31.8 | 6.2* | 0.5 |
| 09 Sept 79 | 28° 45' | 95° 15' | 11.0 | 29.0 | 31.6 | 7.5* | 1.5 |
| 10 Sept 79 | 28° 47' | 95° 20' | 10.0 | 28.8 | 28.3 | 7.1* | 1.4 |
| 11 Sept 79 | 28° 46' | 95° 22' | 10.0 | 28.5 | 28.0 | 7.0* | 4.1 |
| 24 Sept 79 | 28° 44' | 95° 14' | 11.0 | 26.5 | 29.8 | 6.0 | 3.7 |
| 25 Sept 79 | 28° 43' | 95° 14' | 11.0 | 26.7 | 31.0 | 5.8 | 2.3 |
| 26 Sept 79 | 28° 45' | 95° 14' | 11.0 | 26.5 | 30.2 | 7.9 | 2.4 |
| 27 Sept 79 | 28° 46' | 95° 15' | 10.0 | 26.4 | 29.8 | 7.2 | 1.4 |
| 28 Sept 79 | 28° 45' | 95° 16' | 10.0 | 26.5 | 30.4 | 6.8 | 23.0 |
| 29 Sept 79 | 28° 45' | 95° 15' | 11.0 | 26.5 | 31.8 | 7.0 | 1.6 |
| 30 Sept 79 | 28° 44' | 95° 14' | 11.0 | 26.7 | 32.8 | 5.8 | 1.4 |
| 01 Oct 79(1) | 28° 44' | 95° 14' | 11.0 | 26.6 | 33.0 | 6.1 | 1.5 |
| 01 Oct 79(2) | 28° 45' | 95° 16' | 10.0 | 27.0 | 33.6 | 6.2 | 9.0 |
| 02 Oct 79 | 28° 44' | 95° 14' | 11.0 | 27.0 | 34.8 | 6.0 | 2.1 |
| 03 Oct 79 | 28° 44' | 95° 14' | 11.0 | 27.3 | 35.0 | 5.4 | 2.3 |
| 13 Oct 79 | 28° 44' | 95° 15' | 10.5 | 26.1 | 34.6 | 6.5 | 1.8 |
| 14 Oct 79 | 28° 44' | 95° 14' | 11.0 | 26.0 | 34.0 | 6.9 | 6.7 |
| 15 Oct 79 | 28° 43' | 95° 15' | 11.0 | 25.8 | 34.0 | 6.7 | 6.5 |
| 16 Oct 79 | 28° 44' | 95° 14' | 11.5 | 25.5 | 33.8 | 6.4 | 2.4 |
| 17 Oct 79 | 28° 44' | 95° 18' | 11.0 | 25.4 | 33.8 | 6.4 | 6.6 |
| 18 Oct 79 | 28° 44' | 95° 15' | 11.0 | 25.1 | 33.5 | 6.5 | 11.9 |
| 19 Oct 79 | 28° 45' | 95° 16' | 11.0 | 25.1 | 33.8 | 6.7 | 2.8 |
| 20 Oct 79 | 28° 44' | 95° 13' | 11.0 | 25.2 | 33.6 | 6.4 | 3.2 |

.....cont'd

Table 9 (cont'd)

| Date | Location of Release (°lat 'N) | (°long 'W) | Depth (fathoms) | Temperature (°C) | Salinity (ppt) | Dissolved Oxygen (ppm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| 14 Nov 79 | 28° 41' | 95° 14' | 11.0 | 20.6 | 32.3 | 7.4 | 6.9 |
| 15 Nov 79 | 28° 42' | 95° 12' | 11.5 | 20.2 | 32.6 | 7.8 | 3.4 |
| 16 Nov 79 | 28° 41' | 95° 13' | 11.0 | 21.8 | 34.5 | 7.6 | 2.3 |
| 17 Nov 79 | 28° 41' | 95° 14' | 11.0 | 22.0 | 34.6 | 7.5 | 1.7 |
| 18 Nov 79 | 28° 41' | 95° 14' | 11.0 | 21.7 | 34.6 | 7.6 | 2.3 |
| 19 Nov 79 | 28° 41' | 95° 13' | 11.0 | 20.0 | 33.0 | 8.1 | 3.0 |
| 27 Nov 79 | 28° 41' | 95° 12' | 11.5 | 20.9 | 36.2 | 7.7 | 4.9 |
| 17 June 80 | 28° 44' | 95° 14' | 11.0 | 30.2 | 33.0 | 9.9 | 27.5 |
| 18 June 80 | 28° 44' | 95° 13' | 11.0 | 27.5 | 30.0 | 5.7 | 1.7 |
| 19 June 80 | 28° 43' | 95° 13' | 11.0 | 25.5 | 32.0 | 7.7 | 3.8 |
| 20 June 80 | 28° 44' | 95° 15' | 11.0 | 25.5 | 27.0 | 6.1 | 0.9 |
| 21 June 80 | 28° 43' | 95° 14' | 11.0 | 28.0 | 32.0 | 5.2 | 0.8 |
| 22 June 80 | 28° 43' | 95° 14' | 11.0 | 24.5 | 33.0 | 6.1 | 2.6 |
| 23 June 80 | 28° 44' | 95° 15' | 11.0 | 21.9 | 35.0 | -† | 2.3 |
| 24 June 80 | 28° 44' | 95° 14' | 11.0 | 23.1 | 34.0 | -† | 2.5 |
| 25 June 80 | 28° 44' | 95° 14' | 11.0 | 23.5 | 32.0 | -† | 0.8 |
| 26 June 80 | 28° 43' | 95° 14' | 11.0 | 22.5 | 33.0 | -† | 1.5 |
| 27 June 80 | 28° 42' | 95° 13' | 11.0 | 22.6 | 35.0 | -† | 0.8 |
| 22 July 80 | 28° 44' | 95° 14' | 11.0 | 28.9 | 36.0 | 6.8 | 2.5 |
| 23 July 80 | 28° 44' | 95° 14' | 11.0 | 28.8 | 35.0 | 7.5 | 1.7 |
| 24 July 80 | 28° 44' | 95° 15' | 11.0 | 29.2 | 35.0 | 7.2 | 2.7 |
| 25 July 80 | 28° 44' | 95° 15' | 11.0 | 29.5 | 35.0 | 7.3 | 2.5 |
| 26 July 80 | 28° 44' | 95° 15' | 10.5 | 29.5 | 35.0 | 6.8 | 2.9 |
| 27 July 80 | 28° 44' | 95° 13' | 10.8 | 29.6 | 36.0 | 6.9 | 0.6 |
| 28 July 80 | 28° 44' | 95° 14' | 11.0 | 29.5 | 36.0 | 6.7 | 3.0 |
| 29 July 80 | 28° 44' | 95° 15' | 11.0 | 29.5 | 35.0 | 6.9 | 4.3 |

*Dissolved oxygen measurements in holding tank.

†Equipment failure.

Table 10. Recaptures of tagged shrimp released in fall 1979 and spring/summer 1980.

**1979 Releases**

| Release Area | *Penaeus aztecus* No. Released | *Penaeus aztecus* No. Recovered* | *Penaeus aztecus* % Recovered | *Penaeus setiferus* No. Released | *Penaeus setiferus* No. Recovered* | *Penaeus setiferus* % Recovered |
|---|---|---|---|---|---|---|
| Bryan Mound Diffuser | 7,928 | 1,180 | 14.9 | 20,085 | 688 | 3.4 |
| Port O'Connor | | | | 10,107 | 180 | 1.8 |
| San Luis Pass | | | | 10,125 | 51 | 0.5 |

**1980 Releases**

| Release Area | *Penaeus aztecus* No. Released | *Penaeus aztecus* No. Recovered† | *Penaeus aztecus* % Recovered | *Penaeus setiferus* No. Released | *Penaeus setiferus* No. Recovered | *Penaeus setiferus* % Recovered |
|---|---|---|---|---|---|---|
| Bryan Mound Diffuser | 22,222 | 1,519 | 6.8 | 0 | 0 | 0 |
| Port O'Connor | 10,218 | 8 | 0.1 | 0 | 0 | 0 |
| San Luis Pass | 11,350 | 1 | 0.01 | 0 | 0 | 0 |

*1979 recaptures up to 1 December 1980.

†1980 recaptures up to 20 November 1980.

Note: Based on information provided by Mr. Neal Baxter, NMFS, Galveston, Texas.

Table 11. Hydrological data collected at Pond 12 at the Barney M. Davis power plant in Corpus Christi from 5 March to 4 April 1980. Pond 12 was used in the tag mortality-tag loss study.

POND 12

| Date | Temperature (°C) Surface | Temperature (°C) Bottom | Salinity (ppt) Surface | Dissolved Oxygen (ppm) Surface | Dissolved Oxygen (ppm) Bottom |
|---|---|---|---|---|---|
| 05 Mar 80 | 22.0 | 22.0 | 30.4 | 6.9 | 7.0 |
| 06 Mar 80 | 19.0 | 18.5 | 29.0 | 7.4 | 7.4 |
| 07 Mar 80 | 21.0 | 21.1 | 28.0 | 8.0 | 11.8 |
| 08 Mar 80 | 24.0 | 23.5 | 29.0 | 8.9 | 15.0 |
| 09 Mar 80 | 23.9 | 24.1 | 28.0 | 4.8 | 6.3 |
| 10 Mar 80 | 24.5 | 24.8 | 28.0 | 7.8 | 8.4 |
| 11 Mar 80 | 24.5 | 25.0 | 28.0 | 13.7 | 14.3 |
| 12 Mar 80 | 26.3 | 26.8 | 28.0 | - | - |
| 13 Mar 80 | 25.0 | 25.3 | 30.0 | 8.3 | 8.2 |
| 14 Mar 80 | 21.5 | 21.9 | 30.0 | 8.8 | 8.7 |
| 15 Mar 80 | 21.5 | 21.8 | 30.0 | 8.8 | 8.6 |
| 16 Mar 80 | 23.0 | - | - | - | - |
| 17 Mar 80 | 24.2 | 24.5 | 29.0 | 8.3 | 8.1 |
| 18 Mar 80 | 15.5 | 15.9 | 29.0 | 9.6 | 9.8 |
| 19 Mar 80 | 18.9 | 18.9 | 28.0 | 9.8 | 8.5 |
| 20 Mar 80 | 22.5 | - | 30.0 | - | - |
| 21 Mar 80 | 17.5 | 18.0 | 29.0 | 9.4 | 9.3 |
| 22 Mar 80 | 19.5 | 19.8 | 29.0 | 9.1 | 8.9 |
| 23 Mar 80 | 22.5 | 23.0 | 29.0 | 8.9 | 8.6 |
| 24 Mar 80 | 23.0 | 23.5 | 29.0 | 8.6 | 8.6 |
| 25 Mar 80 | 20.0 | 20.0 | 29.0 | 8.9 | 9.0 |
| 26 Mar 80 | 19.0 | 19.5 | 28.5 | 9.1 | 8.8 |
| 27 Mar 80 | 21.0 | 20.9 | - | 5.8 | 5.5 |
| 28 Mar 80 | 21.5 | 21.8 | - | 7.3 | 6.9 |
| 29 Mar 80 | 23.9 | 23.8 | - | 7.9 | 6.8 |
| 30 Mar 80 | 21.0 | 21.0 | - | 9.2 | 8.9 |
| 31 Mar 80 | - | - | - | - | - |
| 01 Apr 80 | 22.0 | 22.3 | - | 8.5 | 8.4 |
| 02 Apr 80 | 23.5 | 23.5 | - | 8.3 | 7.5 |
| 03 Apr 80 | 22.5 | 22.8 | - | - | - |
| 04 Apr 80 | TERMINATE EXPERIMENT | | | | |

NOTE: From 7 March to 4 April 1980 hydrological data were collected by the Texas A&M staff through the courtesy of Dr. Addison Lawrence.

Table 12. Hydrological data collected at Pond 14 at the Barney M. Davis power plant in Corpus Christi from 5 March to 4 April 1980. Pond 14 was used in the tag mortality-tag loss study.

POND 14

| Date | Temperature (°C) Surface | Temperature (°C) Bottom | Salinity (ppt) Surface | Dissolved Oxygen (ppm) Surface | Dissolved Oxygen (ppm) Bottom |
|---|---|---|---|---|---|
| 05 Mar 80 | 22.0 | 22.0 | 30.4 | 6.9 | 7.0 |
| 06 Mar 80 | 19.0 | 18.5 | 29.0 | 7.4 | 7.4 |
| 07 Mar 80 | 21.1 | 21.1 | 28.0 | 7.4 | 11.0 |
| 08 Mar 80 | 23.9 | 23.8 | 28.0 | 8.0 | 15.0 |
| 09 Mar 80 | 24.0 | 24.0 | 28.5 | 4.0 | 6.6 |
| 10 Mar 80 | 24.2 | 24.5 | 28.0 | 7.3 | 8.1 |
| 11 Mar 80 | 24.3 | 24.8 | 28.0 | 13.4 | 14.5 |
| 12 Mar 80 | 26.5 | 27.0 | 28.0 | - | - |
| 13 Mar 80 | 25.2 | 25.5 | 30.0 | 8.2 | 8.3 |
| 14 Mar 80 | 21.5 | 22.0 | 30.0 | 8.7 | 8.6 |
| 15 Mar 80 | 21.5 | 21.9 | 30.0 | 8.7 | 8.5 |
| 16 Mar 80 | 22.8 | - | - | - | - |
| 17 Mar 80 | 24.5 | 24.8 | 29.0 | 8.3 | 8.2 |
| 18 Mar 80 | 15.5 | 16.0 | 29.0 | 9.8 | 9.9 |
| 19 Mar 80 | 18.5 | 18.9 | 28.0 | 9.5 | 9.4 |
| 20 Mar 80 | 22.8 | - | 30.0 | - | - |
| 21 Mar 80 | 17.7 | 18.1 | 29.0 | 9.6 | 9.3 |
| 22 Mar 80 | 20.2 | 20.5 | 29.0 | 9.0 | 8.7 |
| 23 Mar 80 | 21.5 | 22.0 | 29.0 | 9.4 | 9.0 |
| 24 Mar 80 | 23.0 | 23.5 | 29.0 | 8.4 | 8.3 |
| 25 Mar 80 | 20.0 | 20.0 | 29.0 | 8.6 | 9.1 |
| 26 Mar 80 | 19.5 | 20.0 | 29.0 | 9.0 | 8.7 |
| 27 Mar 80 | 21.6 | 21.1 | - | 4.9 | 5.1 |
| 28 Mar 80 | 21.9 | 22.0 | - | 6.7 | 6.0 |
| 29 Mar 80 | 23.9 | 23.9 | - | 8.0 | 7.5 |
| 30 Mar 80 | 21.3 | 21.5 | - | 8.7 | 8.5 |
| 31 Mar 80 | - | - | - | - | - |
| 01 Apr 80 | 22.3 | 22.5 | - | 8.4 | 8.6 |
| 02 Apr 80 | 23.8 | 23.5 | - | 8.4 | 7.8 |
| 03 Apr 80 | 22.0 | 22.5 | - | - | - |
| 04 Apr 80 | TERMINATE EXPERIMENT | | | | |

NOTE: From 7 March to 4 April 1980 hydrological data were collected by the Texas A&M staff through the courtesy of Dr. Addison Lawrence.

Table 13. Hydrological data collected at Pond 11 at the Barney M. Davis power plant in Corpus Christi from 6 March to 5 April 1980. Pond 11 was used in the predation mortality study.

POND 11

| Date | Temperature (°C) Surface | Temperature (°C) Bottom | Salinity (ppt) Surface | Dissolved Oxygen (ppm) Surface | Dissolved Oxygen (ppm) Bottom |
|---|---|---|---|---|---|
| 06 Mar 80 | 18.0 | 18.0 | 29.0 | 7.5 | 7.6 |
| 07 Mar 80 | 20.9 | 21.0 | 28.0 | 8.8 | 11.2 |
| 08 Mar 80 | 22.0 | 22.0 | 28.0 | 9.1 | 15.0 |
| 09 Mar 80 | 22.3 | 22.8 | 28.0 | 4.8 | 15.0 |
| 10 Mar 80 | 23.0 | 23.0 | 29.0 | 7.7 | 9.9 |
| 11 Mar 80 | 24.0 | 24.5 | 28.0 | 14.6 | 14.7 |
| 12 Mar 80 | 25.5 | 26.0 | 28.0 | - | - |
| 13 Mar 80 | 23.3 | 23.6 | 30.0 | 8.3 | 8.6 |
| 14 Mar 80 | 20.0 | 20.3 | 30.0 | 9.1 | 8.9 |
| 15 Mar 80 | 20.3 | 20.7 | 30.0 | 8.9 | 8.8 |
| 16 Mar 80 | 21.3 | - | - | - | - |
| 17 Mar 80 | 22.8 | 23.2 | 29.0 | 8.5 | 8.2 |
| 18 Mar 80 | 14.5 | 15.0 | 29.0 | 9.8 | 9.7 |
| 19 Mar 80 | 17.5 | 17.8 | 28.0 | 9.5 | 9.8 |
| 20 Mar 80 | 21.6 | - | 30.0 | - | - |
| 21 Mar 80 | 20.0 | 20.5 | 28.0 | 9.0 | 8.9 |
| 22 Mar 80 | 19.2 | 19.3 | 30.0 | 9.2 | 9.0 |
| 23 Mar 80 | 22.0 | 22.0 | 29.0 | 8.6 | 8.5 |
| 24 Mar 80 | 21.5 | 22.0 | 29.0 | 8.8 | 8.5 |
| 25 Mar 80 | 19.0 | 19.0 | 29.0 | 9.2 | 9.0 |
| 26 Mar 80 | 18.1 | 18.5 | 29.0 | 9.2 | 5.7 |
| 27 Mar 80 | 21.4 | 21.3 | - | 6.0 | 6.3 |
| 28 Mar 80 | 20.5 | 20.7 | - | 8.7 | 8.4 |
| 29 Mar 80 | 22.8 | 22.8 | - | 8.5 | 8.1 |
| 30 Mar 80 | 20.1 | 20.5 | - | 8.6 | 8.8 |
| 31 Mar 80 | - | - | - | - | - |
| 01 Apr 80 | 21.3 | 21.3 | - | 8.6 | 8.4 |
| 02 Apr 80 | 22.5 | 22.5 | - | 8.2 | 8.6 |
| 03 Apr 80 | 25.7 | 26.0 | - | - | - |
| 04 Apr 80 | 20.5 | 20.8 | 28.0 | 9.0 | 8.9 |
| 05 Apr 80 | | | TERMINATE EXPERIMENT | | |

NOTE: From 7 March to 4 April 1980 hydrological data were collected by the Texas A&M staff through the courtesy of Dr. Addison Lawrence.

Table 14. Hydrological data collected at Pond 13 at the Barney M. Davis power plant in Corpus Christi from 7 March to 6 April 1980. Pond 13 was utilized in the predation mortality study.

POND 13

| Date | Temperature (°C) Surface | Temperature (°C) Bottom | Salinity (ppt) Surface | Dissolved Oxygen (ppm) Surface | Dissolved Oxygen (ppm) Bottom |
|---|---|---|---|---|---|
| 07 Mar 80 | 21.0 | 21.0 | 28.0 | 9.5 | 10.0 |
| 08 Mar 80 | 23.2 | 23.8 | 28.0 | 8.8 | 8.4 |
| 09 Mar 80 | 23.9 | 24.0 | 29.0 | 3.4 | 10.4 |
| 10 Mar 80 | 24.5 | 24.2 | 29.5 | 7.4 | 12.0 |
| 11 Mar 80 | 25.0 | 25.5 | 28.0 | 14.0 | 14.3 |
| 12 Mar 80 | 26.0 | 26.5 | 28.0 | - | - |
| 13 Mar 80 | 25.0 | 25.4 | 30.0 | 8.1 | 8.3 |
| 14 Mar 80 | 22.0 | 22.3 | 30.0 | 8.8 | 8.9 |
| 15 Mar 80 | 22.0 | 22.3 | 30.0 | 8.8 | 8.5 |
| 16 Mar 80 | 22.5 | - | - | - | - |
| 17 Mar 80 | 23.8 | 24.2 | 29.0 | 8.4 | 8.2 |
| 18 Mar 80 | 15.8 | 16.3 | 29.0 | 9.9 | 9.8 |
| 19 Mar 80 | 19.0 | 19.0 | 28.0 | 9.2 | 8.8 |
| 20 Mar 80 | 22.8 | - | 30.0 | - | - |
| 21 Mar 80 | 18.5 | 19.0 | 25.0 | 9.3 | 9.2 |
| 22 Mar 80 | 20.5 | 20.8 | 30.0 | 9.0 | 8.9 |
| 23 Mar 80 | 21.5 | 22.0 | 29.0 | 8.7 | 8.5 |
| 24 Mar 80 | 22.5 | 23.0 | 29.0 | 8.6 | 8.5 |
| 25 Mar 80 | 20.0 | 20.0 | 29.0 | 8.7 | 9.0 |
| 26 Mar 80 | 19.0 | 19.5 | 29.0 | 8.9 | 8.4 |
| 27 Mar 80 | 21.4 | 21.3 | - | 6.0 | 6.3 |
| 28 Mar 80 | 21.6 | 21.9 | - | 7.4 | 7.9 |
| 29 Mar 80 | 23.8 | 23.8 | - | 8.1 | 8.2 |
| 30 Mar 80 | 21.1 | 21.5 | - | 8.8 | 8.5 |
| 31 Mar 80 | - | - | - | - | - |
| 01 Apr 80 | 22.2 | 22.5 | - | 8.6 | 8.4 |
| 02 Apr 80 | 23.1 | 23.5 | - | 8.5 | 7.9 |
| 03 Apr 80 | 26.5 | 26.7 | - | - | - |
| 04 Apr 80 | 20.8 | 21.3 | 28.0 | 8.8 | 8.9 |
| 05 Apr 80 | 22.0 | 22.5 | 26.0 | 8.5 | 8.8 |
| 06 Apr 80 | TERMINATE EXPERIMENT | | | | |

NOTE: From 7 March to 5 April 1980 hydrological data were collected by the Texas A&M staff through the courtesy of Dr. Addison Lawrence.

Table 15. Survival of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds.

| Pond # | Treatment | Total Released | Survivors | Losses | | % Survival |
|---|---|---|---|---|---|---|
| | | | | Tags Recovered | Missing | |
| 12 | Control | 200 | 134 | - | 66 | 67 |
| 12 | Streamer | 200 | 123 | 6 | 71 | 62 |
| 12 | Streamer + Fluorescent Pigment | 100 | 60 | 2 | 38 | 60 |
| TOTAL | | 500 | 317 | 8 | 175 | Total % Survival = 63 $\left(\frac{317}{500}\right)$ |

* * * * * *

| Pond # | Treatment | Total Released | Survivors | Tags Recovered | Missing | % Survival |
|---|---|---|---|---|---|---|
| 14 | Control | 200 | 143 | - | 54 | 72 |
| 14 | Streamer | 198 | 141 | 8* | 49 | 71 |
| 14 | Streamer + Fluorescent Pigment | 100 | 73 | 5† | 22 | 73 |
| TOTAL | | 498 | 357 | 13 | 125 | Total % Survival = 72 $\left(\frac{357}{498}\right)$ |

*Includes 5 tags found in ball of tags.

†Includes 1 tag found in ball of tags.

Table 16. Results of G-tests of pink shrimp survival in pond 12 and pond 14.

| Hypothesis Tested | | DF | G |
|---|---|---|---|
| P x T x S | Independence | 7 | 86.678* |
| P x S | " | 1 | 81.366* |
| P x T | " | 1 | 0.002 |
| S x T | " | 2 | 0.364 |

*Significant at 95% level of confidence.

P = Pond; T = Treatment; S = Survival.

Table 17. Tag loss frequency in pink shrimp (*Penaeus duorarum*) over a 30-day period.

| Pond # | Treatment | Predator | Tag Loss Survivors | Total No. Survivors* | % Tag Loss in Survivors |
|---|---|---|---|---|---|
| 12 | Streamer | 0 | 0 | 123 | 0 |
| 12 | Streamer + Fluorescent Pigment | 0 | 0 | 60 | 0 |
| 14 | Streamer | 0 | 1 | 142 | 0.7 |
| 14 | Streamer + Fluorescent Pigment | 0 | 0 | 74 | 0 |
| | | | 1 | 407 | Total % Tag Loss $=0.25\left(\frac{1}{407}\right)$ |
| 11 | Streamer | 2 redfish | 1 | 216 | 0.5 |
| 13 | Streamer | 3 redfish | 4 | 132 | 3.0 |
| | | | 5 | 348 | Total % Tag Loss $=1.4\left(\frac{5}{348}\right)$ |

*Includes tag loss survivors.

Table 18. Mean total length (mm) and total weight (g) of pink shrimp (*Penaeus duorarum*) at the start and end of the 30-day experiment.

| | | Mean Total Length (mm) | | | Mean Total Weight (g) | | |
|---|---|---|---|---|---|---|---|
| Pond # | Treatment | Start | End | Difference | Start | End | Difference |
| 12 | Control | 96 | 109 | +13 | 8.7 | 11.1 | +2.4 |
| 12 | Streamer | 95 | 107 | +12 | 8.1 | 10.8 | +2.7 |
| 12 | Streamer + Fluorescent Pigment | 96 | 109 | +13 | 8.5 | 11.3 | +2.8 |
| AVERAGE | | 96 | 108 | +13 | 8.4 | 11.1 | +2.6 |
| | | * * * * * * | | | | | |
| 14 | Control | 96 | 113 | +17 | 8.7 | 12.9 | +4.2 |
| 14 | Streamer | 98 | 110 | +12 | 9.1 | 12.4 | +3.3 |
| 14 | Streamer + Fluorescent Pigment | 95 | 110 | +15 | 8.5 | 12.3 | +3.8 |
| AVERAGE | | 96 | 111 | +15 | 8.8 | 12.5 | +3.8 |
| AVERAGE (Ponds 12 and 14 Combined) | | 96 | 110 | +14 | 8.6 | 11.8 | +3.2 |

Table 19. Results of ANOVA and ANACOVA on differences in growth (total length [mm] and total weight [g]) of unmarked shrimp (controls), shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only. (Data corrected for initial means).

A. Analysis of Variance

a) Total Length Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 673 | 32521.53 | | | |
| Pond | 1 | 528.72 | 528.72 | 11.66 | 0.0007 |
| Treatment | 2 | 664.12 | 332.06 | 7.32 | 0.0007 |
| Pond x Treatment | 2 | 586.12 | 293.06 | 6.46 | 0.0017 |
| Residual | 668 | 30299.00 | 45.36 | | |

b) Total Weight Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 673 | 3484.00 | | | |
| Pond | 1 | 130.91 | 130.91 | 27.06 | 0.0001 |
| Treatment | 2 | 8.34 | 4.17 | 0.91 | 0.4018 |
| Pond x Treatment | 2 | 46.58 | 23.29 | 4.81 | 0.0084 |
| Residual | 668 | 3231.32 | 4.84 | | |

B. Analysis of covariance on total length gain using total weight gain as a covariate

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 673 | 32521.53 | | | |
| Weight | 1 | 24935.63 | 24935.63 | 3101.05 | 0.0001 |
| Pond | 1 | 74.25 | 74.25 | 9.23 | 0.0025 |
| Treatment | 2 | 345.45 | 172.72 | 21.43 | 0.0001 |
| Pond x Treatment | 2 | 29.76 | 14.88 | 1.85 | 0.1580 |
| Residual | 667 | 5363.37 | 8.041 | | |

Table 20. Results of ANOVA and ANACOVA on differences in growth (total length [mm] and total weight [g]) of shrimp marked with streamer tags plus fluorescent pigment and shrimp marked with streamer tags only. (Uncorrected data).

## A. Analysis of Variance

### a) Total Length Gain

| Sources | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 396 | 10483.89 | | | |
| Pond | 1 | 96.22 | 96.22 | 3.77 | 0.0527 |
| Treatment | 1 | 352.60 | 352.60 | 13.83 | 0.0002 |
| Pond x Treatment | 1 | 8.63 | 8.60 | 0.34 | 0.5611 |
| Residual | 393 | 10017.28 | 25.49 | | |

### b) Total Weight Gain

| Sources | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 396 | 478.57 | | | |
| Pond | 1 | 47.44 | 47.44 | 44.26 | 0.0001 |
| Treatment | 1 | 7.18 | 7.18 | 6.70 | 0.0100 |
| Pond x Treatment | 1 | 1.17 | 1.17 | 1.09 | 0.2960 |
| Residual | 393 | 421.20 | 1.07 | | |

## B. Analysis of covariance on total length gain using total weight gain as a covariate.

| Sources | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 396 | 10483.89 | | | |
| Weight | 1 | 4514.03 | 4514.03 | 321.54 | 0.0001 |
| Pond | 1 | 145.84 | 145.83 | 10.39 | 0.0014 |
| Treatment | 1 | 98.48 | 98.48 | 7.02 | 0.0084 |
| Pond x Treatment | 1 | 0.37 | 0.37 | 0.03 | 0.8711 |
| Residual | 392 | 5503.25 | 14.04 | | |

Table 21. Survival of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds containing redfish (*Sciaenops ocellata*) as predators.†

| Pond # | Treatment | Predators | Total Released | Survivors | % Survival |
|---|---|---|---|---|---|
| 11 | Control | 2 redfish*[1] | 500 | 219 | 44 |
| 11 | Streamer | | 500 | 215 | 43 |
| TOTAL | | | 1,000 | 434 | Total % Survival =43(434/1000) |

* * * * * *

| Pond # | Treatment | Predators | Total Released | Survivors | % Survival |
|---|---|---|---|---|---|
| 13 | Control | 3 redfish[2] | 500 | 116 | 23 |
| 13 | Streamer | | 500 | 128 | 26 |
| TOTAL | | | 1,000 | 244 | Total % Survival =24(244/1000) |

†509 small fish were added to each pond as alternative prey for the redfish.

*One of the original three redfish died three days after start of the experiment.

[1]Total lengths - 304.8 mm, 349.3 mm.

[2]Total lengths - 311.2 mm, 342.9 mm, 393.7 mm.

Table 22. Results of G-tests of pink shrimp survival in pond 11 and pond 13.

| Hypothesis Tested | | DF | G |
|---|---|---|---|
| P x T x S | Independence | 7 | 9.8832 |
| P x S | " | 1 | 7.831* |
| P x T | " | 1 | 0.006 |
| S x T | " | 2 | 0.90 |

*Significant at 95% level of confidence.

P = Pond; T = Treatment; S = Survival

Table 23. Survival of pink shrimp (*Penaeus duorarum*) after 30 days in 0.1 ha ponds containing redfish.†

| Pond # | Treatment | Predators | Total Released | Survivors | Losses: Tags Recovered | Losses: Missing | % Survival |
|---|---|---|---|---|---|---|---|
| 11 | Control | | 500 | 219 | | 281 | 44 |
| 11 | Orange Streamer | 2 redfish*[1] | 250 | 98 | 34[a] | 118 | 39 |
| 11 | Black Streamer | | 250 | 117 | 24[b] | 109 | 47 |
| TOTAL | | | 1,000 | 434 | 58 | 508 | Total % Survival $= 43 \left(\frac{434}{1000}\right)$ |
| * * * * * * * * | | | | | | | |
| 13 | Control | | 500 | 116 | | 384 | 23 |
| 13 | Orange Streamer | 3 redfish[2] | 250 | 70 | 83[c] | 97 | 28 |
| 13 | Black Streamer | | 250 | 58 | 73 | 119 | 23 |
| TOTAL | | | 1,000 | 244 | 156 | 600 | Total % Survival $= 24 \left(\frac{244}{1000}\right)$ |

†509 small fish were added to each pond as alternative prey for the redfish.

*One of the original three redfish died three days after start of the experiment.

[1]Total lengths - 304.8 mm, 349.3 mm.

[2]Total lengths - 311.2 mm, 342.9 mm, 393.7 mm.

[a]Includes 7 tags in ball of tags.

[b]Includes 3 tags in ball of tags.

[c]Includes 3 tags in ball of tags.

Table 24. Growth in length (mm), general appearance and gut contents of redfish after 30 days in two 0.1 ha ponds.

| | Total Length (mm) | | | | |
|---|---|---|---|---|---|
| Pond 11 | Beginning | End | Difference | General Appearance | Gut Contents |
| Redfish No. 1 | 304.8 | 317.5 | +12.7 | Wounds from gill net not healed; gills not healthy | pieces of shrimp |
| Redfish No. 2 | 349.3 | 362.0 | +12.7 | Wounds from gill-net not healed; gills not healthy branch with thorn piercing left side | 1 = ½" silversides |
| Redfish No. 3 | 381.0 | Died after 3 days | | | |
| **Pond 13** | | | | | |
| Redfish No. 1 | 311.2 | 349.3 | +38.1 | Healthy, wounds healed | a) 1 whole black tagged shrimp<br>b) 1 shrimp carapace + other parts |
| Redfish No. 2 | 342.9 | 374.7 | +31.8 | Healthy | a) 3 shrimp carapaces<br>b) 1 whole untagged shrimp<br>c) 1 orange tag |
| Redfish No. 3 | 393.7 | 419.1 | +25.4 | Healthy | a) 1 partially digested orange tagged shrimp<br>b) 2 partially digested untagged shrimp<br>c) 1 partially digested portunid crab |

Table 25. Mean total length (mm) and total weight (g) of pink shrimp (*Penaeus duorarum*) at the start and end of the 30-day experiment.

| Pond # | Treatment | Mean Total Length (mm) | | | Mean Total Weight (g) | | |
|---|---|---|---|---|---|---|---|
| | | Start | End | Difference | Start | End | Difference |
| 11 | Control | 96 | 106 | +10 | 8.4 | 10.1 | +1.7 |
| 11 | Orange Streamer | 97 | 105 | + 8 | 8.5 | 10.1 | +1.6 |
| 11 | Black Streamer | 96 | 105 | + 9 | 8.4 | 10.1 | +1.7 |
| AVERAGE | | 96 | 105 | + 9 | 8.4 | 10.1 | +1.7 |
| | | * * * * * * | | | | | |
| 13 | Control | 97 | 108 | +11 | 8.8 | 10.2 | +1.4 |
| 13 | Orange Streamer | 99 | 105 | + 6 | 9.0 | 10.6 | +1.6 |
| 13 | Black Streamer | 98 | 108 | +10 | 9.0 | 10.5 | +1.5 |
| AVERAGE | | 98 | 107 | + 9 | 8.9 | 10.4 | +1.5 |
| AVERAGE (Ponds 11 and 13 Combined) | | 97 | 106 | + 9 | 8.7 | 10.3 | +1.6 |

Table 26. Results of ANOVA and ANACOVA on differences in growth (total length [mm] and total weight [g]) of unmarked shrimp (controls), shrimp marked with orange streamer tags and shrimp marked with black streamer tags in the presence of redfish. (Data corrected for initial means).

A. Analysis of Variance

a) Total Length Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 676 | 36460.89 | | | |
| Pond | 1 | 22.94 | 22.94 | 0.43 | 0.5116 |
| Treatment | 2 | 613.09 | 306.55 | 5.76 | 0.0030 |
| Pond x Treatment | 2 | 242.39 | 121.20 | 2.28 | 0.1033 |
| Residual | 671 | 35699.08 | 53.20 | | |

b) Total Weight Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 676 | 3192.95 | | | |
| Pond | 1 | 2.96 | 2.96 | 0.62 | 0.4302 |
| Treatment | 2 | 0.62 | 0.31 | 0.06 | 0.9371 |
| Pond x Treatment | 2 | 0.46 | 0.23 | 0.05 | 0.9524 |
| Residual | 671 | 3188.49 | 4.75 | | |

B. Analysis of covariance on total length gain using total weight gain as a covariate.

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 676 | 36460.89 | | | |
| Weight | 1 | 30778.17 | 30778.17 | 4190.56 | 0.0001 |
| Pond | 1 | 0.31 | 0.31 | 0.04 | 0.8376 |
| Treatment | 2 | 728.20 | 364.10 | 49.57 | 0.0001 |
| Pond x Treatment | 2 | 312.66 | 156.33 | 21.29 | 0.0001 |
| Residual | 670 | 4920.91 | 7.35 | | |

Table 27. Results of ANOVA and ANACOVA on differences in growth (total length [mm] and total weight [g]) of shrimp marked with orange streamer tags and black streamer tags in the presence of redfish. (Uncorrected data).

A. Analysis of Variance

a) Total Length Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 341 | 6695.45 | | | |
| Pond | 1 | 56.30 | 56.30 | 3.12 | 0.0785 |
| Treatment | 1 | 409.66 | 409.66 | 22.67 | 0.0001 |
| Pond x Treatment | 1 | 201.71 | 201.71 | 11.16 | 0.0009 |
| Residual | 338 | 6108.45 | 18.07 | | |

b) Total Weight Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 341 | 235.30 | | | |
| Pond | 1 | 1.09 | 1.09 | 1.58 | 0.2100 |
| Treatment | 1 | 0.03 | 0.03 | 0.04 | 0.8447 |
| Pond x Treatment | 1 | 0.70 | 0.70 | 1.02 | 0.3140 |
| Residual | 338 | 233.52 | 0.69 | | |

B. Analysis of covariance on total length gain using total weight gain as a covariate.

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 341 | 6695.45 | | | |
| Weight | 1 | 1899.45 | 1899.45 | 152.10 | 0.0001 |
| Pond | 1 | 20.39 | 20.39 | 1.63 | 0.2022 |
| Treatment | 1 | 428.63 | 428.63 | 34.32 | 0.0001 |
| Pond x Treatment | 1 | 274.50 | 274.50 | 21.98 | 0.0001 |
| Residual | 337 | 4208.56 | 12.49 | | |

Table 28. Results of ANOVA on difference in growth of unmarked shrimp in the presence of redfish predators and without predators. (Data corrected for initial means).

a) Total Length Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 611 | 34873.19 | | | |
| Model | 1 | 3840.40 | 3840.40 | 75.49 | 0.0001 |
| Residual | 610 | 31032.79 | 50.87 | | |

b) Total Weight Gain

| Source | DF | Sum of Squares | Mean Square | F-Value | Probability |
|---|---|---|---|---|---|
| Total | 611 | 3704.46 | | | |
| Model | 1 | 480.57 | 480.57 | 90.93 | 0.0001 |
| Residual | 610 | 3228.89 | 5.29 | | |

Table 29. Percent of streamer tags not recovered from the 0.1 ha ponds, and presumably eaten by birds.

| Pond # | Total # Shrimp Tagged | Missing Tags | % Missing |
|---|---|---|---|
| 12 | 300 | 109 | 36 |
| 14 | 298 | 71 | 24 |
| 11 | 500 | 227 | 45 |
| 13 | 500 | 216 | 43 |
| TOTAL | 1,598 | 621 | Total %=39( 621 / 1598 ) |

Table 30. Tags returned to LGL port agents by shrimpers, fish house employees and bait dealers in Galveston, Port Bolivar, Kemah, Freeport, Palacios, Port Lavaca, Port O'Connor, Rockport-Fulton and Aransas Pass.

| Port | Shrimper | Fish House Employee | Bait Dealer | Total Returns |
|---|---|---|---|---|
| **SEPTEMBER 1979** | | | | |
| Galveston | 1 | 1 | 0 | 2 |
| Port Bolivar | 0 | 0 | 0 | 0 |
| Kemah | 0 | 0 | 0 | 0 |
| Freeport | 20 | 1 | 0 | 21 |
| Palacios | ┬ | 0 | ┬ | ┬ |
| Port Lavaca | 9 | 0 | 7 | 16 |
| Port O'Connor | ┴ | 0 | ┴ | ┴ |
| Rockport-Fulton* | 1 | 0 | 0 | 1 |
| Aransas Pass* | 0 | 0 | 0 | 0 |
| Total | 31 | 2 | 7 | 40 |
| % of Total | 78% | 5% | 18% | |
| **OCTOBER 1979** | | | | |
| Galveston | 27 | 0 | 0 | 27 |
| Port Bolivar | 8 | 0 | 0 | 8 |
| Kemah | 4 | 0 | 0 | 4 |
| Freeport | 81 | 5 | 1 | 87 |
| Palacios | 48 | 0 | 0 | 48 |
| Port Lavaca | 21 | 39 | 2 | 62 |
| Port O'Connor | 6 | 0 | 2 | 8 |
| Rockport-Fulton* | 22 | 0 | 0 | 22 |
| Aransas Pass* | 2 | 0 | 0 | 2 |
| Total | 219 | 44 | 5 | 268 |
| % of Total | 82% | 16% | 2% | |
| **NOVEMBER 1979** | | | | |
| Galveston | 28 | 0 | 0 | 28 |
| Port Bolivar | 2 | 0 | 0 | 2 |
| Kemah | 4 | 0 | 0 | 4 |
| Freeport | 44 | 0 | 0 | 44 |
| Palacios | 58 | 0 | 0 | 58 |
| Port Lavaca | 9 | 57 | 0 | 66 |
| Port O'Connor | 13 | 0 | 0 | 13 |
| Rockport-Fulton* | 48 | 0 | 0 | 48 |
| Aransas Pass* | 36 | 2 | 0 | 38 |
| Total | 242 | 59 | 0 | 301 |
| % of Total | 80% | 20% | 0% | |

.....cont'd

Table 30 cont'd

| Port | Shrimper | Fish House Employee | Bait Dealer | Total Returns |
|---|---|---|---|---|
| DECEMBER 1979 | | | | |
| Galveston | 9 | 0 | 0 | 9 |
| Port Bolivar | 0 | 0 | 0 | 0 |
| Kemah | 0 | 5 | 0 | 0 |
| Freeport | 57 | 0 | 0 | 0 |
| Palacios | 21 | 2 | 0 | 23 |
| Port Lavaca | 28 | 0 | 2 | 30 |
| Port O'Connor | 25 | 0 | 0 | 25 |
| Rockport-Fulton* | 6 | 0 | 0 | 6 |
| Aransas Pass* | 38 | 0 | 0 | 38 |
| Total | 184 | 7 | 2 | 193 |
| % of Total | 95% | 4% | 1% | |
| JANUARY 1980 | | | | |
| Galveston | 2 | 0 | 0 | 2 |
| Port Bolivar | 0 | 0 | 0 | 0 |
| Kemah | 3 | 0 | 0 | 3 |
| Freeport | 14 | 0 | 0 | 14 |
| Palacios | 42 | 0 | 0 | 42 |
| Port Lavaca | 1 | 46 | 0 | 47 |
| Port O'Connor | 2 | 0 | 0 | 2 |
| Rockport-Fulton* | 1 | 0 | 0 | 1 |
| Aransas Pass* | 6 | 0 | 0 | 6 |
| Total | 71 | 46 | 0 | 117 |
| % of Total | 61% | 39% | 0% | |
| FEBRUARY 1980 | | | | |
| Galveston | 6 | 0 | 0 | 6 |
| Port Bolivar | 2 | 0 | 0 | 2 |
| Kemah | 0 | 0 | 0 | 0 |
| Freeport | 9 | 3 | 0 | 12 |
| Palacios | 3 | 0 | 0 | 3 |
| Port Lavaca | 0 | 0 | 0 | 0 |
| Port O'Connor | 0 | 0 | 0 | 0 |
| Rockport-Fulton* | 0 | 0 | 0 | 0 |
| Aransas Pass* | 0 | 0 | 0 | 0 |
| Total | 20 | 3 | 0 | 23 |
| % of Total | 87% | 13% | 0% | |

....cont'd

Table 30 cont'd

MARCH 1980

| | | | | |
|---|---|---|---|---|
| Galveston | 0 | 0 | 0 | 0 |
| Port Bolivar | 2 | 0 | 0 | 2 |
| Kemah | 0 | 2 | 0 | 2 |
| Freeport | 1 | 0 | 0 | 1 |
| Palacios | 1 | 4 | 0 | 5 |
| Port Lavaca | 0 | 0 | 0 | 0 |
| Port O'Connor | 0 | 0 | 0 | 0 |
| Rockport-Fulton* | 1 | 0 | 0 | 1 |
| Aransas Pass* | 0 | 0 | 0 | 0 |
| Total | 5 | 6 | 0 | 11 |
| % of Total | 46% | 54% | 0% | |

APRIL 1980

| | | | | |
|---|---|---|---|---|
| Galveston | 0 | 0 | 0 | 0 |
| Port Bolivar | 1 | 1 | 0 | 2 |
| Kemah | 0 | 0 | 0 | 0 |
| Freeport | 0 | 0 | 0 | 0 |
| Palacios | 14 | 1 | 0 | 15 |
| Port Lavaca | 0 | 0 | 0 | 0 |
| Port O'Connor | 1 | 0 | 0 | 1 |
| Rockport-Fulton* | 0 | 0 | 0 | 0 |
| Aransas Pass* | 0 | 0 | 0 | 0 |
| Total | 16 | 2 | 0 | 18 |
| % of Total | 89% | 11% | 0% | |

MAY 1980

| Port | Shrimper | Fish House Employee | Bait Dealer | Total Returns |
|---|---|---|---|---|
| Galveston | 4 | 0 | 0 | 4 |
| Port Bolivar | 1 | 0 | 0 | 1 |
| Kemah | 1 | 0 | 0 | 1 |
| Freeport | 1 | 0 | 0 | 1 |
| Palacios | 5 | 1 | 0 | 6 |
| Port Lavaca | 0 | 0 | 0 | 0 |
| Port O'Connor | 5 | 0 | 0 | 5 |
| Rockport-Fulton* | 0 | 0 | 0 | 0 |
| Aransas Pass* | 1 | 0 | 0 | 1 |
| Total | 18 | 1 | 0 | 19 |
| % of Total | 95% | 5% | 0% | |

.....cont'd

Table 30 cont'd

JUNE 1980

| | | | | |
|---|---|---|---|---|
| Galveston | 1 | 1 | 0 | 2 |
| Port Bolivar | 1 | 1 | 0 | 2 |
| Kemah | 0 | 1 | 0 | 1 |
| Freeport | 7 | 0 | 0 | 7 |
| Palacios | 3 | 1 | 0 | 4 |
| Port Lavaca | 0 | 0 | 0 | 0 |
| Port O'Connor | 0 | 0 | 0 | 0 |
| Rockport-Fulton* | 0 | 0 | 0 | 0 |
| Aransas Pass* | 0 | 0 | 0 | 0 |
| Total | 12 | 4 | 0 | 16 |
| % of Total | 75% | 25% | 0% | |

JULY 1980

| | | | | |
|---|---|---|---|---|
| Galveston | 4 | 0 | 0 | 4 |
| Port Bolivar | 4 | 0 | 0 | 4 |
| Kemah | 0 | 0 | 0 | 0 |
| Freeport | 20 | 0 | 0 | 0 |
| Palacios | 53 | 34 | 0 | 87 |
| Port Lavaca | 122 | 91 | 0 | 213 |
| Port O'Connor | 8 | 0 | 0 | 8 |
| Rockport-Fulton* | 1 | 0 | 0 | 1 |
| Aransas Pass* | 9 | 0 | 0 | 9 |
| Total | 221 | 125 | 0 | 346 |
| % of Total | 64% | 36% | 0% | |

AUGUST 1980

| Port | Shrimper | Fish House Employee | Bait Dealer | Total Returns |
|---|---|---|---|---|
| Galveston | 19 | 1 | 0 | 20 |
| Port Bolivar | 4 | 0 | 0 | 4 |
| Kemah | 0 | 0 | 0 | 0 |
| Freeport | 30 | 0 | 0 | 30 |
| Palacios | 47 | 14 | 0 | 61 |
| Port Lavaca | 7 | 0 | 0 | 7 |
| Port O'Connor | 1 | 0 | 0 | 1 |
| Rockport-Fulton* | 17 | 0 | 0 | 17 |
| Aransas Pass* | 16 | 0 | 0 | 16 |
| Total | 141 | 15 | 0 | 156 |
| % of Total | 90% | 10% | 0% | |

....cont'd

Table 30 cont'd

| | | | | |
|---|---|---|---|---|
| SEPTEMBER 1980 | | | | |
| Galveston | 4 | 0 | 0 | 4 |
| Port Bolivar | 57 | 0 | 0 | 57 |
| Kemah | 2 | 0 | 0 | 2 |
| Freeport | 4 | 0 | 0 | 4 |
| Palacios | 1 | 0 | 0 | 1 |
| Port Lavaca | 0 | 31 | 0 | 31 |
| Port O'Connor | 3 | 0 | 0 | 3 |
| Rockport-Fulton* | 3 | 0 | 0 | 3 |
| Aransas Pass* | 3 | 0 | 0 | 3 |
| Total | 77 | 31 | 0 | 108 |
| % of Total | 71% | 29% | 0% | |
| OCTOBER 1980 | | | | |
| Galveston | 47 | 0 | 0 | 47 |
| Port Bolivar | 263 | 1 | 0 | 264 |
| Kemah | 2 | 0 | 0 | 2 |
| Freeport | 15 | 0 | 0 | 15 |
| Palacios | 0 | 0 | 0 | 0 |
| Port Lavaca | 0 | 77 | 0 | 77 |
| Port O'Connor | 1 | 0 | 0 | 1 |
| Rockport-Fulton* | 3 | 0 | 0 | 3 |
| Aransas Pass* | 3 | 0 | 0 | 3 |
| Total | 334 | 78 | 0 | 412 |
| % of Total | 81% | 19% | 0% | |

*Tag returns by shrimpers = 78%; non-reporting of tags by shrimpers = 22%.

Table 31. Percent non-reporting of tagged shrimp by shrimpers, based on random interviews with shrimpers, fish house employees and bait dealers conducted after the fall 1979 tagging effort.

| | FALL 1979 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shrimper | | | | | Fish House Employee | | | | | Bait Dealer | | | | | % Shrimper | % Shrimper |
| Port | 1 | 2 | 3 | Avg[1] | Avg[2] | 1 | 2 | 3 | Avg[1] | Avg[2] | 1 | 2 | 3 | Avg[1] | Avg[2] | Non-Reporting[1] | Non-Reporting[2] |
| Galveston | 20 | 20 | 20 | 20 | 20 | 20 | 0 | 20 | 13 | 9 | 0 | 0 | - | 0 | 0 | 13 | 8 |
| Port Bolivar | 0 | 0 | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | * | * | † | - | - | 0 | 0 |
| Kemah | 20 | 20 | - | 20 | 20 | † | † | - | - | - | 20 | † | † | 20 | 20 | 20 | 20 |
| Freeport | 20 | 20 | 20 | 20 | 20 | 20 | 80 | 20 | 40 | 39 | † | † | - | - | - | 30 | 29 |
| Palacios | 20 | 20 | 0 | 13 | 9 | 20 | 20 | 20 | 20 | 20 | 20 | 0 | 20 | 13 | 9 | 16 | 12 |
| Port Lavaca | 20 | 20 | 20 | 20 | 20 | 0 | 45 | 50 | 32 | 47 | 40 | 50 | - | 45 | 47 | 31 | 27 |
| Port O'Connor | 50 | - | - | 50 | 50 | 20 | 20 | - | 20 | 20 | * | * | - | - | - | 30 | 29 |
| Rockport-Fulton | 25 | 25 | - | 25 | 25 | 20 | 20 | - | 20 | 20 | † | † | - | - | - | 22 | 22 |
| Aransas Pass | 25 | 25 | 20 | 23 | 23 | 25 | 25 | 20 | 23 | 23 | * | * | - | - | - | 23 | 23 |
| Average percent non-reporting of tags by shrimpers = | | | | | | | | | | | | | | | | 20% | 16% |

[1]Average obtained using uncorrected data.

[2]Average obtained using arcsin transformation ($\arcsin\sqrt{p}$) and then converting back to the original scale.

*Closed.

†No tags ever recovered.

Table 32. Percent non-reporting of tagged shrimp by shrimpers, fish house employees and bait dealers, respectively, based on random interviews conducted after the summer 1980 tagging effort.

FALL 1980

| Port | Shrimper | | | | | Fish House Employee | | | | | Bait Dealer | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | Avg[1] | Avg[2] | 1 | 2 | 3 | Avg[1] | Avg[2] | 1 | 2 | 3 | Avg[1] | Avg[2] |
| Galveston | 20 | 10 | 40 | 23 | 22 | 15 | 20 | 10 | 15 | 15 | 0 | 10 | 0 | 3 | 1 |
| Port Bolivar | 20 | 70 | 30 | 40 | 39 | 10 | 10 | 0 | 7 | 5 | 10 | 0 | 20 | 10 | 7 |
| Kemah | 20 | 30 | 10 | 20 | 19 | 10 | 20 | 35 | 22 | 21 | - | - | - | - | - |
| Freeport | 10 | 25 | 5 | 13 | 12 | 0 | 0 | 0 | 0 | 0 | † | † | † | - | - |
| Palacios | 25 | 20 | 75 | 40 | 39 | 0 | 10 | 50 | 20 | 21 | * | * | * | - | - |
| Port Lavaca | 0 | 66 | 50 | 39 | 30 | 10 | 50 | 0 | 20 | 13 | 0 | 0 | - | 0 | 0 |
| Port O'Connor | 20 | 0 | 10 | 10 | 7 | 0 | 0 | 10 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| Rockport-Fulton | 25 | 50 | 0 | 25 | 18 | 0 | 0 | 5 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Aransas Pass | 30 | 50 | 10 | 30 | 32 | 2 | 5 | 5 | 3 | 4 | * | * | * | - | - |

Average % non-reporting[1] - Shrimper = 27%; fish house employee = 10%; bait dealer = 3%
Average % non-reporting[2] - Shrimper = 23%; fish house employee = 6%; bait dealer = 1%

[1]Average obtained using uncorrected data.

[2]Average obtained using arcsin transformation ($\arcsin\sqrt{p}$) and then converting back to the original scale.

*Closed.

†No tags ever recovered.

Table 33. List of factors responsible for non-reporting of tagged shrimp.

| |
|---|
| • Sceptical of lottery system (no chance of winning) |
| • Desire monetary reward for each tagged shrimp returned |
| • Have never received letter of acknowledgement or feedback concerning tagged shrimp returned |
| • Are unaware of tagging studies and importance of returning tagged shrimp |
| • Have difficulty seeing black tags |
| • Takes too much time to sort out tagged shrimp |

Table 34. Recovery of tagged shrimp placed on a conveyer belt as shrimp catch was being unloaded at various ports along the Texas coast.

| Port | Date Released | No. Marked Shrimp Released | No. Recovered | Percent Recovery |
|---|---|---|---|---|
| Freeport | 10 Oct 80 | 10 | 0 | 0 |
| Aransas Pass | 25 Sep 80 | 3 | 0 | 0 |
| Aransas Pass | 16 Oct 80 | 2 | 2 | 100 |
| Brownsville | 11 Sep 80 | 5 | 0 | 0 |

Table 35. Number of continuous bottom temperature measurements obtained at Buccaneer Gas and Oil Field with Hydrolab unit.

| Dates of Operation | No. Days of Operation | No. Days of Data Available | Problems |
|---|---|---|---|
| Nov 8-Dec 9 | 32 | 21.33 | Unit ran out of memory - set at 15 min rather than 1 h intervals |
| Dec 9-Dec 23 | 15 | 0 | Unit ran out of memory - measured six parameters |
| Dec 23-Feb 4 | 44 | 16.96 | Battery failure |
| Feb 4-Feb 12 | 8 | 8 | Unit measured six parameters again |
| Feb 12-Apr 8 | 56 | 55.46 | Unable to service on schedule because of weather |
| Apr 8-May 28 | 50 | 20.88 | Unable to service on schedule because NMFS field party chief not available |
| May 28-Jun 1 | 4 | 0 | Replacement unit taken out, malfunctioning on installation |
| Jun 1-Jun 23 | 22 | 22 | Complete data set |
| Jun 23-Jul 14 | 21 | 0 | Transmitter cable broken by sport fishing vessel |
| Jul 14-Jul 25 | 0 | 0 | - |
| Jul 25 | - | - | New transmitter failed in field |
| Jul 26-Sep 16 | 52 | 0 | No vessel available |
| Sep 17-Oct 24 | 37 | 37 | Complete data set |
| Oct 24- | - | - | - |
| TOTALS | 341 | 181.63 | |