TITLE and APPROVAL SHEET

4 January 2011

Project Title:
Fecundity of Barnegat Bay blue crabs:
the influence of size, season and relative fishing effort.

Project Institution:
Rider University

Project Manager:
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Effective Date of Plan:
17 May 2010

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4.0 Project/Task Organization

Dr. Jivoff will manage the project, train the students in field techniques and data collection, lead the field sampling and data collection, assist with data management, analyze the data, and write any progress reports and publications resulting from this project. Mr. Muffley will assist with sampling design. Two students (unknown at this point) will act as field technicians and assist with data collection, data entry and data checking. Laurie Whitley, assistant to the assistant dean of life science, will be the quality assurance officer. The sampling will commence on 17 May 2010 and continue through September 2010.

5.0 Special Training Needs/Certification

None

6.0 Problem Definition/Background

6.1 Problem Definition

We do not know the potential impact fishing may have on the reproductive output of the blue crab population in Barnegat Bay because we lack information on adult population structure and biological information on reproductive potential and reproductive output of Barnegat Bay blue crabs and we have an incomplete understanding of fishing effort or fishing mortality of blue crabs in the Bay. The overall goal of this project is to examine the factors that influence the reproductive output of adult female blue crabs in Barnegat Bay using field sampling with commercial-style traps and experiments in the field and laboratory. I will also measure temporal and spatial variation in aspects of the reproductive potential (e.g., sperm stores of both sexes). The expected users of these data include Dr. Jivoff. Jivoff will include these data in manuscripts submitted for publication in peer reviewed journals and publications for the general public, as well as oral presentations at scientific meetings and public outreach events. Jivoff will also provide these data to Brandon Muffley, Division of Marine Fisheries at NJ-DEP for use in population modeling and management.

6.2 Background

Blue crabs are one of the most important commercial and recreational fisheries in New Jersey (Kennish et al. 1984; Stehlik et al. 1998) and throughout the mid-Atlantic region (Jordan 1998). Over the past three decades, blue crab populations in other mid-Atlantic estuaries (e.g., Chesapeake Bay and Delaware Bay) have declined drastically (Abbe and Stagg 1996; Cole 1998; Uphoff 1998). These

reductions may stem from a number of factors including loss or degradation of habitat for recruits and juveniles (Lipcius et al. 2005), reduced water quality (Mistiaen et al. 2003), and significant natural and fishing mortality (Lipcius and Stockhausen 2002). Over the past decade, as crab catches continue to decline in the Delaware portion of Delaware Bay, the relative importance of New Jersey blue crab populations has increased 10-fold in terms of both commercial landings and economic value (NOAA fisheries data). Some of this increase stems from New Jersey estuaries other than Delaware Bay. For example, in the past decade, the proportion of New Jersey's blue crab catch from Barnegat Bay has doubled (NJ-DEP fisheries data; Figure 1). As the relative importance of blue crab populations in estuaries like Barnegat Bay increases, the extent of fishing effort and the potential for user conflicts may also increase. Therefore it is critical to gather information about the population status and the extent of fishing effort (commercial and recreational) on blue crab populations in estuaries like Barnegat Bay. Indeed, as indicated in the BBNEP Monitoring Program Plan (MPP): an assessment of the seasonal availability and habitat use patterns associated with finfish and blue crab resources should be conducted for Barnegat Bay.

In finfish (Conover and Munch 2002; Rochet 1998; Trippel 1995) and other crustaceans (Daniel et al. 1989; Nickerson et al. 1966; Sainte-Marie et al. 1995), exploitation influences the biology of organisms in a variety of complex ways. Over the past decade in Barnegat Bay, during the summer reproductive season males have been removed at increasing rates relative to females while during the winter dormancy period females have been removed at increasing rates relative to males (NJ-DEP fisheries data; Figure 2). In other mid-Atlantic estuaries, there are indications that intense fishing mortality, particularly on large males during the summer fishery and adult females during the winter dredge fishery, has produced significant alterations in blue crab population structure, including reduced numbers of large reproductive adults of one or both sexes (Abbe 2002; Cole 1998; Lipcius and Stockhausen 2002), which may negatively impact blue crab reproduction in significant but subtle ways (Hines et al. 2003) and exacerbate population declines. Based on the mating system of the blue crab, these changes in population structure may lead to profound effects on the reproductive potential of crabs, including limited sperm stores in both sexes and reduced reproductive output of females (Jivoff 2003). In Chesapeake Bay, fisheries biologists have indicated that incorporating the vulnerability of crabs to the fishery based on their size and sex has helped them understand fisheries impacts (Bunnell and Miller 2005) but that empirical data on spatial variation in fecundity and movement of blue crabs are needed to improve the predictive capacity of fisheries models (Miller 2003). Recent work on blue crab reproductive output in other estuaries indicates blue crabs are far more fecund than previously thought (Dickinson et al. 2006; Hines et al. 2003). We do not know the potential impact fishing may have on the reproductive output of the blue crab population in Barnegat Bay because we lack the biological information on reproductive potential and reproductive output of Barnegat Bay blue crabs and we have an incomplete understanding of fishing effort or fishing mortality of blue crabs in the Bay. Further information is critical for effective management of the blue crab population, especially in the face of potentially increasing fishing effort on blue crabs in Barnegat Bay. I will collaborate, consult and share this information directly with Brandon Muffley, fisheries biologist at NJ-DEP-Division of Fish and Wildlife.

7.0 Project/Task Description

Field Sampling: I will examine abundance, size, reproductive status, and spawning biology of adult female blue crabs using baited (with menhaden) commercial-style traps sampled daily for four consecutive days, every other week from May-September 2010. In September, sampling will occur at least once per week. Traps will have consistent "soak times" and bait will be replaced daily. My work from previous years indicates that in Barnegat Bay adult female blue crabs are especially abundant near the inlets (Barnegat and Little Egg) as they are blue crab spawning sites. Therefore, sampling will occur at 4 sites near each inlet (see Figure 3 and maps in Appendix) and four sampling locations in

each site will be used (see maps of each area with sites and trap orientations in Appendix). The sites are far enough from shore such that turtle excluders are not required. Each sampling day, at least 4 traps at each site (placed at least 50m apart from one another) will be randomly assigned to one of the 4 sampling locations within each site. Sites will be chosen to minimize the proximity to anthropogenic disturbance including boat and jet-ski traffic and they share a similar water depth. Crabs will be separated by trap in moistened burlap bags, returned to the Rutgers University Marine Field Station, and measured for carapace width and age, sexual maturity, sex, molt stage, limb loss and regeneration, and ovigerous stage (adult females). Sexual maturity and molt stage will be determined using previously established methods (see pp 369-370) (Jivoff 1997). Crabs from these collections are greater than 90 mm carapace width; the collections are allowed under the Rutgers University Marine Field Station collecting permit and not subject to NJDEP regulations for sizes and number of crabs collected. Crabs from these collections will be also used for measurements of reproductive potential (see below). Physical characteristics including depth, salinity, temperature, and dissolved oxygen will be taken with a hand-held YSI datalogger at the first and last trap in each sampling location; therefore each sampling day 2 sets of physical measurements will be taken at each site for a total of 16 sets of physical measures. Because the sampling locations are randomly assigned each day and the locations are distributed throughout each site, the physical measures taken during the sampling week provide an adequate representation of the water characteristics in the site. Where possible, I will also count the number of commercial crab traps seen in route between sampling sites. These data will supplement bay-wide estimates obtained by NJ-DEP by providing "on-the-ground" approximations of commercial fishing effort at smaller spatial and temporal scales in the Bay.

Seasonal Reproductive Output Studies: A sample ($n > 20$) of adult females captured near each inlet in May (or prior to the appearance of broods) will be maintained in flow-through tanks to monitor the incidence, size, egg viability, and timing of each brood produced. The flow through tanks will either be square (3' wide x 3' long and 2' deep) containing no more than 10 females or round (2' in diameter and 1' deep) containing no more than 2 females. These females will be checked daily (in the morning except for during sampling weeks when they will be checked in the afternoon). A sample ($n > 10$) of adult females captured near each inlet in each month (May-August) will be maintained individually in traps partially sunken in the sediment and accessible at low tide (see pp 274-276) (Dickinson et al. 2006) to monitor the incidence, size, egg viability, egg size, and timing of each brood produced. The size and egg viability of each brood will be assessed using previously established techniques (Dickenson et al. 2006 [see pp 274-276]; Hines 1982 [see pp 311]; Hines 1988 [see pp 558]; Hines 1991 [see pp 268-269]). Briefly, the size of broods will be qualitatively delineated as small, medium or large based on the width and length of the entire brood and quantitatively by collecting the released larvae and estimating the number of larvae volumetrically. Egg viability and size will determined by removing a sub-sample of eggs ($n \geq 100$ eggs; 25 from each section of 4 areas of the brood) every 3 days and examining the eggs under a dissecting microscope. Egg size will be measured using an optical reticule.

In addition, a sample ($n > 30$) of recently mated adult females captured near each inlet in August or September (the end of the reproductive season) will be maintained in each of two treatments that simulate different seasons: winter ($5^{\circ}C$ temperature and 10 hr:14 hr day:night light regime) and summer ($20^{\circ}C$ temperature and 14hr:10hr day:night light regime) in aquaria at Rider University. A sub-sample ($n>5$) of females from each treatment will be sacrificed and dissected each month for 3-4 months to assess sperm stores, ovarian weight and developmental stage using previously established techniques (Hines et al. 2003 [pp 290-292]; Jivoff 1997 [pp 369-370]). The remaining females from each treatment will be maintained to monitor the incidence, size, egg viability, egg size, and timing of each brood produced.

Reproductive Potential Studies: A weekly sample of crabs ($n \geq 10$ of each sex) and of ovigerous females ($n \geq 10$) from each site will be combined in a plastic bag with a label indicating the

date, area, site and sampling location of collection and placed in a freezer (located at the Rutgers Field Station) for subsequent dissection and measurement of reproductive potential: sperm stores and seminal fluid weight in males; sperm stores, ovarian weight and developmental stage, brood stage and egg number in females using previously established techniques (Hines et al. 2003 [pp 290-292]; Jivoff 1997 [pp 369-370]). The Rutgers collecting permit allows for the collection of ovigerous blue crabs (see Species List, page 3 of permit). These data will provide estimates of the reproductive capacity of Barnegat Bay blue crabs, which can be compared to blue crabs from other populations in the mid-Atlantic region, as well as provide the first estimates of seasonal reproductive output of individual adult female blue crabs in Barnegat Bay and indeed from any New Jersey estuary.

Continuous variables (e.g., physical variables, crab abundance, crab size) will be analyzed using analysis of variance with month, sample area, and sample site as independent variables.

8.0 Quality Objectives and Criteria for Measurement Data

8.1 Precision

Data precision of environmental parameters will be maintained by using the same instrument for all parameters. All parameters are taken to the nearest 0.01 unit of measure. Replicate readings (i.e., from the same area, site, and trap) will not be taken, however two readings will be taken per site and sampling location. The instrument will be maintained and the calibration checked daily. Data precision of the seasonal reproductive output study will be maintained by using the same data collectors for all of the crabs and the same microscope to assess egg viability and egg size. Data precision of the reproductive potential study will be maintained by using the same dissectors for all of the crabs. Weights of reproductive tissue will be assessed to the nearest 0.01g. Weights of each side of the reproductive system will be taken as a check of accurate dissection technique. The balance will be maintained and the calibrated daily.

8.2 Bias

Bias in the environmental parameters will be minimized by using the same instrument for all parameters. The instrument will be maintained and the calibration checked on a daily basis. Bias in the seasonal reproductive output study and the reproductive potential study will be minimized by using the same laboratory equipment for data collection.

8.3 Representativeness

The sampling design will insure data representativeness: particularly the spatial extent of the sampling areas, the consistency in physical characteristics among sampling locations within each site, the daily randomized selection of sampling locations and the frequency of sampling (daily, every other week). All of these aspects will allow me to capture the temporal and spatial variation that exists in environmental parameters and in population structure of adult female blue crabs. Data representativeness will be insured in the reproductive potential study by examining females across the size spectrum and from females collected from different areas. Frozen crabs will also represent the adult size spectrum and will be from each sampling area. Non-intermolt crabs and those regenerating limbs will not be used for dissection.

8.4 Comparability

The data from this project will be directly comparable to fisheries data from NJ-DEP (and fisheries data from other states) because of the similarity in sampling gear and sampling design.

8.5 Completeness

Because the sampling of environmental data is replicated (twice) at each sampling site, 50% of these data (on a daily basis) would be required for completeness.

8.6 Sensitivity

The instrument that will be used to measure the environmental parameters is capable of detecting the minimum levels that could occur in each environmental parameter: temperature=14°C,

salinity=0ppt, dissolved oxygen=0 mg/L, depth=0.5 m. The balance that will be used to measure the weights of reproductive tissue is capable of detecting the minimum levels that could occur: 0.01g.

9.0 Non-Direct Measurement (Secondary Data)

Non-direct measurement will not be used in this project.

10.0 Field Monitoring Requirements

10.1 Monitoring Process Design

The study is designed to assess population characteristics and spawning biology of adult female blue crabs in Barnegat Bay during the summer months. The monitoring design is probability based: spawning locations (near the inlets) in Barnegat Bay will be targeted for sampling (see Figure 3). Near each inlet, four sampling sites will be established (via GPS) that are consistent in the distance from shore and depth, with each sampling site containing 4 sampling locations. Each sampling day, at least four commercial-style traps will be randomly assigned to one of the four sampling locations in each site. Therefore, during each sampling week, each sampling location will be used once in each site. The traps will be placed at least 50m apart from one another to minimize effects between adjacent traps. Replicate samples of environmental parameters will be taken each sampling day (at the first and last trap at each sampling location). The target population and the environmental parameters are temporally and spatially variable, therefore the spatial coverage and the frequency of sampling will insure we capture the inherent variation that exists.

10.2 Monitoring Methods

Blue crabs will be sampled using commercial-style traps. Traps will have consistent (24 hours) "soak times" and bait will be replaced daily. All crabs (regardless of species) from each trap will be placed in labeled (using waterproof labels inside the bag), moistened burlap bags to minimize injury and mortality. Dead crabs can also be processed as in Section 7 above without a loss of information. Species representing by-catch (e.g., fish) will be also recorded. Environmental parameters will be taken with a YSI data logger (model 6800) at the first and last trap at each sampling site. An additional YSI data logger (model 6800), will be used as a back-up instrument in case of problems with the original model 6800. The data logger will be cleaned daily. Sampling locations will be located using a hand-held GPS unit (Magellan). Water depth will be taken with a pole marked at every 10 cm and verified using an electronic "fish finder". All data will be entered into Excel and statistical analysis will be performed using Systat (Version 10.2). The data are entered by one person and checked by at least one other person. Jivoff will train students in the SOPs for each aspect of the study (see attached), which will insure internal consistency and comparability to previous work.

10.3 Field Quality Control

The instrument used to collect environmental parameters will be maintained and the calibration checked on a weekly basis.

11.0 Analytical Requirements

11.1 Analytical Methods

I will use the default options on the environmental data logger for measuring temperature, salinity, and dissolved oxygen. See section 7 (and attached SOPs) for field and laboratory methods, many of which are based on previous methods (see Jivoff, 1997, Methods, page 370) and are methods used in previous studies that have received. Methods of statistical analysis will also be the same as previous studies that have been approved via the QAPP process of the EPA.

11.2 Analytical Quality Control

Frozen crabs are labeled as to the date, area and site of collection. Reproductive tissues removed from these crabs and stored in vials are also labeled (on the outside of the vial) with this information as well as a unique identification number for each crab. This information as well as crab

size, molt stage, weight of appropriate reproductive tissues and qualitative information about the reproductive tissue will also be noted on the data sheets. Each vial will contain the tissue of a single crab. Reproductive tissues will eventually be homogenized (e.g., for sperm counts) using a tissue grinder. The balances used for measuring the weights of the reproductive tissues can detect to 0.01g.

12.0 Sample Handling and Custody Requirements

Crabs for dissection will be frozen on the day of collection. Dissections will take place from September 2010-April 2011. Dissectors will include Rider University undergraduate students who will be shown the SOP for dissection by Jivoff (see attached SOP and Jivoff, 1997, Methods, page 370). Extracted reproductive tissues will be stored at Rider University in 40ml vials with 10ml of 70% EtOH. Approximately 1500 vials (standard vials from a biological supply company) will be used. The vials will be stored in their original protective packaging in Jivoff's laboratory. The remainder of the crab material will be disposed of in the ocean.

13.0 Testing, Inspection, Maintenance and Calibration Requirements

13.1 Instrument/Equipment Testing, Inspection and Maintenance

The environmental data loggers are inspected and calibrated to manufacturers specifications annually by the manufacturer (see attached inspection/maintenance record for 2008-2009). Regular maintenance as suggested by the manufacturer occurs after each use but is not recorded (see attached SOP for daily maintenance).

13.2 Instrument/Equipment Calibration and Frequency

The environmental data loggers will be checked for calibration and probe maintenance will occur each week using the manufacturers recommended procedures.

13.3 Inspection/Acceptance of Supplies and Consumables

Supplies and consumables for the environmental data loggers include standard batteries, and membranes and solutions for the probes which are obtained from the manufacturer. Burlap sacks are from Kane Supply Inc., in Baltimore, MD, only intact (e.g., no holes) bags are used. Dissecting equipment and vials are from Carolina Supply Inc. Consumables are checked for expiration dates and general working condition.

14.0 Data Management

All field data are taken on pre-made waterproof data sheets (see attached). Information from these data sheets is entered into Excel spreadsheets within 7 days of collection. The data are entered by one person and checked by at least one other person. During the field season, data files are maintained on networked computers that are backed-up daily at the Rutgers University Marine Field Station. After the field season, the data files are transferred (via e-mail attachment, posted directly to the Rider network, and copied to a thumbnail drive) to a networked computer that is backed-up daily at Rider University.

15.0 Assessments/Oversight

Not applicable.

16.0 Data Review, Verification, Validation and Usability

16.1 Data Review, Verification, and Validation

All data are transcribed from the original data sheets to spreadsheets in Excel. One person typically enters the data into Excel and a different person(s) checks the digital version against the original data sheet. The original data sheets are labeled with the data-taker's name such that if the data enterer has questions they can be addressed by the original data taker. The data sheets are also labeled by the data checker such that if a subsequent data user has questions they can be addressed by the data

enterer. Crab abundance may be calculated as catch per unit effort (CPUE) if the number of traps varies among sampling times or sites. Irresolvable errors in the data will result in the removal of those data from analyses. Data users (e.g., NJ Division of Fish and Wildlife) will be apprised of data collection methods and data management techniques so that they may make informed decisions about the usability of the data.

16.2 Reconciliation with User Requirements

During statistical analysis, the data will be examined for outliers and for deviations from assumptions of statistical tests (e.g., homogeneity of variances). Statistical tests that may be performed include: analysis of variance, linear regression, and chi square tests. Outliers will be removed from analyses and data not conforming to assumptions of statistical test will be transformed appropriately. The limitations of the data will be noted and discussed in any written document (e.g., annual report, manuscript) in which they are incorporated.

17.0 Reporting, Documents and Records

All of the data (both hard and electronic versions) and biological samples will reside at Rider University for a period of at least 5 years. A progress report (half-way through the study period) and final report will be submitted by Dr. Jivoff to the Barnegat Bay National Estuary Program.

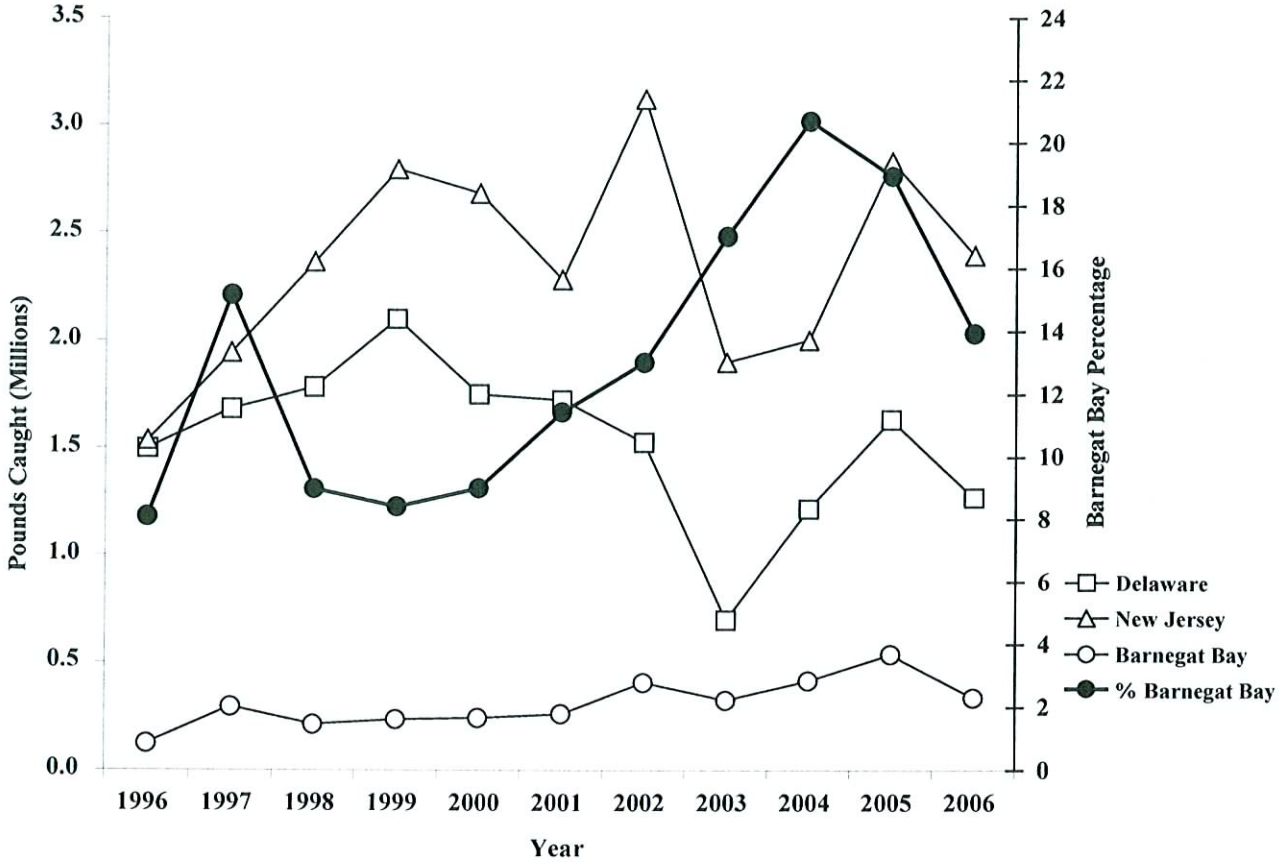

Figure 1. Annual summer-time (June-August) catch in traps of blue crabs ("hard crabs") in Delaware, New Jersey, and Barnegat Bay (open symbols, left Y axis) and the percentage of the total New Jersey summer-time catch represented by Barnegat Bay (filled circles, right Y axis). Data from NOAA and NJDEP.

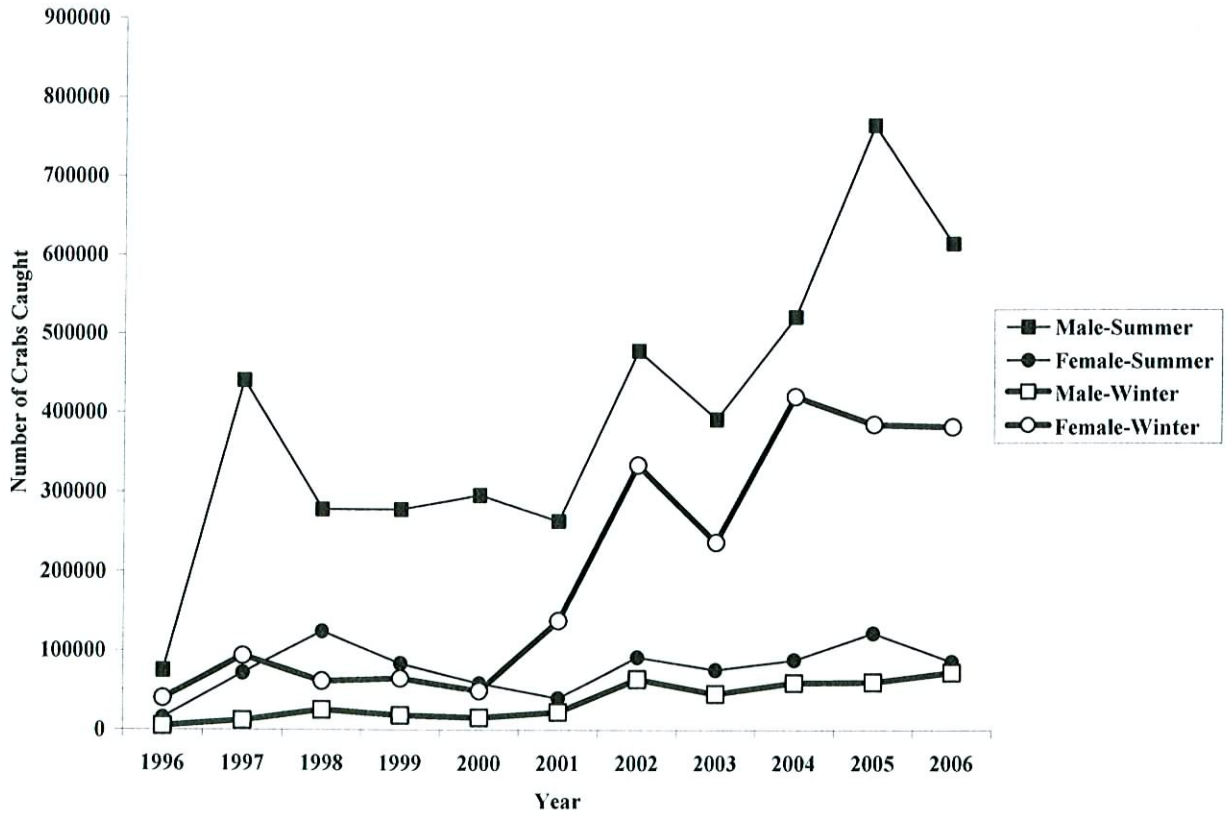

Figure 2. Annual summer (closed symbols) and winter (open symbols) catch of male (squares) and female (circles) blue crabs in Barnegat Bay, 1996-2006. Data from NJ-DEP.

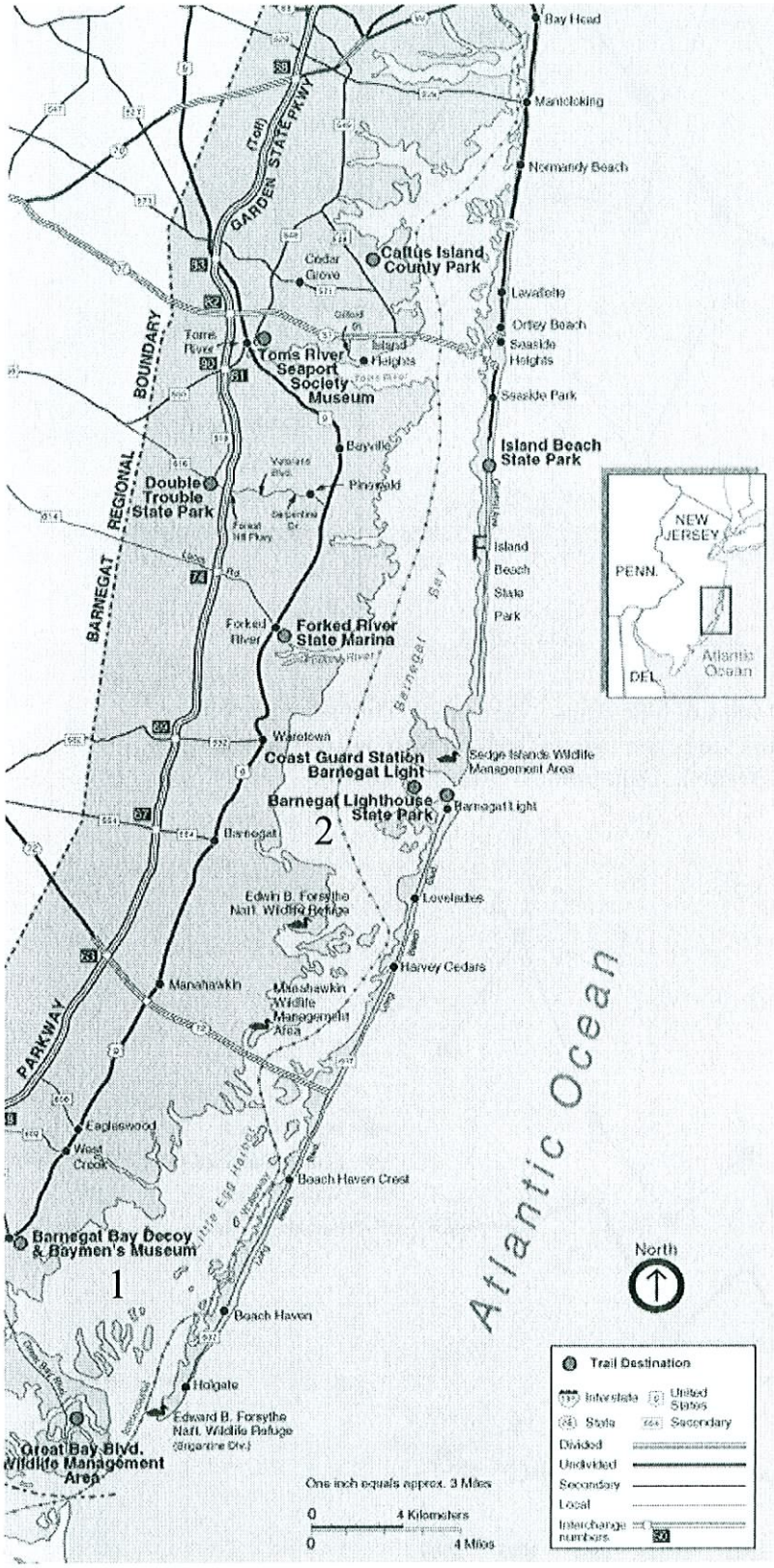

Figure 3. Map of Barnegat Bay showing locations of two sampling areas for this study.

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Appendix: Example Data Sheets

Blue Crab Collection Data Sheet

BLUE CRABS-2010 Y our initials= page #=

Entered By=

Checked By=

Pre-Molt color	molt	Post-Molt hardness	molt
none	C	fully hard	C
thin, red	D0	soft	A
white	D1	leathery	B1
orange-pink	D2	brittle	B2
pink-red	D3	barely gives	B3

						A			I=intact				0=none	
	7	1	1	CS	M	J			R1L2				1,2	
	6	2	2	LE	F	P			R123		Y	Y	3,4	
6-Jun-08									-		N	N	5=rem	barnacle

Date	Area	Site	Trap	Species	Sex	Age	Width	Molt	Rlimb	#Limbs	Flap	Pleo	Ovig	Comment

Physical Characteristics Data Sheet

BLUE CRAB -PHYSICALS-2010										I N	OUT	
Date	Area	Site	Trap	Temp	Salinity	DO	Depth	Tide	Time	Traps	Traps	Comment

Blue Crab Dissection: Male Data Sheet

This info on tag in bag							*pre*							
						I=hard	*post*							
					mm	*Post=gives*	*s=single*	*g*	*g*	*g*	*g*			
Day	**Month**	**Year**	**Area**	**Site**	**Size**	**Molt**	**Mate**	**Sperm Weight**		**Sem fluid Weight**		**Comment**	**Store #**	
							Status	**Left**	**Right**	**Left**	**Right**			

Blue Crab Dissection: Female Data Sheet

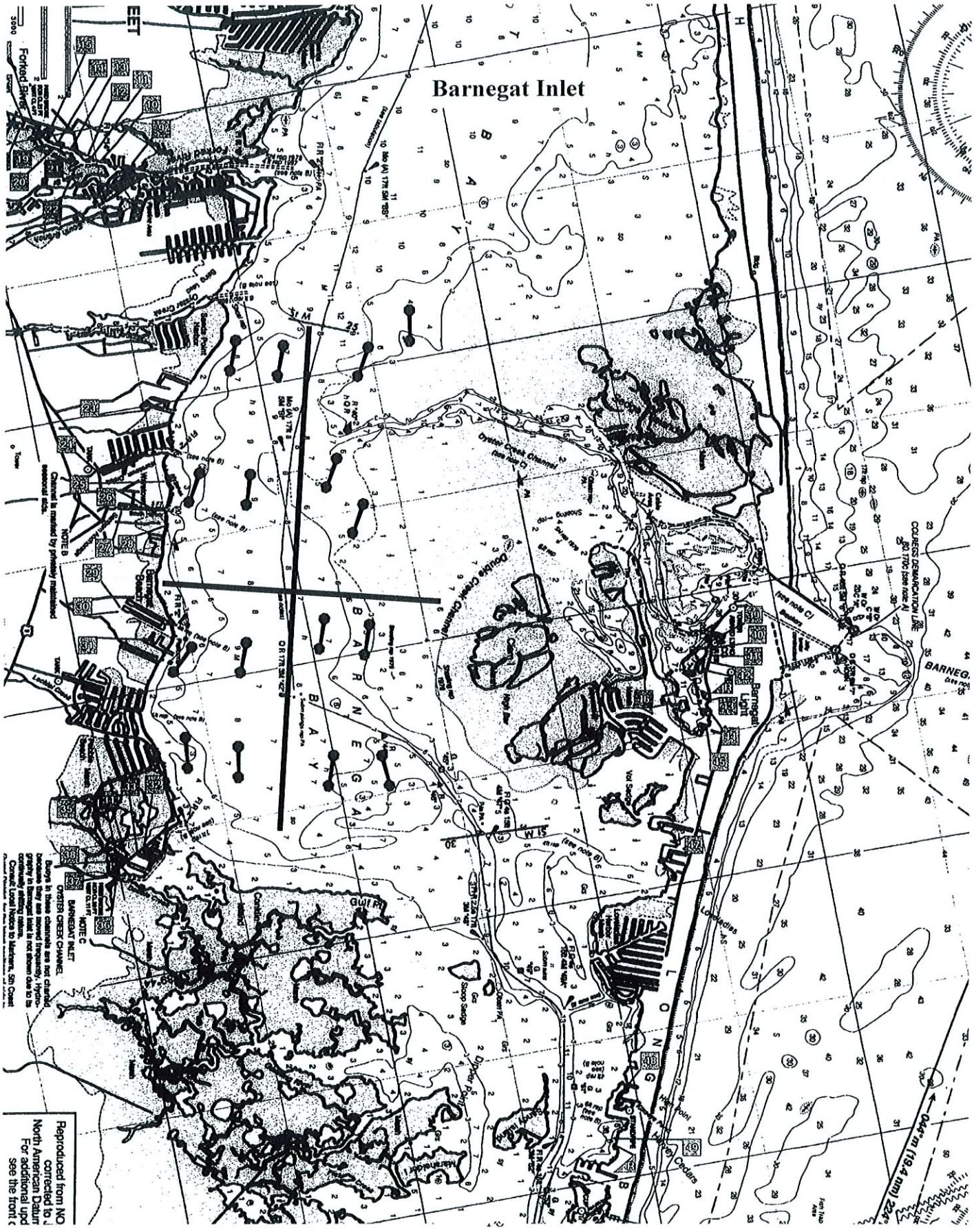
										pink	hard			0=none		
										lite pink	soft			1=thin, pink		
										clear	mushy			2=thin, orange		
							1=hard	post		white	viscous			3=thick,orange		
This info on tag in bag						mm	Post=gives	s=single	g	g	none	none	g	g	4=thick,red		
Day	Month	Year	Area	Site	Size	Molt	Mate Status	SR Weight		SR color	SR texture	Ovary Weight		Ovary Stage	Comment	Store #
								Left	Right			Left	Right			

Blue Crab: Brood Number Data Sheet

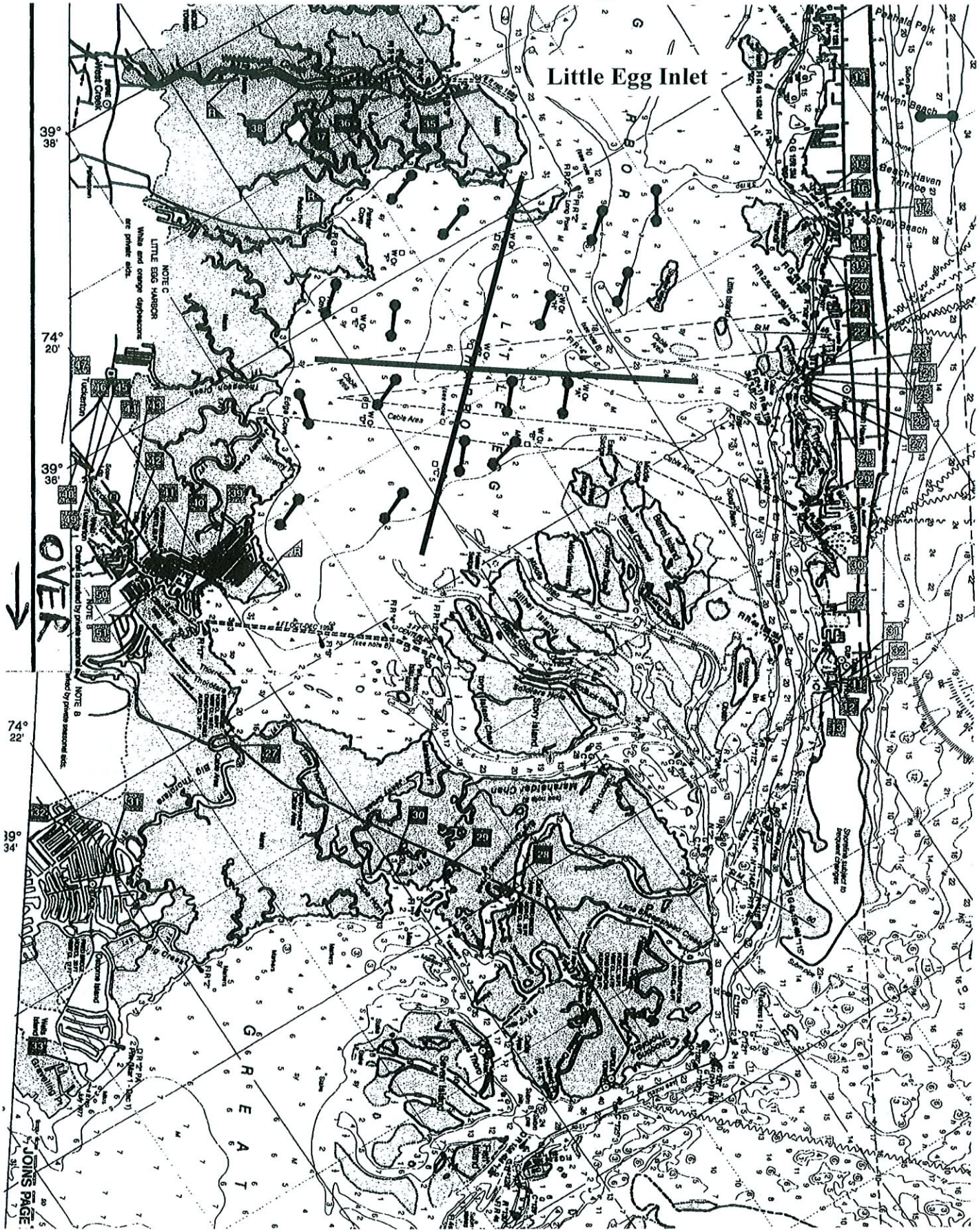
						DATES					
Crab ID	Capture Date	Area	Width	Limbs	Plug	Brood 1	Brood 2	Brood 3	Brood 4	Brood 5	Comments

Appendix

Maps with potential site locations and trap orientations: Barnegat Inlet (trap line indicated by ●—●)



Maps with potential site locations and trap orientations: Little Egg Inlet (trap line indicated by ●—●)



Appendix

Standard Operating Procedures

Crab Sampling

Pull trap and determine if mate guarding pairs are present, visually identify individuals, and manually separate paired crabs from single crabs
Empty single crabs into bin
Label burlap bag with water proof label containing:
    Date, Area #, Site #, Trap #
Empty bin into burlap bag and immerse in water to moisten bag
Store burlap bag in storage tub for transport

Environmental Monitoring

Turn environmental data logger on 15 minutes before first use with sonde cap on
Examine dissolved oxygen (in % saturation) and calibrate if reading is less than 95%
Measure water depth with depth pole and record
Lower YSI probe until it touches the bottom, then raise it ~10 cm
Read display; when values are stable record the following:
    Temperature, Salinity, and Dissolved Oxygen in mg/L

Maintenance of Environmental Data Logger

Rinse sonde cord in fresh water
Remove sonde cover and rinse cover and probes in fresh water
Examine probes for damage and contamination
Replace sonde cover with sonde cap containing 5ml of freshwater
Wipe hand-held display unit

Crab Processing

Empty crabs from burlap bag into sorting bin
Obtain waterproof label and record information
Process each crab for the following:
    Carapace width (mm), Sex, Age, Molt Stage, Regenerating Limbs, # missing limbs, ovigerous stage of adult females, abdominal flap attachment and pleopod insertion of males (see Jivoff, 1997, Methods)
Save for dissection two males (intermolt, intact, sexually mature) and two adult females from each of the following carapace width size classes from each area:
100-109, 110-199, 120-129, 130-139, 140-149, $\geq$ 150

Crab Dissection (see Jivoff, 1997, Methods, page 370)

Males

Carefully remove carapace
Identify and remove (via dissecting scissors) each side of the anterior vas deferens and middle vas deferens
Place each side of vas deferens in separate petrie dish
Indentify anterior and mid vas deferens using size, color, and texture and bisect the two sections of the vas deferens
Weigh each section of each side of vas deferens (to nearest 0.01 g)
Place both sides of anterior vas deferens in labeled scintillation vial with 10ml of 70% EToH
Label on vial should include:

Crab ID number, Date, Area, Site, Sex, Size

Females

Carefully remove carapace
Identify and remove (via dissecting scissors) each sperm storage organ and each side of the ovary
Place each sperm storage organ with its' corresponding each side of ovary in separate petrie dish
Remove connective tissues from sperm storage organ and ovary
Weigh each tissue (to nearest 0.01 g)
Place both sperm storage organs in labeled scintillation vial with 10ml of 70% EToH
Label on vial should include:
Crab ID number, Date, Area, Site, Sex, Size

Egg Viability and Size of Brooding Females (held in tanks or field enclosures)

Capture female using dip net (to minimize stress and damage to brood)
Gently lift abdominal flap to expose brood
Using tweezers, remove sub-sample of eggs from each of 4 sectors of the brood (left, right, top, bottom)
Examine and measure diameter (with eyepiece reticule) of eggs from each sector under dissecting scope.
Score eggs as viable or inviable using previously published methods (see Dickinson, 2006 Methods)

YSI Incorporated

1700/1725 Brannum Lane
Yellow Springs, Ohio 45387 USA
Tel: 937-767-7241 • Fax: 937-767-9353

Sea-Bird/YSI Inc.
San Diego, CA

REMIT TO:

CHECKS (DRAWN US BANKS ONLY):
YSI INCORPORATED
PO BOX 640073
CINCINNATI, OH 45264-0073

ACH (WITH ADDENDA RECORD):
US BANK NA
CINCINNATI, OH 45202
ACCT# 4506321; ABA# 042000314

INVOICE

NUMBER	PAGE
938707	1 of 1
CUSTOMER NUMBER	**DATE**
2634	10-NOV-08
PURCHASE ORDER NUMBER	
CREC TCAIRO	
SALES ORDER NUMBER	**TECHNICIAN**
020565	Not Specified

BILL TO:
RIDER UNIVERSITY
2083 LAWRENCEVILLE RD
DEPT OF BIOLOGY
LAWRENCEVILLE NJ 08648

SHIP TO:
RIDER UNIVERSITY
2083 LAWRENCEVILLE RD
DEPT OF BIOLOGY
LAWRENCEVILLE NJ 08648

#218 Heather

TERMS	CURRENCY	DUE DATE	SALESPERSON
NET 30 DAYS	USD	10-DEC-08	
WAYBILL	**SHIP DATE**	**SHIP VIA**	**CUSTOMER CONTACT**
8454D3180410941	10-NOV-08	FEDEX	

LINE	PART NUMBER	ITEM DESCRIPTION	QUANTITY ORDERED	QUANTITY SHIPPED	UNIT PRICE	EXTENSION
1	6820	REPAIR MODEL 6820	1	1	$ 0.00	$ 0.00
		Repair Notes : Model 6020 SN: 04D1553 AA				
		Conductivity replaced with new due to caustic temp readings				
		PH probe replaced with new due to out of specs.				
		Turbidity replaced with new due to moisture inside probe				
2	6136-30	6136 TURBIDITY PROBE HS# 9027.80.8958	1	1	$ 0.00	$ 0.00
3	605561	6561 PH PROBE KIT HS# 9027.80.6950	1	1	$ 0.00	$ 0.00
4	6560-30	6560 CONDITEMP PROBE KIT HS# 9027.80.8530	1	1	$ 460.00	$ 460.00

SUBTOTAL	TAX	SHIPPING/HANDLING	TOTAL
$ 460.00	$ 0.00	$ 10.00	$ 470.00

FOR TERMS AND CONDITIONS REFER TO
WWW.YSI.COM/TERMS_CONDITIONS

Appendix
Rutgers University Marine Field Station Collecting Permit

Date Issued: **01/27/10**
Number: **1011**

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Acting Commissioner

Division of Fish & Wildlife
P. O. Box 400
Trenton, NJ 08625-0400
David Chanda, Directo
609-292-9410
njfishandwildlife.com

01/27/10 to 12/31/10

SCIENTIFIC COLLECTING PERMIT

TO WHOM IT MAY CONCERN:

Under provisions of New Jersey Statutes Annotated Title 23:4-52, permission is hereby given to:

Dr. Francisco E. Werner, Director Rutgers, the State University of New Jersey, Institute of Marine and Coastal Sciences, 71 Dudley Road, New Brunswick, NJ 08901-8521 to collect various species (see attached list) and sediment samples for the purpose of study. For location of sampling, gear to be used, and vessel to be used see attached lists.

This permit is subject, but not limited to, the following conditions:

1. The person(s) named herein shall have this permit in their possession when collecting scientific specimens in marine, fresh, or estuarine waters of the State and must present it upon request to any official or citizen.

2. The holder of this permit shall notify the Marine Law Enforcement Region Office of his/her scientific collecting activities in any of the State's marine, fresh, or estuarine waters at least 24 hours in advance of their activities. Notification can be made in writing to the Marine Enforcement Office, P.O. Box 418, Port Republic, NJ 08241, or by calling 609-748-2050.

3. A report of the organisms collected (species, numbers, specific location where taken, dates of sampling) or a final report for the study for which the permit is requested shall be sent to the Administrator, Marine Fisheries, P.O. Box 400, Trenton, NJ 08625, within four (4) weeks of the expiration date or upon request for permit renewal, whichever is earlier.

4. The provisions of this permit may not apply to any of the species listed by the United States Government as endangered. Special provisions may apply for certain of these endangered species.

5. This permit does not convey the right to trespass.

6. Violation by the permittee or subsidiary permit holders of any condition of the permit or any state law or regulation promulgated pursuant to N.J.S.A. 23 or 50 or N.J.A.C. 7:25 or

7:25A shall render this permit null and void and subject all parties to prosecution in addition to permit revocation upon conviction. Applications for future permits may also be denied.

7. The holder of this Scientific Collecting Permit is also required to have in his/her possession a "Special Permit for Research" from the Division of Watershed Management, Bureau of Marine Water Monitoring, P.O. Box 405, Leeds Point, NJ 08227, prior to the taking of shellfish (clams, oysters, mussels) for scientific purposes from the marine or estuarine waters of the State that are designated "Prohibited," "Special Restricted," or "Seasonal Special Restricted" (N.J.S.A. 58:24-3, and N.J.A.C. 7:12-2). A chart of these designated waters may be obtained from the Bureau of Marine Water Monitoring.

Thomas W. McCloy, Administrator
Marine Fisheries Administration

bd

c: Marine Enforcement Region Office
Timothy Cussen, Chief, Bureau of Law Enforcement
Lt. Chris Simmermon State Police
Deborah Watkins, Bureau of Marine Water Monitoring

Subsidiary Student or Employee Permit Holders:
See attached lists

Institute of Marine and Coastal Sciences – 2010 Permit Application

Kenneth Able
Andrew Altieri
Ramya Ambikapathi
David Aragon
Maria Aristizabal
Justin Ash
John Balletto
Lauren Bergey
Mark Bertness
Kay Bidle
Josi Bonventre
Monica Bricelj
Steven Brown
Sean Bugel
Bronwyn Cahill
Colette Cairns
Allison Candelmo
Kimberly Capone
Carly Cappelluzzo
Jaime Caridad
Bob Chant
Keith Cooper
Michael Crowell
Dan Crowell
Cathy Czerwinski
Kevin DeCristofer
Robert Denno (U Md)
Bill Dixon
Joe Dobarro
Mark Donio
Rich Dunk
Jack Facciolo
Farnaz Farhang
Kate Faugno
Deborah Finke (U Md)
Gef Flimlin
Michael Fox
Jaime Fraser
Heidi Fuchs
Charlotte Fuller
Yuan Gao
Michael Garzio
Keryn Gedan
Scott Glenn
Dakota Goldinger
Rachel Goeriz (U Md)
Donglai Gong
Max Gorbunov
Frederick Grassle
Judith Grassle
Thomas Grothues
Sean Gryger
Jige Guo
Scott Haag
Roland Hagan
Dale Haidvogel
Clinton Haldeman
Ethan Handel
Bill Hanson
Sharon Harrison
Jean Marie Hartman
Nicholas Hermann
Jessica Hines (U Md)
Elizabeth Hirsch
Jessica Hoffman
Danielle Holden
Christine Holdredge
Stephen Horvath
Andrea Huberty (U Md)
Christopher Huch
Eli Hunter
Olaf Jensen
Jennifer Jitner
Paul Jivoff
K. Martha Joens
Joseph Jurisa
Alex Kahl
Ian Kaplan (U Md)
Jessica Kelly
Caitlin Kennedy
Michael Kennish
John Kerfoot
Daniel Kleuskens
Courtney Kohut
Josh Kohut
Matthew Kozak
Jessica Kurth
Marcus Kwasek
Kelsey Lane
Ron Lau ck
Richard Lathrop
Je=oe Lesnieski
Dan Lewis (U Md)
Ester Leibovich
Charles Sage
Lichtenwalner
Harmony Liff
Tany Lubansky
Anthony Lund
Richard Lutz
James MacDonald
Thomas Malatesta
Holly Martinson (U Md)
Sonia Mason
Janice McDonnell
Lora McGuiness
Dave Messerschmidt
Sara Monath
Martin Montes
Mark Morgan
Alfred Mottola
Shannon Murphy
Tori Musumeci
Jennifer Nannen
Frank Natale
Carola Noji
Karl Nordstrom
Lisa Ojanen
Laura Palamara
Rodney Pendry
Rosemarie Petrecca
Gina Petruzzelli
Joan Pravatiner
Norbert Psuty
Jenna Rackovan
Patricia Ramey
Evan Randall-Goodwin
Melanie Reding
Jessica Reichmuth
Paul Reiss
Reah Reys
Hugh Roarty
Emily Rogalsky
Gregg Sakowicz
Jennifer Samson
Rachel Sargent
Bill Scharf
Oscar Schofield
Silke Severmann
Barry Shafer
Christine Shafer
Justin Shapiro
Rob Sherrell
Shelia Shukla
Jennifer Smith
Valerie Sodi
Andrea Spahn
Peter Shipton
Ken Strait
Mark Sullivan
Gary Taghon
Kelly Tait
Melissa Tressault
Steven Tuorto
Lei Ann Van-Tull
Jason Turnure
James Vasslides
Costantino Vetriani
Eric Vowinkle
Glenn Wagner
Judith Weis
Tyler Weisbarth
Amy Werda
John Wilkin
Gina Wimp (U Md)
Mark Wong
Yi Xu
Matthew Yergey
Lily Young
Steve Zeck

Species to be collected in 2010:

Summer flounder
Winter flounder
Windowpane flounder
Black sea bass
Bluefish
Searobin
Tautog
Bonita
Albacore
Atlantic Herring
Atlantic tomcod
Pike
Naked goby
Atlantic silverside
Seaboard goby
Cunner
Black drum
Croaker
Spot
Weakfish
Goosefish
Catfish
Menhaden
Striped bass
White perch
Killifish
Smooth dogfish
Bait fish
River herring
Hickory shad
Alewife
Blueback
Mummichogs
American eel
Conger eels
Diamondback terrapins
Bay anchovy
Hard clams
Softshell clams
Oysters
Bay scallops
Horseshoe crabs
Blue crabs
Green crabs
Rock crabs
Lady crabs
Spider crabs
Shore crabs
Mole crabs
Sand shrimp
Fiddler crabs
Grass shrimp
Hermit crabs
Mud snails
Polychaete worms
Spartina cynosuroides
Spartina patens
Phragmites australis
Distichilis spicata
Spartina alterniflora
Macrofauna
Macroalgae
Widgeon grass
Eel-grass
Red Drum
Sturgeons
Benthic organisms

Various benthic organisms (clams, crabs, scallops, assorted invertebrates)
Submerged Aquatic Vegetation (eelgrass, Zostera marina, and Widgeon grass, Ruppia maritime)
Exotic/introduced species (Japanese shore crab)
Assorted benthic and pelagic invertebrates
Assorted sediments from bay, saltmarsh and near-shore zone
Assorted marine and estuarine species

Purpose:
Study of fish predators
Study of juvenile and adult fishes of various species (estuarine and oceanic)
Study of population dynamics and recruitment of assorted fish and pelagic species
Survey of benthic invertebrates of Great Bay and LEO-15 site (15 meters depth)
Study of bay sediments and sedimentation processes
Study of saltmarsh sediments and sedimentation processes
Study of behavioral ecology of fish food organisms
Collection of plankton for laboratory pollution experiments;
Collection of sediments for isotopic dating
Study of surf clam recruitment
Study of orientation of juvenile fish in environmental gradients
Oxygen saturation measurements
Migration patterns of juvenile and adult with ultrasonic tracking
Datalogger and nutrient monitoring, weather monitoring
Submerged aquatic vegetation (SAV) sampling

Time of collection: Sporadic activity year-round, both day and night; peak in summer and fall

Gear Types to be used:

Otter trawl
Tucker trawl
Methot trawl
Plankton nets
Ichthyoplankton pump
Shrimp bait net
Dredge
fyke net
Small mesh experimental gill nets
Hook and line
spear fishing
Fish weirs
Crab pots
Small mesh fish traps
Throw traps
Hand held nets
Automatic water samplers
Geiger counter
In situ auto analyzer
Autonomous vehicles, ROVs
Under ice sampler
Ice sled
Dataloggers
Dip nets
Shovels

Rakes
Tracking equipment (hydrophone and receiver for ultrasonic fish tagging)
Hand-held environmental probes
Benthic traps
Killifish traps
Gill nets
Cast nets
Beam trawls (1 and 2 m)
Mobile zooplankton pump
Moored zooplankton pump
Niskin bottles
Seine
Haul Seine
Pop net
Data loggers
Pit traps
Flumes
Bongo Nets
Still camera
Underwater video camera
Eel ladders
Eel collectors
Optical fish counters
Grabs
Diver hand cores
Quadrats

Sediment Samples Equipment:

Halley-Smith bed load sampler
Box corer
Eljekamp sediment corer
Vibracorer
Marsh McBirmy current velocity meter
Dalhousie pressure transducer
Eolian bed-load sampler
Van Veen grab sampler
Diver-collected sediments
In sediment camera
Tube corer
Ponar grabs
Coring devices
Shovel
Post-hole digger
Plexiglass core tubes

Vessels to be used:

R/V Maritime Skiff	NJ 3048GB	R/V Jon Boat	NJ 3377GB
R/V Maritime Skiff	NJ 3371GB	R/V Jon Boat	NJ 3318GB
R/V Maritime Skiff	NJ 3386GB	R/V Caleta	NJ 0908FS
R/V Carolina Skiff	NJ 2090FX	R/V Mullica Explorer	NJ 3610GR
R/V Michelle Rose	NJ 2714FE	R/V Arabella	NJ 3061GB
R/V Thunderbird	NJ8150GM	R/V Roccus	NJ6118FR
R/V Ursula	NJ 6360FA	RV Hugh R. Sharp	DE DL 467 AS
R/V White Whale	NJ 0030FD		

Locations:

Delaware Bay
Great Bay
Sandy Hook Bay
Raritan Bay
Newark Bay
Barnegat Bay
Hackensack Meadowlands
Arthur Kill/Kill van Kull
Little Egg Harbor
Great Egg Harbor
NJ/NY Harbor
Cheesequake Estuary
Ortley Beach
Union Beach
Island Beach State Park
Bass River
Hackensack River
Hudson River
Mullica River system
Navesink River
Passaic River
Raritan River
Shrewsbury River
Wading River
Nacote Creek system
Shark Inlet
Tuckerton
Point Pleasant
Lavalette
Belmar
Upper and Lower Millpond Port Republic
Cape May Harbor
Cape May Canal
Pinelands ecological preserve
Sandy Hook

New Jersey beaches and North Atlantic Ocean (Sandy Hook to Cape May)
Jacques Cousteau National Estuarine Research Reserve at Great Bay - Mullica River
North Atlantic Ocean outside Little Egg Inlet (LEO-15)
Atlantic Ocean (off Long Beach Island)
Varied estuary and coastal habitats
Various creeks in South Jersey
Sporadic low intensity sampling may be conducted from time to time at other locations within the state in marine and estuarine waters.

Technique: Lab Technique is defined as how well are you prepared to perform the day's experiment. Specific items are covered in the first section of the rubric. Do you work diligently or do you waste time? If you ask questions, are they reasonably thoughtful? Asking questions is an important part of the learning process. Asking too many questions with obvious answers because you are too lazy to think is not a learning process.

Final exam: There is a laboratory Final Exam that counts equivalent to one lab report in your total lab grade. The Final Exam is an 'open lab notebook' exam, which means you will be only able to use your laboratory notebook as a source during the exam.

Questions will be drawn from procedures and data you should have written down during the course of your experiments.

Only attached pages of records that are numbered and in sequence can be used for the final exam.

Experimental Schedule:

Date		Report Due
July 6th	Check-In / Intermolecular Forces	July 12th
July 12th	A Study of Chemical Kinetics, Part I	
July 13th	A Study of Chemical Kinetics, Part II	July 14th
July 14th	Spectrophotometric Analysis of *o*-Nitrophenol	July 19th
July 19th	Spectrophotometric Determination of an Equilibrium Constant	July 21st
July 21st	The Equilibrium of Ethyl Acetate	July 26th
July 26th	Buffer Solutions	July 28th
July 28th	Potentiometric Titration of a Weak Acid	August 2nd
August 2nd	Potentiometric Titration of a Diprotic Acid	August 4th
August 4th	Nuclear Chemistry Lecture	August 9th
August 9th	Kinetics of Radioactive decay	August 11th
August 11th	Potentiometric Determination of Ag^+ ion constants	August 16th
August 16th	Check-Out and Lab Final Exam	