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INITIAL DEVELOPMENT OF A DEEP-SEA CRAB FISHERY IN THE GULF OF MEXICO

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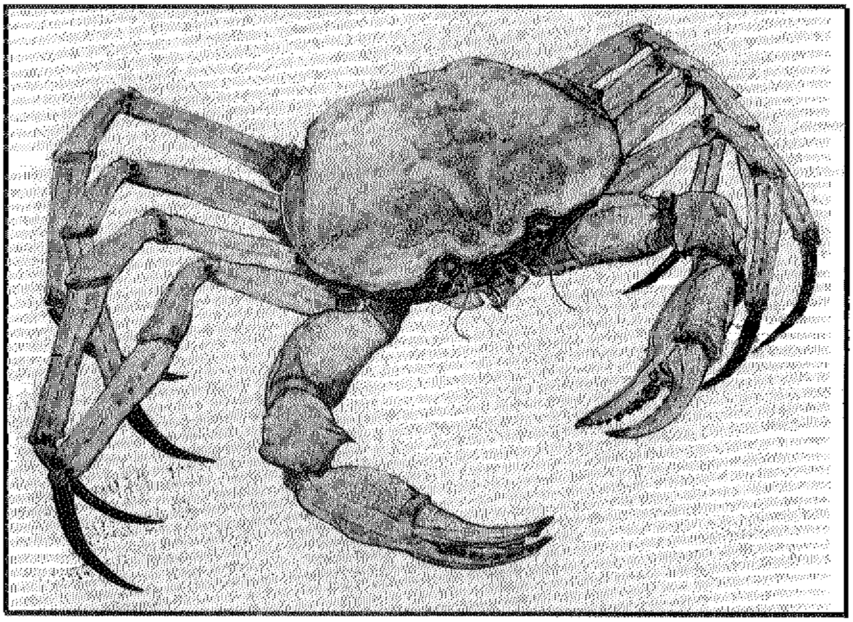

Gulf & South Atlantic Fisheries Development Foundation, Inc.

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INITIAL DEVELOPMENT OF A DEEP-SEA CRAB FISHERY IN THE GULF OF MEXICO

by

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Numerous individuals and programs need to be acknowledged for their support and involvement in this project.

By far the most important recognition belongs to Mr. Orlen Oakleaf, "Snatch" for his expertise, inquisitive nature and unselfish commitment of time in cooperative investigation to demonstrate the potential for a new crab fishery in the Gulf of Mexico. His extraordinary effort exemplifies the hard working, sincere character of today's fishermen, and is a testimony to his concern for the future of Florida's seafood industry.

A very special thanks to "Mr. Red Crab," Bill Whipple and his High Seas Corporation staff. Bill's open, unselfish advice was a major influence on the project. If I had the time he would be my subject for a most unforgettable character article in Reader's Digest. I admire his knowledge, courage and commitment to his ideas.

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Thank you's are due for the NMFS Pascagoula lab, Bennie Rohr, and Southeast Director, Jack Brawner, for providing Geryon data print-outs from previous exploratory cruises.

Finally, a special thanks to the Gulf and South Atlantic Fisheries Development Foundation for making this all possible.

INITIAL DEVELOPMENT OF A NEW DEEP-SEA CRAB FISHERY IN THE GULF OF MEXICO

SUMMARY

The Gulf and South Atlantic Fisheries Development Foundation, Inc. and the Florida Sea Grant College Program funded a one year study beginning May 1, 1982 to demonstrate potential for initiating a deep-sea crab fishery for golden crab (*Geryon* sp.) in the Gulf of Mexico. The work indicates that a fishery is feasible, yet the recommendations include many cautions unique to this deep-sea crab species.

The work included an inital literature review and industry tour to learn from similar fisheries, primarily the deep-sea red crab fishery (*Geryon quinquedens*) in New England. Fishing gear was modeled similar to the bottom longline gear used for New England red crabs. Numerous trap designs, baits, locations, and soak-times were fished in depths ranging from 210 to 350 fathoms adjacent to Florida's west coast. All fishing activity occurred through the cooperation of Mr. Orlen Oakleaf aboard his 67 foot vessel, Margueritte 'B', based in St. Petersburg, Florida. Specific results relative to fishing gear and methods are summarized on page 16.

Portions of the crab harvest were used to study primary handling and processing conditions. Evaluations included work with onboard survival, product yields and composition, controlling melanosis, microbial attributes, cooking, and sensory assessments. Crabs were processed onboard and in the pilot plant at the Department of Food Science and Human Nutrition at the University of Florida. Handling and processing results are summarized on page 25.

INTRODUCTION

Exploratory fishing ventures during 1981 and 1982 by commercial boats operating in deep waters along the southwest coast of Florida indicated the presence of a potential commercial resource of deep-sea crabs. These fishing efforts coincided with the current decreasing and limited supply of traditional king crab *(Paralithodes camtschatica)* and snow crab (*Chionoectes* sp.). Likewise, in the Gulf and South Atlantic region processors have been advocating a strong interest for any additional crab resources which could be directed to the increasing market demand for whole crab parts and picked meat. Thus the Gulf and South Atlantic Fisheries Foundation, Inc. (Tampa), initiated investigations of potential new crab fisheries in the Gulf of Mexico.

The primary objective of the Foundation's investigation was to demonstrate potential for developing a fishery for the golden crabs in the Gulf of Mexico. A preliminary demonstration was necessary to direct and encourage industry investments and to support and justify further investigations to describe and predict the available resource. The work included specific objectives to:

- investigate harvest gear which could produce enough crabs for commercial utilization;
- investigate onboard handling techniques necessary to maintain the quality of the catch;
- investigate preliminary processing parameters which would influence final product yield, quality and shelf-life;
- and provide information to support an estimate of the economic feasibility of the fishery and associated options.

The potential deep-sea resource belongs to the crab family, *Geryonidae*. Most previous reports have concerned two primary *Geryon* species, the 'true' red crab, *Geryon quinquedens* and the congener, *Geryon affinis*. Although the latter species, *G. affinis* has a more buff colored shell it also has been commonly called a red crab. The primary species studied in the project is thought to be a newly described *Geryon* species. It differs from the commercial red crab in that it is larger and has a distinct cream, buff shell color. The Curator of Crustacea in the National Museum of Natural History, Smithsonian Institution, has recently proposed a new scientific name for this crab (Manning, 1984). Recent common commercial names used to identify this deep-sea species include the Empress, Golden, Golden Gulf, and Gold Empress crab. This nomenclature distinguishes the newer species from the smaller, red orange species. For simplicity in text this report will henceforth refer to this new deep-sea species as the "golden crab."

METHODOLOGY

The project began, 1 May 1982, with an extensive literature search which indicated information on *Geryon* was limited to a few reports on the species description and distribution. Most biological information on these crabs resulted in conjunction with the recent development of the New England red crab fishery. In order to learn from this established fishery, two industry tours were arranged to observe existing harvest gear, traps, and processing parameters. Based on this methodology, gear was adapted and modified to suit the conditions and vessel for fishing demonstrations along Florida's west coast during July and September 1982, and May 1983. The fishing vessel was the Marguerite 'B', a 67 foot commercial fishing boat based in John's Pass Inlet, Florida (St. Petersburg). Experiments were arranged to determine onboard handling requirements and subsequent processing and storage methods. Lab work included quality evaluation, yield and composition analysis, and cooking and sensory assessments. Further detail on methodology accompanies the respective sections of this report.

LITERATURE REVIEW

Species

Difficulty in distinction of the *Geryon* species can confuse interpretation of the previous literature. For example, Schroeder (1959) felt previous reports by Mary Rathbun (1929 and 1937) had misidentified *Geryon affinis* as *Geryon quinquedens.* He noted that a creamy, buff shell color could distinguish *G. affinis* from the red *G. quinquedens,* but the most common reference for distinction of *G. affinis* and *G. quinquedens* only lists anatomical differences which do not include color specifications (Chace, 1940). Also the newly identified golden crab from the Gulf of Mexico has a creamy, buff shell color. More recently, Crustacean experts believe the golden crab is a unique species found most commonly in the western Atlantic (Manning, 1984). Previous accounts of the golden crab found in regions of the Gulf of Mexico and about the coasts of Florida have probably misidentified the species as *G. affinis* or *G. quinquedens* (Manning, 1984 and Rohr, 1984). Thus, to avoid confusion in this text, *G. quinquedens* will be referred to as the deep-sea red crab, and the new Gulf of Mexico species will be denoted as the golden crab.

Distribution

Description of the red crab was first provided from exploratory sampling from deep waters along the coasts from Casco Bay, Maine to the Chesapeake Bay, Virginia (Smith, 1879 and 1886). Later sampling indicated a deep-sea distribution southward along South Carolina and Brazil (Rathbun, 1929 and 1937). Red crabs have been reported to occur as deep as 800 and 1000 fathoms (Schroeder, 1959; and Pequegnat, 1970), but 350 fathoms is the common depth reported for greatest red crab abundance (Haefner and Musick, 1974; and Wigley et al., 1975). Reports imply 250 to 400 fathoms is the recommended depth for the most productive crabbing along the New England coasts (Holmsen, 1968; Meade and Gray, 1973; and Gerrior, 1981). These fishing recommendations refer to depths for commercial size crabs because smaller crabs are more common in greater depths. The inverse distribution of size by depth suggests an up-slope migration related to crab size and age (Wigley et al, 1975). Seasonal migrations are doubtful and annual movement is thought to be limited and nondirectional (Lux et al., 1982). Wigley et al. (1975) found red crabs are most common in bottom water temperature of 41° to 56.5°F (5° to 8°C).

Descriptions of the *Geryon* sp. crab about Florida's coast were initially provided by Chace (1940) from a few samples taken from 265 and 425 fathoms east of St. Augustine and later by Pequegnat (1970) in the Gulf of Mexico. Their reports indicate Smith (1879) introduced the name, *Geryon quinquedens* to denote the red crabs. Pequegnat's (1970) exploratory work during 1964 to 1969 on the 'Alaminos', utilizing a skimming dredgelike device, suggests *Geryon* sp. crabs were distributed throughout the Gulf of Mexico except in the southwest quadrant. This suggestion was based on samples taken along the northern Gulf of Mexico in depths ranging from 240 to 800 fathoms. He concluded that *Geryon* sp. crabs occurred in more substantial numbers in the eastern Gulf of Mexico.

The most extensive records for *Geryon* sp. about Florida were provided by the sampling expeditions of the National Marine Fisheries Service based in Pascagoula, Mississippi. During 1956-1976 the NMFS exploratory cruise reports reflect a broad distribution along both Florida coasts, about the Keys and throughout the Gulf of Mexico, extending into deepwaters on the northern coasts of Central and South America (Table 1 and Figure 1). These records do not clearly distinguish *G. quinquedens* from *G. affinis,* and often only list *Geryon.* Records from depths just north of the keys most commonly list *G. affinis* suggesting collection of the buff shell color or golden crab. Although the species distinction is questionable, *G. affinis* was also

Table 1. National Marine Fisheries Service* (Pascagoula Laboratory) exploratory fishing data indicating the harvest of *Geryon* crabs during research cruises, 1956-1976. The data is grouped by pre-established faunal zones (see Figure 1). Primary harvest gear was shrimp or fish trawls.

Faunal Zone	Number Trawls	Depth (fm) Range	Species Recorded**		
			Geryon	*G. quinquedens*	*G. affinis*
1	3	260- 320	26	46	—
2	5	190- 467	5	43	1
3	201	175- 375	533	132	89
4	26	150- 300	37	3	—
5	11	150- 410	—	1552	12
6	258	150-1000	4757	7213	280
7	54	100- 630	504	94	—
8	17	197- 912	32	96	—
9	6	235- 600	943	44	—
11	2	350& 400	3	—	—
13	1	500	—	1	—
14	2	257- 400	—	2	—
15	22	220- 700	333	—	1
16	19	225- 440	—	137	6
21	1	600	4	—	—
25	2	356- 405	1	1	—
26	5	220- 330	3	1	—
28	145	160- 500	473	233	258

*Data provided courtesy of the assistance from Bennie Rohr, Fishery Biologist and permission from Jack Brawner, NMFS Southeast Regional Director.

**Species identification was not always confirmed, especially prior to 1967-1969. Species designations could be in error and records for *Geryon affinis* may refer to the golden crab.

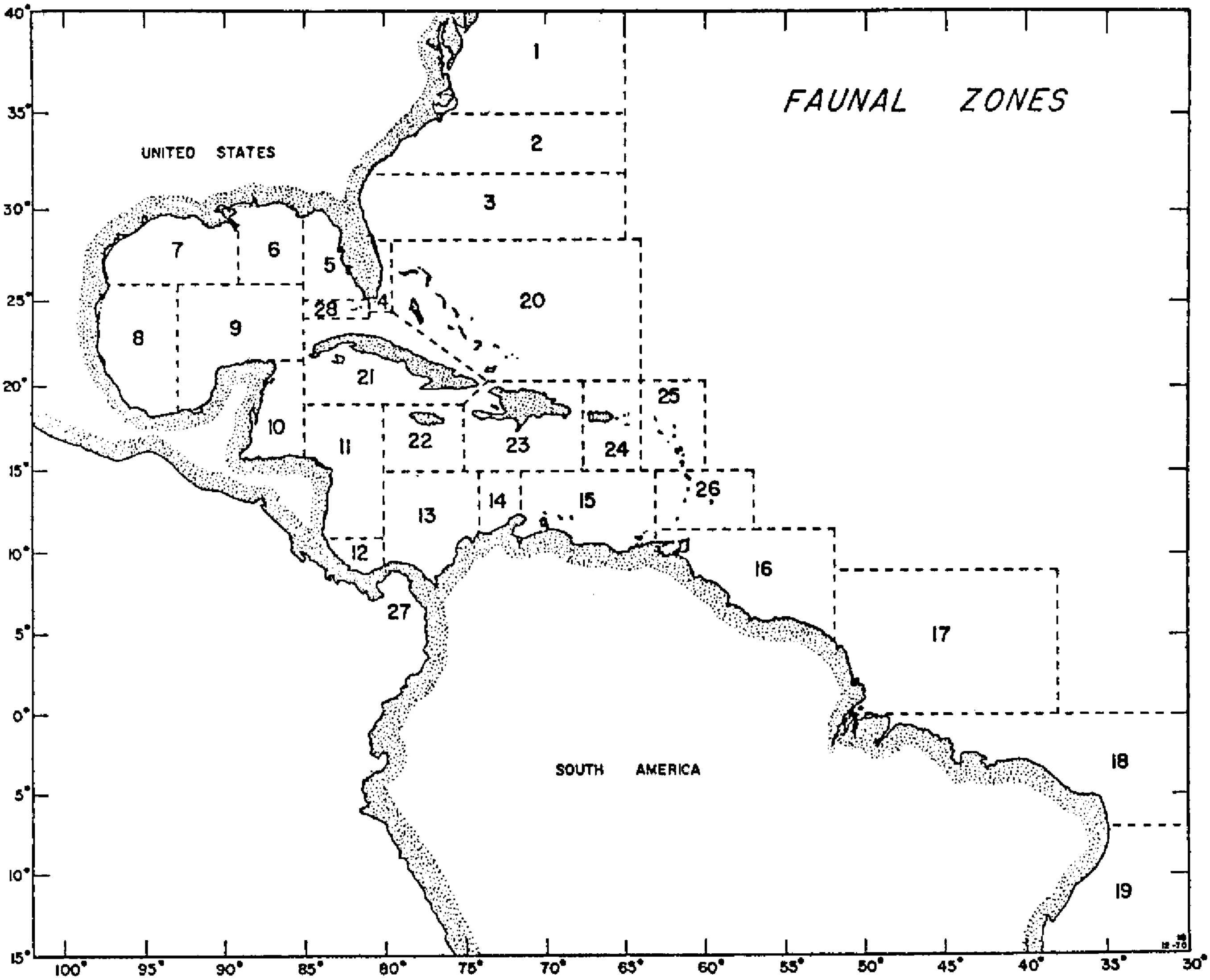

Figure 1. Faunal zones established and used by the National Marine Fisheries Services, Pascagoula Facility, to delineate records for exploratory cruise work. Figure provided courtesy of Bennie Rohr, NMFS Fishery Biologist.

recorded from deep-sea samples on Florida's east and west coasts and the coasts from Colombia through French Guiana. The *G. affinis* were taken from 90 to 350 fathoms along Florida's east coast and in 190 to 480 fathoms north of the Florida Keys. All *Geryon* sp. were taken from bottom temperatures ranging from 41° to 55°F (5 to 13°C), most commonly 45° to 50°F (7 to 10°C).

Biology

The *Geryon* sp. crabs are nonswimming crabs with distinct sexes. The males are much larger and further distinquished by their unique narrower shaped ventral apron (Figure 2). Additional biological information is limited to studies of the New England red crabs (Figure 3). The size for male red crabs has been reported to range in carapace width from 0.7 to 5.6 inches (1.7 to 14.2 cm) with a corresponding range in body weight from 0.002 to 2.1 pounds (0.8 to 964 g) (Wigley et al., 1975). The same report recorded female red crabs ranging in width from 0.7 to 4.8 inches (1.8 to 12.1 cm) and body weight from 0.002 to 1.1 pounds (1 to 490 g). The recommended minimum size for harvest in the New England fishery is a 4.5 inch carapace width which represents a 1.0 pound male crab (Holmsen and McAllister, 1974). Females are released and the common commercial size for male red crabs ranges from 1.0 to 2.0 pounds.

Female red crabs are thought to be sexually mature at a carapace width of 3.1 to 3.5 inches (80-90 cm) (Haefner, 1977 and Gerrior, 1981). Ganz and Herrmann (1975) described three color stages in the development of the egg color. The red or orange egg represents the first stage appearing in the summer and fall, the brown middle stage occurs in winter, and the final black egg color, obvious prior to hatching, is most evident in spring. The mode of reproduction is thought to include internal insemination during an intermolt stage whereby the female can then store the sperm for a prolonged

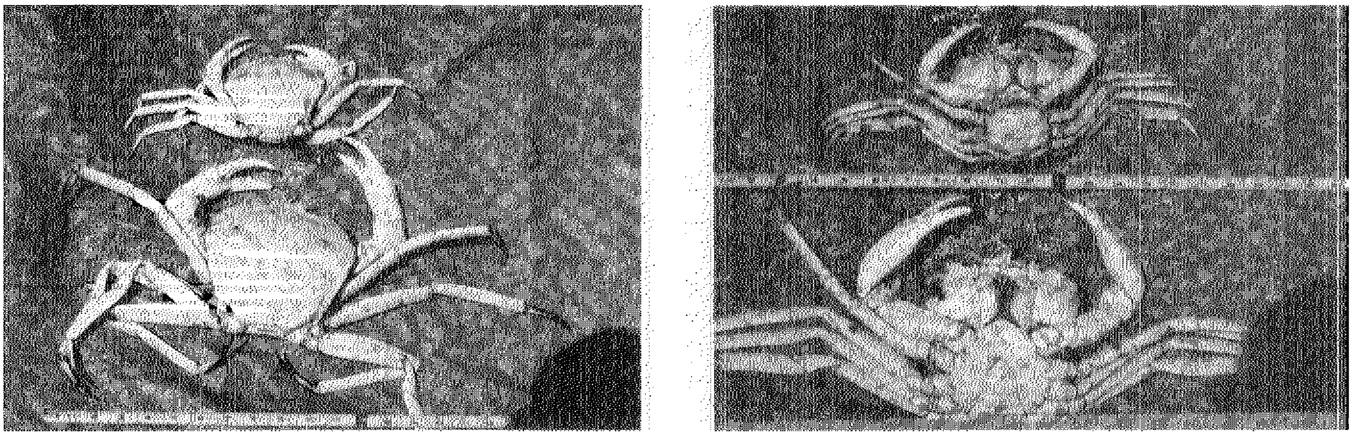

Figure 2. Dorsal and ventral views of the smaller female and larger male golden crabs. These selections represent the approximate average size caught together along the West coast of Florida during the study.

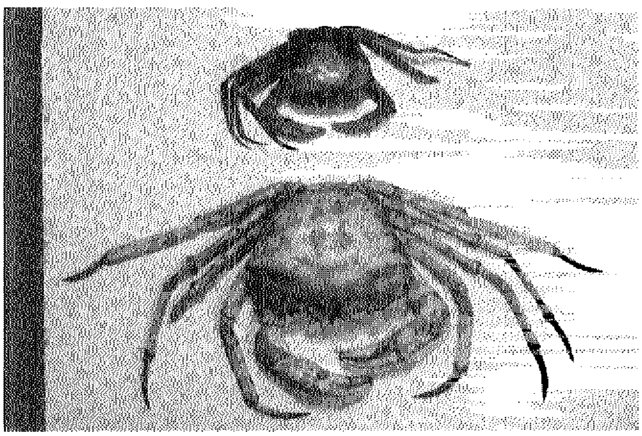

Figure 3. Comparison of the New England red crab, Geryon quinquedens *(above), with the Gulf of Mexico golden crab (below). Both selections represent the common commercial size landed.*

period of time for subsequent fertilization (Wigley et al., 1975; and Lux et al., 1982). The red crab larvae have been reported to hatch in 6° to 10°C water (Kelly et al., 1982) and larval development and behavior has been studied in laboratory cultures (Perkins, 1973; Sulkin and Van Heukelem, 1980; and Kelly et al., 1982).

The feeding habits of *Geryon* sp. are varied. Feeding studies (Gray, 1969), stomach content analysis (Beyers and Wilke, 1980) and successful baiting for traps (Haefner and Musick, 1974) indicate the *Geryon* sp. will ingest some invertebrates and all types of fish, both fatty and lean varieties, including shark meat (LeLoeuff et al., 1974).

Growth rates of the red crab are thought to be slow. A similar growth is expected for all *Geryon*. Marking tags have been recovered from red crabs which had been previously tagged over 10 years prior (Lux et al., 1982 and Lux, 1984). These tags were the type which should be lost during a molt or growth, thus indicating the crab had not molted or increased in size in over 10 years. Although, it is not clear from his data if these crabs had reached a terminal molt stage, or if the tag interfered with the molting process, Lux et al. (1982) suggested red crab harvest could exert a significant mortality on the marketable segment of the crab population.

Fisheries

Commercial fisheries for *Geryon* sp. crab have developed along the southwestern coast of Africa, and the northeastern Atlantic coasts of Canada and the United States. Bottom traps are the primary gear used for harvest in both regions. The African fishery was initiated in the shelf waters of Angola by Portuguese and Spanish vessels in 1970 through 1973 (Dias and Machado, 1973 and LeLoeuff et al., 1974). Their primary interest was crab claws. The Japanese followed with a more intense effort which landed nearly 8 million pounds (live weight) in 1973 (Beyers and Wilke, 1980). Current information on this fishery is scant.

The Canadian fishery was the first commercial effort in North America but interest in the fishery has been inconsistent. Stone and Bailey (1980) reported the red crab distribution on the Canadian continental slope is much more restricted by depth than on the American continental slope. Further studies have been conducted to assist the Canadian fishery (McElman and Elner, 1982), but development has been limited.

Currently, the most consistent fishery is for the red crabs taken along the coasts of Maine through Virginia. Most of the information describing the New England red crab fishery is credited to the comprehensive work of Gerrior (1981). This red crab fishery is most dependent on production in shelf waters of Massachusetts and Rhode Island, although some ventures continue in the Middle Atlantic states, New Jersey through Virginia. These fisheries were initiated in 1967 by development work of the University of Rhode Island and the respective State Division of Conservation (Holmsen, 1968). Subsequent work by the University (Meade and Gray 1973; Holmsen and McAllister, 1974; and Simpson and Howe, 1977), Rhode Island (Ganz and Herrmann, 1975), and the National Marine Fisheries Service

(Rathjen, 1974; Wigley et al., 1975; Gerrior, 1981; and Lux et al., 1982) helped assist further developments. The first fishing efforts were trial and error demonstration type work. Initially refrigerated seawater systems were expensive, troublesome to maintain, and vulnerable to total mortalities in warm weather or when weak crabs began to die. Onboard processing was later designed to butcher to a finished raw or cooked, fresh or frozen product.

Actual commercial red crab production did not begin until 1973. Processing began with assistance from established blue crab processing firms in Maryland. The fishery struggled with processing problems until 1975 when firms adopted mechanized removal of the meat. Currently there is one major red crab processing firm in Massachusetts. Since 1975 Massachusetts landings have accounted for over 98 percent of the annual U.S. red crab production. Since 1980, the Massachusetts fishery has accounted for well over 5.0 million pounds of red crabs annually. More specific production information on this red crab fishery is considered confidential relative to the one primary producer.

TOURS

On May 3-5, 1982 a tour of the existing red crab fishery in Falls River and Danvers, Massachusetts was arranged for industry participants from Florida. The tour group and schedule are outlined in previous Foundation reports. The tour concentrated on observing red crab production (vessels, gear, deployment of gear, onboard handling, unloading, etc.), and included a brief visit to one of the primary processing firms. In respect for the confidentiality of the New England firms the description of existing methods are restricted to that which was published or provided openly by the New England hosts.

Production

The High Seas Corporation in Falls River, Massachusetts is the only consistent fishing company currently harvesting red crabs. The species caught is *Geryon quinquedens*. Shell color ranges from dark pink, orange to red. Common fishing gear is bottom longlines with wooden traps. The groundline is ⅞ inch polypropylene and the traps are attached in intervals by patented metal clamps. One set of line and traps is called a 'trawl'.

The common wooden trap design was adapted from the off-shore lobster fishery. The sloped sides are wood (oak) lath forming a trapezoid shape (47 x 31.5 x 19 cubic inches). The one entrance (6 x 6 square inches) is a pre-molded, plastic collar fitted in the top laths. The center portion of the top laths is one section secured in place with a common elastic cord. This top portion can be removed to empty the crabs. Each trap is weighted with four bricks placed one in each bottom corner.

Fishing time ranges from 7 to 10 days arranged to minimize dock time to 24 hours between trips. Two vessels (approximately 87 ft. and 120 ft.) are employed with 11 men and 18 men crews, respectively. The crews are staggered during the daily operations. Traps are recovered and set during the day and soak at night.

Soaktime for the traps depends on the fishing schedule and weather. Average soaktime ranges from 18 to 24 hours. Between trip soaktime can range from 3 to 4 days. Excessive soaktime would diminish catch rates due to exhausted bait and crab escapement.

Retrieving the 'trawl' requires approximately four hours depending upon depth, catch, and weather. The 'trawl' is retrieved along the starboard side of the vessel. After the highflier and buoys have been lifted, the endline is thread through a power block. As traps reach the side, they are detached from the groundline by a patented, automated clip release which frees the gangion. Two men empty the traps onto a culling table, then the traps are pushed onward for rebaiting and repair. The catch is culled for larger males, preferably 4.5 inch carapace width or 1.0 pounds minimum weight per crab. Females and soft crabs are returned.

The common bait is fresh, frozen fish, preferably oily varieties which are firm and resist disintegration while in the water. Bait is held in position in small onion sacks suspended from the top of the trap. After rebaiting, the traps are repaired, if necessary, then stacked in special racks ready for resetting. Trap life ranges from 6 to 12 months.

The large crew is necessary to handle onboard processing. Experience has indicated processing is necessary to prevent product damage (black discoloration and leg loss) and rapid spoilage typical of red crabs. Processing requirements have evolved from initial attempts at live-holding in refrigerated seawater, to butchering, dipping (bisulfite), and refrigeration of parts. Currently the boats are being equipped for onboard butchering, cooking (steam retort), and frozen storage. These latter developments seem paramount to maintaining quality.

The processing room onboard the smaller vessel houses two men—one for sorting and handling the crabs and a second man for positioning the crabs in the automated processing equipment. The equipment is a butchering machine originally designed for tanner (snow) crabs (Key Electrosonic Equipment Co.). The machine has conveyor chains, cutting blades, water jets and brushes which reduce the whole crab to cut legs, claws, and body halves. The excess shell, gills and viscera are washed overboard. The legs and claws, and body sections drop down separate chutes to the hold. Each chute drops into a reinforced plastic mesh bag which holds approximately 100 pounds of product. Each full bag is soaked in chilled sodium bisulfite before final iced storage.

Processing

The only U.S. processing firm specifically handling red crabs is Bay Trading Company, Inc., Danvers, Massachusetts. Although their firm is involved in export and distribution of other seafoods, red crab is their only processing commitment.

The primary concern in processing is controlled cooking to prevent meat from sticking to the shell. Partially cooked body parts are passed through adjustable rollers which squeeze the meat from the flexible shell parts. The leg meat is the largest recovered section. The body or core meat is removed with the same rollers readjusted for cores. Any remaining meat in the shell is recovered in a minced form utilizing typical Baader debone meat extractors. The recovered meats are leg meat, body flake, and 'riced' (minced) meat. All recovered meats go through a final steam cook. The claws are scored with the typical cut for cocktail claws.

Product grades include various mixtures or single packs of the various meats (i.e., body, leg or claw meat, chunk or whole leg meat, salad meat, etc.). The preferred meat is leg meat which has more local distribution about Massachusetts. Packaging is simply 5 pound boxes, prefrozen before placing in masters.

Samples of the final red crab product were assessed during informal taste sessions. The product had been previously cooked and frozen onboard. Samples tasted included legs, claws and body meat. The texture was softer than stone crab (*Menippe mercenaria*) meat and somewhat similar to king crab (*Paralithodes camtschatica*) leg meat, although the pieces were smaller. The flavor was noticeably salty.

FISHING DEMONSTRATIONS

Three fishing trips were arranged to demonstrate the more effective methods for harvesting golden crab from the Gulf of Mexico. The purpose of each trip was to assess gear handling and preservation of the catch. Resource assessment was beyond the scope of this project.

Each trip was arranged in cooperation with Mr. Orlen Oakleaf, captain of the Marguerite 'B' fishing out of John's Pass Inlet, St. Petersburg, Florida. The 67 foot fishing vessel (Desco, fiberglass) was initially equipped to fish bottom or surface longlines for tilefish and grouper or swordfish and shark. The only onboard gear modification was the addition of a hydraulic powered pot puller (16 inch Hydro-slave unit) driven by the main engine power take-off. This system could be used to retrieve the entire crab gear within 1 to 1.5 hours depending on tide and current. The crab fishing gear (traps, lines, anchors, high flyers and buoys) was assembled and constructed with assistance from Mr. Oakleaf and his crew. The mode of operation was to fish crab gear to suit the project objectives and to fish longline gear as the work schedule permitted. This arrangement demonstrated possible complimentary fishing.

The basic crab gear used on all trips was designed similar to the longline crab 'trawls' used in the New England red crab fishery (Figure 4) (Sweat and Otwell, 1983). The groundline and buoylines were ¾ inch twisted polypropylene line; anchors were cement weights and window weights; and the highflyers were common arrangements of aluminum poles and deflectors floated with a 60-inch rubber ball buoy. Experience with unpredictable currents indicated additional surface buoys, two 60-inch or two 100-inch rubber balls were necessary to assure the gear remained on the surface. Optional weights were used to prevent any excessive buoyline from floating on the surface near boat traffic. A variety of trap designs were used during each trip (Figure 5). Each crab trap was fitted with gangions (⅜-inch twisted nylon line) and a common standard stainless steel longline clip (with swivels). Small clips would attach to loops of ⅜-inch twisted nylon line which had been pre-spliced into the ¾-inch groundline. Use of large clips for direct attachment to the ¾-inch groundline was discontinued because they would spring and break as the gear was retrieved. Distance between traps and between traps and the groundline anchors was usually 75 yards (68.5 m).

One set consisted of an arrangement of gear (lines, floats, traps, etc.) placed in one location. The number and types of traps, baits and soaktimes varied per set. After baiting, one set could be lowered into place within 20 to 30 minutes depending on the number of attached traps (Figure 6). After soaking, one set could be totally recovered within 1 to 1.5 hours depending on tides, currents and weather (Figure 7). Each trip report outlines specific methods and results. Figure 8 plots the set locations for each trip.

First Trip (July 6-13, 1982)

The objectives of the first trip were to check gear performance at various depths, use different baits, and note onboard handling problems. Two trap designs were used; collapsible and nested (Figure 9). These traps were designed to conserve deck space. Six nested traps or twenty collapsible traps could be racked or collapsed to occupy the same space as two open traps of similar dimensions.

Running time from port to the first fishing location was 18 hours. Eight sets were completed during this trip. All sets were located within latitudes 27°10′ and 26°50′, and longitudes 84°50′ and 85° (Figure 8). Fishing depths ranged from 210 to 340 fathoms. Surface water temperatures were between 85° and 87°F and, bottom temperatures were not recorded. Substrata varied from a sand-mud mix to soft mud. Mud was most common at northern stations. Weather was hot (>90°F), dry and calm. Two sets (310 and 340 fathoms) were nonproductive because they became fouled by excessive currents which rolled and tangled the gear.

Twenty traps were used per set, either alternating the trap designs or with exclusive use of one trap design. Approximately 3 to 5 pounds of bait tied in net bags was used per trap. Various baits included spanish sardines, pacific mackerel, tilefish or grouper heads. After baiting, one set could be lowered in place in approximately 30

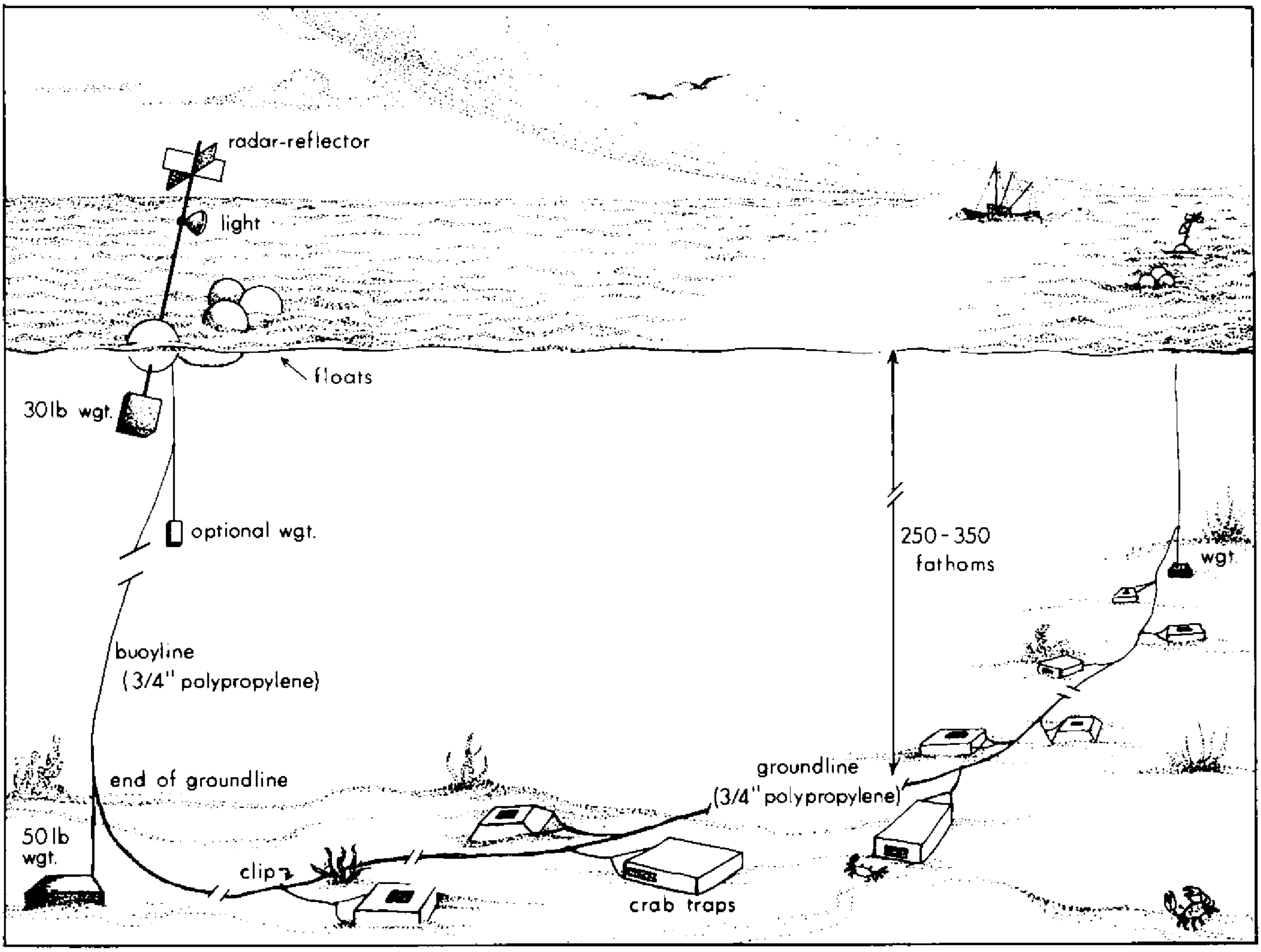

Figure 4. Illustration of bottom longline gear used to trap crabs.

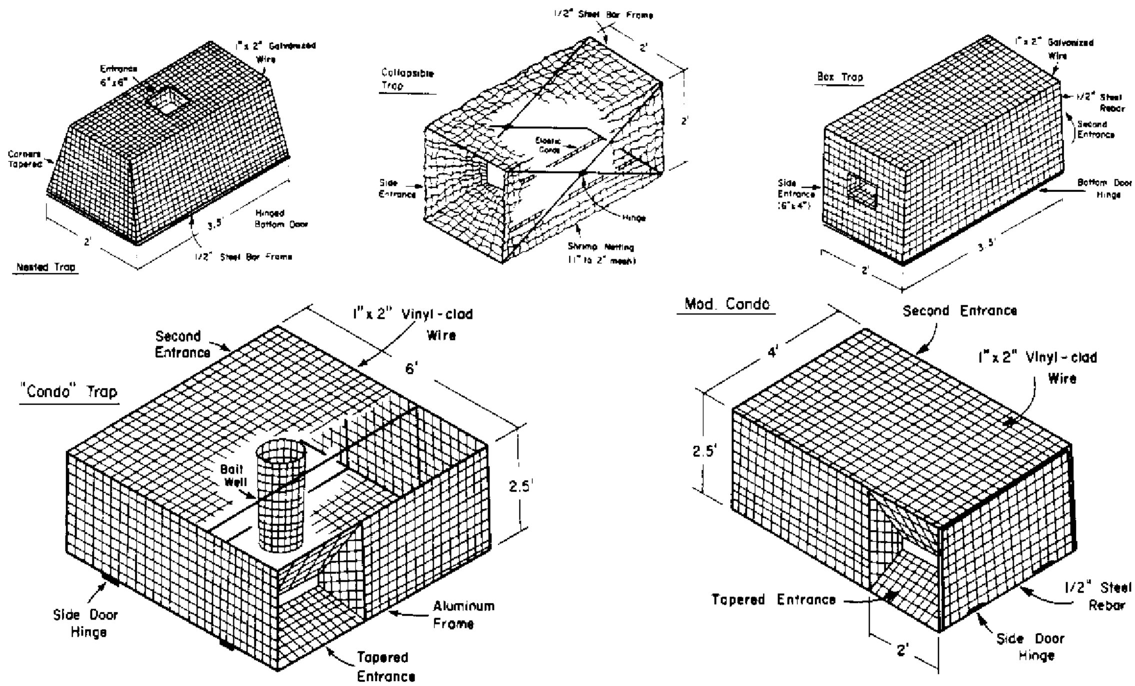

Figure 5. Various trap designs used during the study. Different designs were used during three consecutive trips.

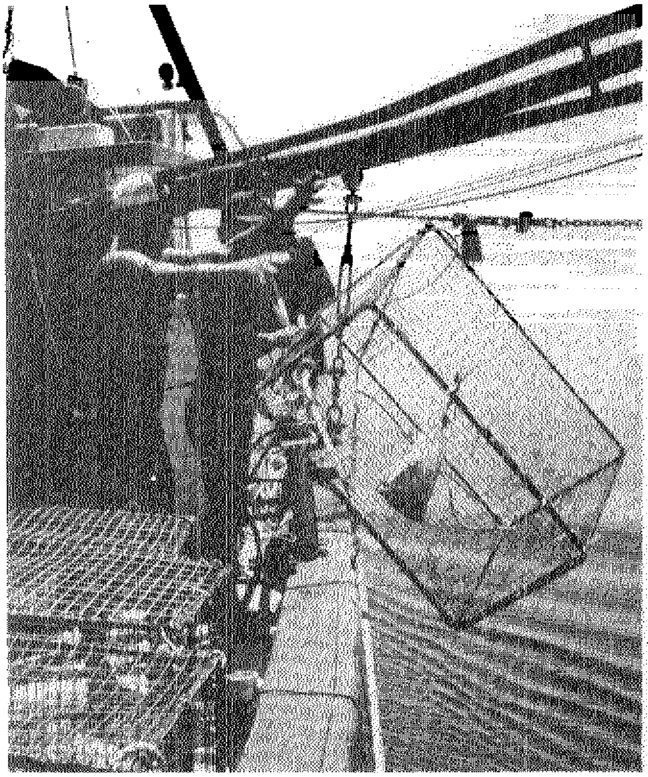

Figure 6. Setting the gear was simply a matter of attaching traps to the groundline with regular longline clips. The traps were placed in 75 foot intervals on prespliced sections of the groundline.

minutes. Soaktime (duration on bottom) ranged from 13 to 22 hours.

Total production for the first trip was 1,300 pounds of crabs, 750 pounds male and 550 pounds female (Figure 10). The nested traps were more productive than the collapsible traps (Table 2). For the entire trip, including all nonfouled sets, 80 nested traps soaking 13 to 22 hours yielded 1,065 pounds of crab, 640 pounds of males and 425 pounds of females. Although the nested trap was heavier, the flimsy collapsible trap was more difficult to handle and the loosely hung netting and insecure entrance may have deterred crabs. After the fourth set, use of the collapsible traps was discontinued. The collapsible trap was ideal for conserving deck space, but design improvements to secure netting and a reconsideration of mesh size are recommended before further use.

There was no apparent pattern in total production by depth (210 to 310 fathoms) or soaktime (13 to 22 hours). Crabs were attracted to all baits, but two simultaneous sets using only nested traps, soaked for the same time in the same location (275 to 280 fathoms), caught over two times more crabs attracted to pacific mackerel than to grouper heads. The other sets utilizing spanish sardines and tilefish were placed in variable depths for various soaktimes which would influence interpretation of the results. Generally, the fresh 'oily' baits were more successful. The longer lasting mackerel was preferable and sardines worked well.

As expected the harvest included both sexes and the larger male crabs were easily distinguished from the

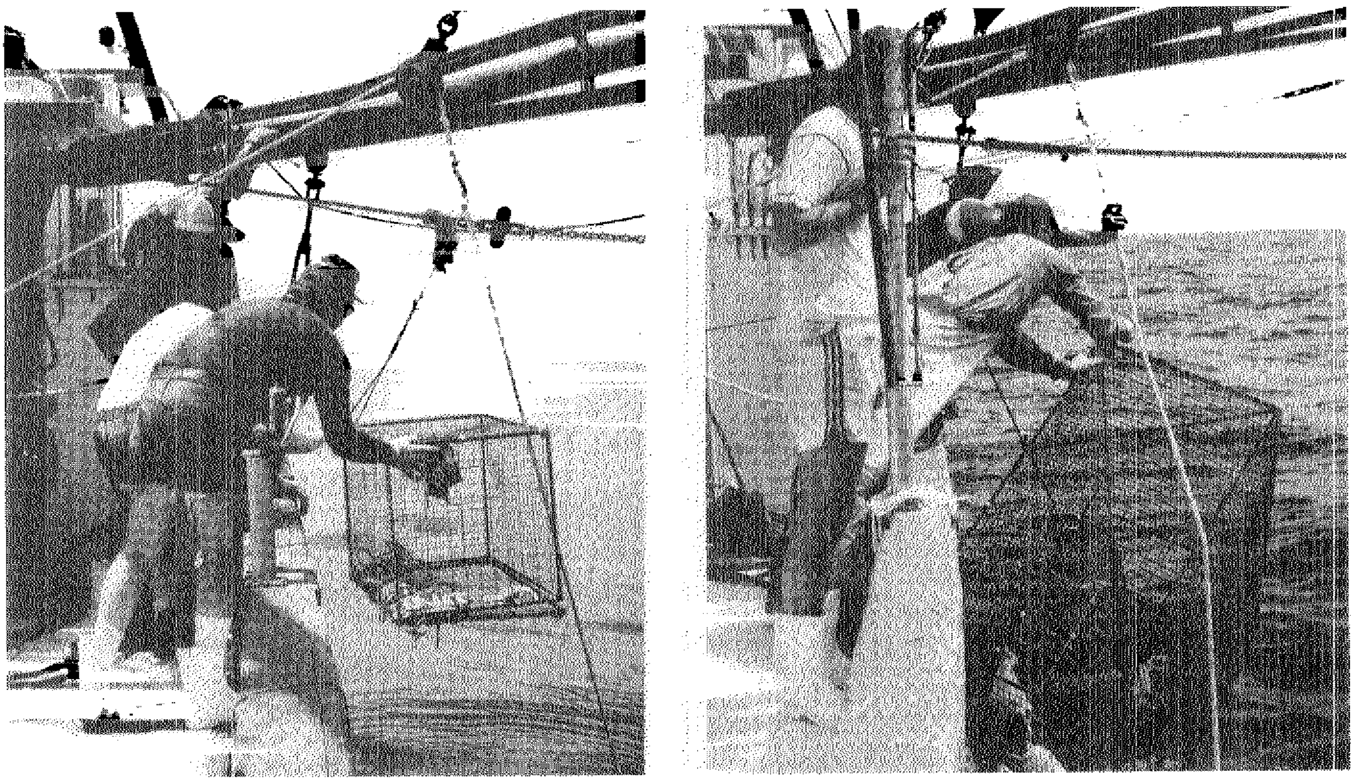

Figure 7. Recovering the gear utilized a block suspended on the starboard and a hydraulic powered pot puller (16 inch Hydro-slave unit). Gangions were short to minimize tangling with the groundlines.

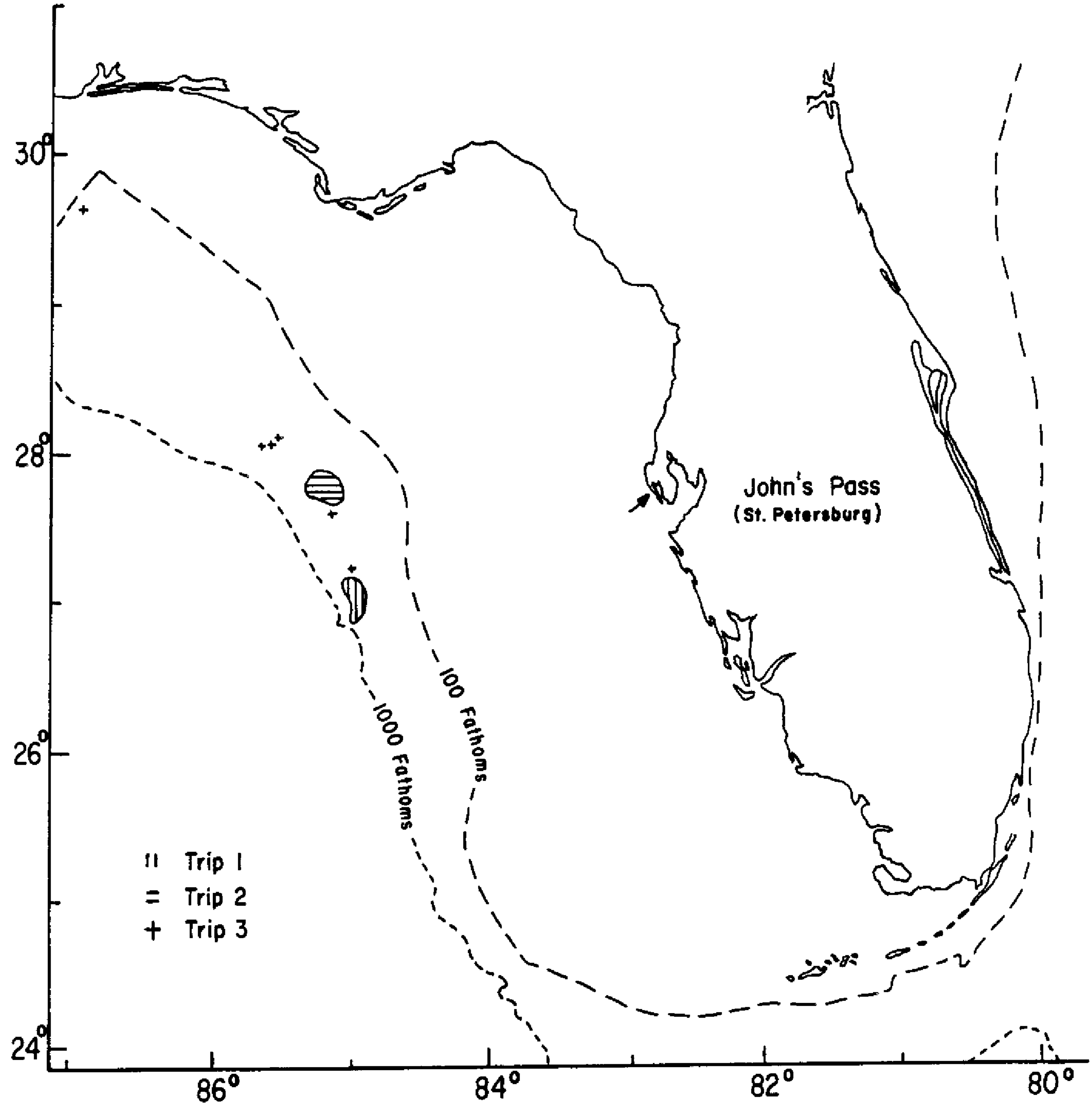

Figure 8. Location for crab gear sets during three consecutive trips to demonstrate harvest.

females. The average male was 6.2±0.4 inches wide (carapace width) and weighed 2.5±0.4 pounds. The average female was 4.9±0.3 inches wide and weighed 1.1±0.2 pounds. Size variations and ranges are listed in Table 3. These sizes are substantially larger than the average commercial size red crabs harvested in New England. The average commercial New England male red crab is 5.0 inches wide and weighs 1.5 pounds, and the female red crabs usually weigh less than 1.0 pound. Surprisingly the average size for female golden crabs harvested from the Gulf of Mexico was within the commercial size range for northern male red crabs.

Although the largest male golden crab was taken from a nested trap, there was no obvious difference in crab size for either sex relative to trap design, depth fished, soaktime or bait. Failure to harvest smaller crabs suggests distribution by size.

Sex ratio per trap design was similar, but more females were harvested at shallower depths (Table 4). More males were harvested in depths greater than 275 fathoms. This distribution is similar as reported for red crabs harvested in New England (Wigley et al, 1975).

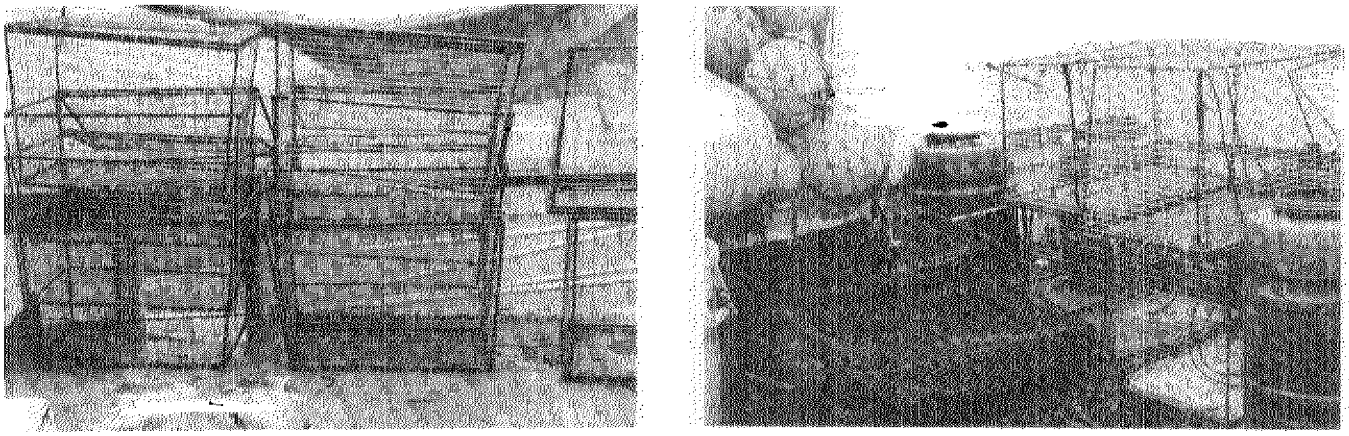

Figure 9. Nested traps (left) inverted in the storage position and collapsible traps (right) closed in the storage position. Note the required space for four nested traps when stacked next to the callapsed traps.

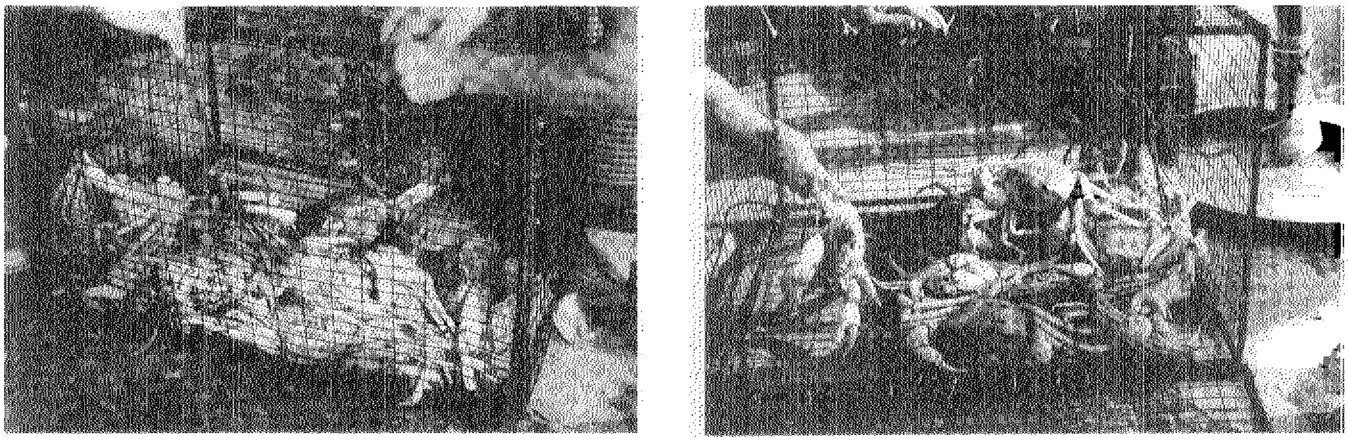

Figure 10. Opening the bottom door to remove golden crabs caught in one nested trap.

The incidental catch included approximately 1000 pounds of the large isopods, *Bathynomus giganteus,* commonly called the sea roach, and an occasional hake *Urophycis* sp. or small deep-sea shark, *Squalus.*

In addition to the crabbing activity, two night sets of surface longlining (approx. 10 miles of gear) produced a supplementary catch of swordfish and sharks. Thus two fishing activities could be conducted from the same vessel with the same crew.

Second Trip (September 1-8, 1982)

Objectives of the second trip were to use additional trap designs, variable soaktimes, and initiate more onboard handling and processing. The gear was similar to that used on the first trip except more traps were used per set and one buoyline was eliminated to minimize the risk of tangling due to currents. Spanish and pacific mackerel were the only baits. Isolated attempts to use catfood (16 oz. cans, moist variety) attracted crabs but the material rapidly dissolved and did not allow a sufficient soaktime.

Eleven sets were completed within latitudes 27°45′ and 28°, and longitudes 85°9′ and 85°16′ (Figure 8). This location was north of the first trip. Surface water temperatures were similar to the first trip, but climatic conditions shifted to rainy weather with 10 to 20-m.p.h. winds and 30-m.p.h. gusts. The gear could be successfully fished in these conditions.

Fishing depth ranged from 245 to 290 fathoms to concentrate effort in depths previously noted to contain a higher proportion of males. Soaktimes were originally selected to vary from one to four days, but an unexpected concentration of 'sea lice' (½-inch isopods, unidentified) preyed on the bait, thus restricting soaktime from 17 to 42 hours. In one particular set, sixty pounds of bait in the largest trap was devoured by isopods within 24 hours. Without bait the traps failed to attract crabs.

Traps included the original nested design, a new boxed design and one large square trap affectionately called the 'condo' (Figures 5 and 11). The box design provided similar volume as in the nested trap but the box trap was easier to build. The box trap did not conserve deck space. Entrances on box traps were slightly smaller than on the nested traps. Some of the box traps had two end entrances, and others had one top entrance as on the nested trap.

For the entire trip including eleven sets, 253 traps caught over 1,950 pounds of crabs. Catch rates for

Table 2. Catch rates for nested and collapsible traps used during the first trip (7/6-13/82).

Set	Soak (hrs)	Depth (fms)	Trap (No.)	Crab/ trap	Male/ trap
1	13	260	Nested (10)	15.9	3.4
			Collap. (10)	3.7	1.0
2	14	310	Nested (10)	5.1	4.5
			Collap. (10)	2.1	1.9
3	12	245	Nested (10)	5.2	1.5
			Collap. (10)	1.8	0.2
4	14	210	Nested (10)	10.4	0.3
			Collap. (10)	7.1	0.2
5	21	340	Nested (20)	Fouled*	
6	22	310	Nested (20)	Fouled*	
7	19	280	Nested (20)	9.2	5.3
8	17	275	Nested (20)	4.5	2.6
Average			Nested	8.4	
			Collap.	3.6	

*Nonproductive set due to strong currents which tangled and fouled the gear.

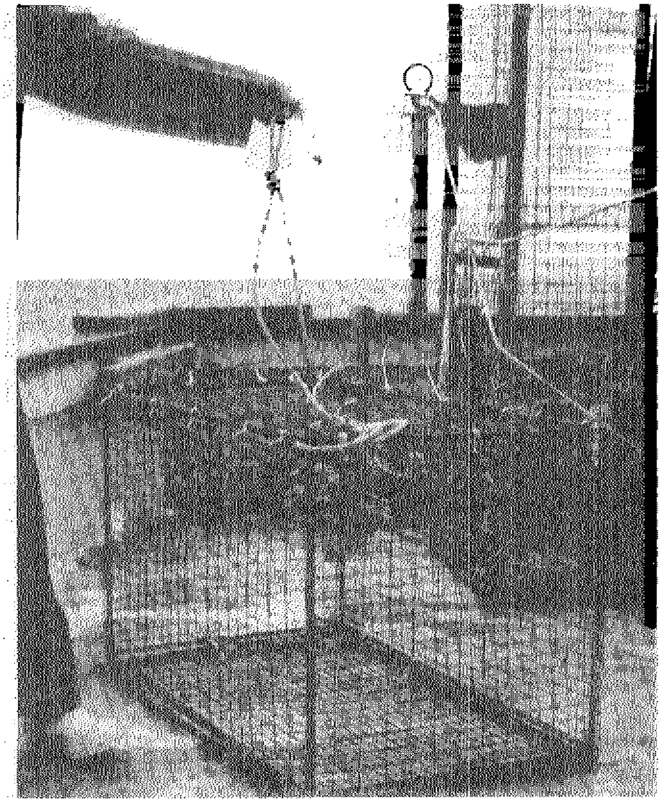

Figure 11. Boxed trap design with attached gangion and longline clip.

Table 3. Size crabs harvested with nested and collapsible traps during the first trip (7/6-13/82).

Trap	Sex	Carapace Width cm (inch) Range	Mean	Std. Dev.	Whole Weight kg (lbs) Range	Mean	Std. Dev.
Nested	Male	14.0-17.8 (5.5-7.0)	15.8 (6.2)	(0.4)	0.73-1.68 (1.6-3.7)	1.15 (2.5)	(0.4)
	Female	9.9-14.5 (3.9-5.7)	12.4 (4.9)	(0.3)	0.32-0.73 (0.7-1.6)	0.48 (1.1)	(0.2)
Collapsible	Male	14.0-16.8 (5.5-6.6)	15.5 (6.1)	(0.3)	0.82-1.41 (1.8-3.1)	1.07 (2.4)	(0.3)
	Female	10.9-14.5 (4.3-5.7)	12.3 (4.9)	(0.3)	0.36-0.82 (0.8-1.8)	0.48 (1.1)	(0.2)

Table 4. Golden crabs harvested by depth, only using data from nested traps from the first trip (7/6-13/82).

Set	Depth (fms)	Total Crabs Caught	Percent Males
4	210	104	3
3	245	52	29
1	260	159	21
8	275	90	58
7	280	183	58
2	310	51	88

nested and boxed traps were only recorded separately for the first six sets. Overall the nested traps were more productive and caught more males than the boxed traps (Table 5). This difference in catch rate may be explained by the slightly larger entrance on nested traps. There was no difference in catch rate for box traps with end or top entrances. The condo was set only twice but harvested 143 crabs. Compared to the smaller traps fished on the same set, the condo caught as many crabs as 8 nested or 22 box traps depending on location and soaktime. Likewise, the condo caught a higher percentage of males. The better performance of the condo was attributed to the larger and tapered entrance. Again the incidental catch was primarily the larger isopods, *Bathynomus giganteus*, present at all stations and accounting for approximately 1500 total pounds.

There was a direct relationship between soaktime and total crabs caught in the smaller traps (Table 6). Soaktimes greater than 24 hours were more productive. Soaktimes longer than 42 hours were not possible due to isopod predation on bait. Soaktimes for the condo trap were limited to only two sets, 20 and 42 hours. The

Table 5. Catch rates for crab traps used during the second trip (8/1-8/82).

Set	Soak (hrs)	Depth (fms)	Trap (No.)	Crab/ trap	Male/ trap
1	40	250	Nested (12)	8.2	2.1
			Boxed (12)	9.1	1.8
2	24	260	Nested (6)	8.8	2.3
			Boxed (18)	3.6	0.9
3	27	275	Nested (5)	7.8	2.8
			Boxed (17)	6.7	1.9
4	42	280	Nested (5)	7.4	2.4
			Boxed (16)	8.0	2.2
			Condo (1)	58.0	39.0
5	23	270	Nested (5)	5.0	2.4
			Boxed (17)	3.6	0.8
6	26	290	Nested (12)	7.2	2.2
			Boxed (12)	5.1	0.9
7*	24	290	Nested (12)	4.4	1.2
			Boxed (12)		
8*	19	260	Nested (6)	4.8	0.3
			Boxed (18)		
9*	20	245	Nested (10)	3.8	0.6
			Boxed (9)		
			Condo (1)	85.0	40.0
10*	17	280	Nested (12)	1.7	0.3
			Boxed (12)		
11*	18	280	Nested (12)	3.9	1.3
			Boxed (10)		

*For sets no. 7-11 data was recorded pooled for nested and boxed traps.

Table 6. Catch rate by soaktime for golden crabs caught during second trip (8/1-8/82).

Set	Soak (hrs)	Depth (fms)	Trap (No.)	Crab/ trap	Male/ trap
10*	17	280	Nested (12)	1.7	0.3
			Boxed (12)		
11*	18	280	Nested (12)	3.9	1.3
			Boxed (12)		
8*	19	260	Nested (6)	4.8	0.3
			Boxed (18)		
9*	20	245	Nested (10)	3.8	0.6
			Boxed (9)		
			Condo (1)	85.0	40.0
5	23	270	Nested (5)	5.0	2.4
			Boxed (17)	3.0	0.8
7*	24	290	Nested (12)	4.4	1.2
			Boxed (12)		
2	24	260	Nested (6)	8.8	2.3
			Boxed (18)	3.6	0.9
6	26	290	Nested (12)	7.2	2.2
			Boxed (12)	5.1	0.9
3	20	275	Nested (5)	7.8	2.8
			Boxed (17)	6.7	1.9
1	40	250	Nested (12)	8.2	2.1
			Boxed (12)	9.1	1.8
4	42	280	Nested (5)	7.4	2.4
			Boxed (16)	8.0	2.2
			Condo (1)	58.0	39.0

*For sets no. 7-11 catch data was recorded pooled for nested and boxed traps.

longer set caught less crabs, but it can not be determined if the lower catch was due to location or possible escapement through the larger entrance.

There was no pattern in total crabs, crab size or sex ratio caught per set across all depths (245 to 290 fathoms). Overall the average male crab weighed 2.3 pounds and measured 6.2 inches (carapace width). The average female weighed 1.0 pounds and measured 4.9 inches. Variations and ranges in size are listed in Table 7. There was no obvious difference in crab size per trap design. The average crab size was smaller from the second trip, but these golden crabs were substantially larger than the commercial New England red crabs. The average female golden crabs were still large enough to suit the New England commercial grade for the male red crabs.

The sex ratio in the harvest from depths of 245 to 290 fathoms was different from that found during the first trip. The smaller traps consistently caught a higher proportion of females from all depths (Table 8), but the larger condo trap caught more males. Again the larger, tapered entrance may account for the performance of the condo trap. This is clear evidence that the sex ratio in the harvest can be influenced by trap design and may not reflect the actual ratio at particular depths. Soaktime did not appear to influence the sex ratio in the harvest.

Third Trip (April 27-May 4, 1983)

Objectives of the third and final trip were to demonstrate harvest with additional trap designs and to set gear at similar depths in more northern latitudes. Traps used included the original nested and boxed designs, a modified condo style, and wooden and plastic designs (Figures 5 and 12). The wooden traps were identical to the most common wooden traps currently used in the New England red crab fishery. In fact, the newly constructed wooden traps were purchased from the

Table 7. Size golden crabs ' arvested with nested, boxed and condo traps during second trip (8/1-8/82).

Trap	Sex	Carapace Width cm (inch) Range	Mean	Std. Dev.	Whole Weight kg (lbs) Range	Mean	Std. Dev.
*Nested and Boxed	Male	14.2-18.5 (5.6-7.3)	15.7 (6.2)	(0.3)	0.59-1.58 (1.3-3.5)	1.09 (2.4)	(0.4)
	Female	11.2-14.7 (4.4-5.8)	12.4 (4.9)	(0.3)	0.27-0.68 (0.6-1.5)	0.45 (1.0)	(0.2)
**Condo	Male	14.2-18.0 (5.6-7.1)	16.0 (6.3)	(0.3)	0.77-1.41 (1.7-3.1)	1.09 (2.4)	(0.3)
	Female	10.7-14.5 (4.2-5.7)	12.7 (5.0)	(0.3)	0.36-0.68 (0.8-1.5)	0.50 (1.1)	(0.2)

*Size data reported for nested and boxed traps only includes crabs caught during sets no. 1-6.
**Size data reported for condo traps only includes crabs caught during sets no. 4 and 9.

Table 8. Data reflecting sex ratio for golden crabs harvested with nested, boxed and condo traps during the second trip (8/1-8/8/82).

Trap Design	Number of Traps Set	Total Crabs Caught	Percent Males
Nested	45	339	31
*Boxed	92	532	27
**Condo	2	143	55

*Data listed for nested and boxed traps from stations 1-6.
**Data listed for condo traps from stations 4 and 9.

major red crab producer in Massachusetts (High Seas Corporation). The plastic trap was a small oval shaped cage design made from high density, black polyethylene. The plastic traps were provided by Fathoms Plus, San Diego, California. The condo style trap retained the basic design of the intial condo with two wide tapered entrances, but the dimensions were rearranged to facilitate construction from basic 30-inch and 36-inch wide wire stock. The nested and boxed traps were made with galvanized wire and the condo used vinyl-clad wire.

New bait wells (Bellairs jugs) were used to minimize bait consumption by the small isopods encountered during previous trips (Figure 13). The new bait wells were simply plastic gallon jugs prepunctured with numerous ⅛-inch holes. The punctures protected the bait while allowing release of the attractants. The metal

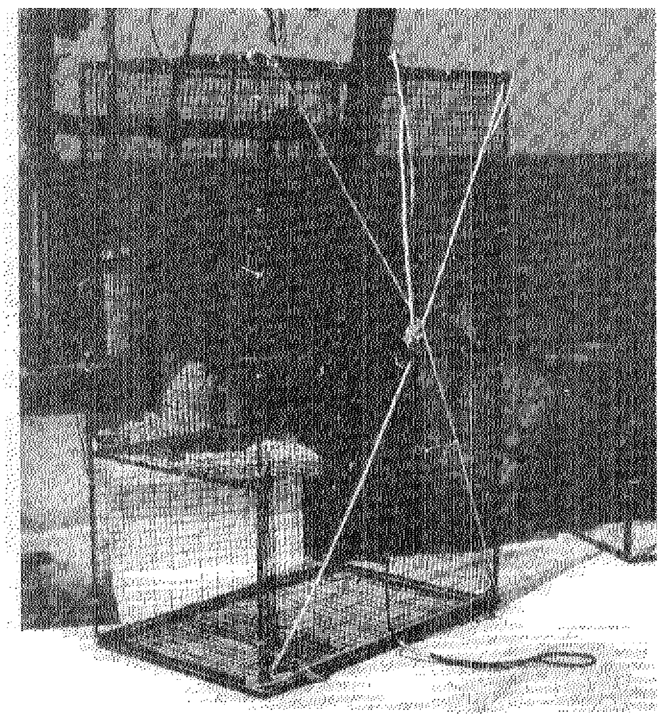

Figure 12. Modified condo traps (left) and small plastic trap used during the third trip.

Figure 13. Bellairs jug used to hold bait in crab traps. The small holes prevented isopods from devouring the bait.

jug lids were fitted with hooks to suspend the bait from the upper, central portion of the traps. The smaller traps were baited with one full jug of bait (mullet and pacific mackerel) and the larger modified condo held two full jugs.

The first four sets were all about one location, latitude 29°28′ and longitude 86°54′, on the northeast edge of DeSoto Canyon (Figure 8). This site was selected anticipating crab abundance about the canyon. All four sets were in 280 to 285 fathoms for 11 to 12 hours soaktime. Each set had between 12 to 8 traps with random placement of the various trap designs. Unexpectedly and unfortunately, no *Geryon* crabs were caught in any trap during any of the first four sets. The large isopod, *Bathynomus giganteus* and a hake, *Urophycis* sp. were the only animals caught. The bottom type was a thick, sticky mud which hampered retrieval of the gear and two modified condos and two wooden traps were lost.

Realizing 3.5 days of vessel time had accrued without harvesting one crab, the original trip plan was altered in favor of harvesting enough crabs necessary for handling and processing studies. Thus the remaining sets were located where previous trips had caught crabs. The six final sets were placed in more southern locations between latitudes 28°03′ and 27°10′ and longitudes 85°32′ and 84°57′ in depths ranging from 255 to 325 fathoms (Figure 8). Between 13 to 15 traps per set were randomly located on the groundline with at least 75 yards (68.5 m) between individual traps and the anchors. These six sets accounted for 85 traps of variable design soaking for 12 to 17 hours. The short soaktime was scheduled to assure crab production within the few remaining days of the trip.

The final six sets produced 600 pounds of male and 160 pounds of female golden crabs. The catch rates per trap design indicated the larger modified condo and the

Table 9. Catch rates for crab traps used during the third trip (4/27-5/4/83).

Set	Soak (hrs)	Depth (fms)	Trap (No.)	Crab/ trap	Male/ trap
1* thru 4	11-12	280	Nested (11)	0	0
			Boxed (13)	0	0
			M. Condo (6)	0	0
			Wooden (5)	0	0
			Plastic (1)	0	0
5	13	260	Nested (5)	1.6	1.2
			Boxed (6)	0	0
			M. Condo (2)	4.0	2.5
			Wooden (2)	8.5	6.0
6	14	325	Nested (4)	2.0	1.8
			Boxed (6)	2.2	1.5
			M. Condo (2)	5.5	2.0
			Wooden (10)	4.0	1.0
			Plastic (1)	3.0	3.0
7	15	325	Nested (4)	7.0	2.8
			Boxed (5)	3.4	1.0
			M. Condo (2)	9.5	3.5
			Wooden (1)	17.0	5.0
			Plastic (1)	2.0	1.0
8	14	255	Nested (5)	2.2	2.0
			Boxed (6)	2.2	1.3
			M. Condo (2)	13.5	12.0
			Wooden (2)	8.5	3.0
9	18	265	Nested (4)	3.5	3.0
			Boxed (6)	2.0	1.3
			M. Condo (2)	19.0	9.5
			Wooden (2)	7.5	5.0
10	18	300	Nested (4)	4.5	4.5
			Boxed (6)	1.3	1.1
			M. Condo (2)	12.5	12.0
			Wooden (1)	7.0	6.0
			Plastic (1)	6.0	5.0

*The initial sets, 1 thru 4 were all about latitude 29°28′ and longitude 86°54′. No crabs were caught and two wooden and two modified condo traps were lost during retrieval.

**The number of listed traps per set only accounts for traps successfully retrieved. More traps were lost on successive sets. The M. Condo denotes the modified condo trap.

Table 10. Size of crabs harvested per set during the third trip (4/27-5/4/83).

Set	Sex	Carapace Width cm (inch) Range	Mean	Std. Dev.	No. Crabs
5	Male	13.5-18.0 (5.3-7.1)	15.5 (6.1)	(0.4)	23
	Female	10.2-13.2 (4.5-5.2)	12.4 (4.9)	(0.2)	11
6	Male	14.5-17.8 (5.7-7.0)	16.0 (6.3)	(0.3)	24
	Female	11.2-13.7 (4.4-5.4)	12.7 (5.0)	(0.3)	15
7	Male	14.0-18.0 (5.5-7.1)	16.3 (6.4)	(0.3)	29
	Female	19.4-12.9 (3.7-5.1)	11.9 (4.7)	(0.3)	54
8	Male	14.7-18.3 (5.8-7.2)	15.7 (6.2)	(0.3)	50
	Female	10.9-12.9 (4.3-5.1)	11.9 (4.7)	(0.2)	20
9	Male	14.2-17.8 (5.6-7.0)	16.2 (6.4)	(0.3)	30
	Female	10.9-15.0 (4.3-5.9)	12.7 (5.0)	(0.3)	49
10	Male	14.4-19.3 (5.5-7.6)	16.0 (6.3)	(0.4)	55
	Female	13.2-14.0 (5.2-5.5)	13.5 (5.3)	(0.2)	4

Table 11. Size of male golden crabs harvested per trap design with six sets during the third trip (4/27-5/4/83).

Trap	Male Carapace Width cm (inch) Range	Mean	Std. Dev.	No. Crabs
Nested	13.5-17.8 (5.3-7.0)	16.0 (6.3)	0.4	63
Boxed	14.0-19.3 (5.5-7.6)	16.0 (6.3)	0.4	38
Condo	14.0-18.3 (5.5-7.2)	16.0 (6.3)	0.4	84
Wooden	14.7-17.3 (5.8-6.8)	16.0 (6.3)	0.4	40
Plastic	14.5-17.0 (5.7-6.7)	15.7 (6.2)	0.3	0

Table 12. Overall harvest of crabs per depth during the third trip (4/27-5/4/83).

Depth (fms)	Latitude (Approx.)	Soaktime (hrs)	Mean Carapace Width, cm (inch) Male	Female	Ratio No. Crabs Male/Female
255	27°37′	12:55	15.8 (6.2)	11.9 (4.7)	2.5
260	28°05′	12:38	15.5 (6.1)	12.4 (4.9)	2.1
265	27°11′	16:25	16.3 (6.4)	12.7 (5.0)	1.6
300	27°10′	17:08	16.0 (6.3)	13.2 (5.2)	13.8
320	27°37′	15:22	16.3 (6.4)	11.9 (4.7)	0.5
325	28°03′	13:10	16.0 (6.3)	12.7 (5.0)	1.6

wooden traps were the most productive for total crabs and male crabs (Table 9). For all six stations the modified condo was the most productive trap. Again, the nested traps were more productive than the boxed traps which supported the thought that a tapered or inclined surface was more productive than the right angled entrance on boxed traps. This thought was further enforced when the unproductive boxed traps from set 5 were altered with larger, tapered entrances which proved to be more productive in subsequent sets.

The one black, plastic trap was more productive than anticipated. The small entrances and small chamber (smallest interior trap space for any trap design used) was productive even for large male crabs. Work with this trap was limited, but indicates a need for further investigations to assess use of the design and/or the

Table 13. Influence of soaktime on the total crabs and percent male golden crabs caught during the third trip (4/27-5/4/83).

Set	Soak (hrs)	Depth (fms)	Total No. Crabs	Percent Males
10	17:08	300	64	93.7
9	16:25	265	79	62.0
7	15:22	320	83	34.9
6	13:19	325	39	61.5
8	12:55	255	69	71.0
5	12:38	260	34	67.6

Table 14. Percent catch of male golden crabs per trap design across all six sets during the third trip (4/27-5/4/83).

Traps	No. Traps	Total No. Crabs	Percent Males	Males/ trap
Nested	26	87	74	2.5
Boxed	35	63	70	1.1
Condo	12	125	66	6.9
Wooden	9	77	52	4.4
Plastic	3	14	86	4.0

color and type of trap materials. Also, the productive modified condo traps were constructed with plastic, vinyl-clad wire.

Although individual crab body weights were not recorded during the third trip, the average crabs sizes (carapace width) were similar to the previous trips. There was no discernible pattern in size of crab caught per set or trap design (Tables 10 and 11). Overall the male crabs averaged approximately 2.4 pounds and the females 1.1 pounds per crab. The only soft, recently shed crab taken during the entire study was a female with a 'leathery' shell texture caught at set nine.

Likewise, there was no pattern in crab size for either sex harvested per depth (225 to 325 fathoms), latitude or soaktime (13 to 18 hours) (Table 12). A size distribution by depth is expected as reported by Wigley et al., (1975) for New England red crabs, but the limited sampling within depths from 255 to 325 fathoms could not demonstrate any pattern in size distribution for the golden crab.

Soaktimes only ranged from 12.5 to 17 hours. With the exception of set 8, the longer soaktimes produced more crabs (Table 13). A higher percentage of male crabs, the preferred catch, were caught at all depths from 255 to 325 fathoms except in set 7 (Table 13). Across all depths and soaktimes the trap design appeared to influence the percentage of males caught (Table 14). The larger, modified condo trap was the most productive design based on the catch of males per trap, producing almost twice as many males as the nearest competitive trap, the wooden design. The wooden trap was more productive than the nested, boxed or plastic traps, but it produced a larger portion of the smaller female crabs.

Again the mullet and mackeral baits proved effective and the jug bait wells prevented predation on the baits by the small isopods. Occurrence of isopods was spotty, but appeared more prevalent in the northern latitudes about DeSoto canyon. Five to eight pounds of bait were sufficient for 12 to 17 hours soaktime.

Intermittent sets of bottom longline gear produced modest catches of tilefish (*Caulolatilus microps* and *Lopholatilus chamaeleonticeps*) and yellowfin grouper, (*Mycteroperca venenosa*). The stations for the longline sets differed from those used for crab gear.

Conclusions

Data from the three fishing trips demonstrate that large golden crabs present in the Gulf of Mexico can be harvested with existing commercial gear. Selection of trap design, depths and soaktime will influence the catch. Interpretations from the harvest data are somewhat speculative realizing the limited gear used and broad geographic range fished. Also, non-uniform distribution and spotted congregation of the crabs could influence the results. Contradictions in existing literature are a particular consequence of these factors. Thus the results relative to crab distribution and gear performance should be viewed as initial guidelines rather than final conclusions.

1. The deep-sea golden crab can be harvested from the Gulf of Mexico at depths ranging from 210 to 350 fathoms within latitudes 29°03′ and 26°50′, and longitudes 84°50′ and 85°32′. Golden crab distribution is expected to extend beyond this range. Production decreased in the more northern latitudes and no golden crabs were caught in 280 to 285 fathoms on the eastern edge of DeSoto canyon.
2. Golden crabs are attracted to all fish baits (mullet, mackerels, grouper heads, sardines, bonito, shark, etc.), but a firm bait with a high oil content is recommended for easier handling, durability and effectiveness during soak. Fresh bait is essential to catching crabs. Five to ten pounds of bait is sufficient for a 24 hour soaktime for small traps. Bait wells (i.e., Bellairs jugs) with restrictive holes (less than ¼ inch diameter) are recommended to prevent small isopods from consuming bait. This precaution is necessary regardless of the soaktime.
3. Soaktime should exceed 24 hours. Longer soaktimes catch more crabs, depending on durability of bait. Longer soaktimes allow other fishing

activity. Bait is the limiting factor for soaktime. In the event of a long soaktime (greater than 48 hours) extra bait and a one-way entrance apparatus is necessary to retain all trapped crabs.

4 The basic bottom longlining gear, using ¾-inch polypropylene line, worked effectively; but a few modifications are recommended. Attaching the trap to and removing the traps from the groundline is a tedious operation which can be dangerous. Attachment to the groundline with longline clips can be convenient, but the line should be metered out at a proper pace to allow attachment of the baited traps at pre-spaced intervals. Large longline clips should not be used for direct attachment to the groundline. The gangions should be short to prevent excessive tangling and winding when retrieved. Trap size and arrangement of the pulling system for retrieving the gear should be designed to minimize strenuous labor in removing, lifting and emptying the traps. The difficulty in these tasks is magnified by the excessive strain on the gear during haul-back.

5. The best trap design should incorporate tapered entrances with elongated openings (3 to 4 inches x 12 to 24 inches). Two side entrances can be effective if positioned some distance from a central bait well. Two entrances would allow at least one opening in case one entrance becomes blocked as the trap settles. If a top entrance is used the sides of the trap should be sloped. The trap design should not have ninety degree angles at side joints or at an entrance. Built from standard construction materials, an overall dimension of 2.5 x 4 x 6 feet is recommended to allow maximum interior capacity. Wire mesh construction (1 x 2 inches) which is lighter and less expensive to build than wood traps was found to be adequate. Vinyl-clad wire or plastic traps warrant further investigations. Steel rebar (½ inch) was sufficient for trap support and bottom weight. Stackable or collapsible traps should be used to conserve deck space. Netting either on collapsible or any other type of traps, should be taut.

6. Harvest location should be selected to catch a higher percentage of male crabs since the larger males are the preferred catch. The males appear to be more abundant in depths greater than 300 fathoms. Cleaner crabs (less external shell damage and discoloration) were caught in the more southern latitudes. This may be a result of environmental influence and/or possible molting activity.

7. Complimentary fishing activity with bottom and surface longlining was possible, but would require separate storage facilities and careful planning to minimize running time between locations.

HANDLING AND PROCESSING

Requirements for handling and processing the golden crabs were demonstrated using the harvest from each trip. The primary objectives were to land a quality product, determine yields and composition, and investigate the consequences of cooking and storage. A major portion of this work constituted a graduate thesis project which should be referenced for detailed methodology (Bellairs and Otwell, 1983; and Bellairs, 1984).

In general, *Geryon* crabs are highly perishable, as are most marine invertebrates. Their body chemistry, which is necessary for functions at great depth along with the cold temperatures of their habitat, may contribute to rapid autolytic and bacterial decomposition. The primary onboard handling problems are body damage, mortality, and potential melanosis. Processing practices used in traditional crab fisheries can be used, but the final product forms may require special marketing considerations.

Onboard Handling

The onboard handling operations were influenced by the catch rate, as well as the placement and total traps used per set. Using the gear previously noted, a set of 20 traps, placed at 75 yards (68.5 meters) per trap was effectively handled by three deck hands. The crabs were unloaded and packed in the hold within 30 minutes after catch. Only live crabs were butchered and the finished product was immediately returned to some form of refrigeration. Live crabs were butchered between sets or after a series of sets.

When the golden crabs were removed from the traps they were lethargic and easy to handle. They were handled by the body rather than by the legs or claws. Although the appendages of the golden crab are significantly more durable than reported for the red crab (Meade and Gray, 1973; Holmsen and McAllister, 1974; and Whipple, 1984), any loss of appendages would decrease product yield and quality. Sorting by sex and size into typical plastic baskets or boxes was easy. This packaging aided in removing the product from the hold.

The only incidental catch of any significant amount was the large 'sea roaches', or isopods, *Bathynomus giganteus* which are easily sorted and handled. These isopods survived over two weeks packed directly in ice.

Survival

Although the golden crab is sturdier than the red crab, poor survival rates were encountered. For comparison, high mortalities are common for the New England red crab fishery despite attempts to use ice, moist burlap bags, or refrigerated sea water systems (Holmsen, 1968 and Meade and Gray, 1973). Holmsen and McAllister (1974) recommended using a refrigerated seawater system or live hold maintained at 40°F or lower with at least a 100 percent change in hold water three times per day. They indicated the Nova Scotia Department of Fisheries recommended that 25 pounds of crabs per cubic foot could be stored in an aerated tank refrigerated to 36°F. Despite this advice the current red crab fishery adopted onboard processing to avert survival problems and increase product storage capacity.

To demonstrate survival problems, a simple one time storage study was conducted in the boat hold (50°F—ice as the refrigerant). Three separate samples, each containing 25 male and 25 female crabs, less than one hour out of water were either:

A) directly held on top of ice (Figure 14);

B) separately packed into burlap bags moistened with seawater and iced;

C) or separately packed in open baskets (Figure 14). Procedures B and C were replicated. The results indicate live onboard storage was poor (Table 15) (Bellairs and Otwell, 1983). Male crabs stored directly on ice and in open baskets exhibited mortality rates ranging from 64 to 100 percent after three days. Moist burlap bag storage produced a male crab mortality rate of 28 percent after two days. Female crabs appeared to be more durable than their male counterparts. Although this research was limited, the resulting mortalities indicate that these simple storage methods are impractical for commercial application.

Butchering, Yields, and Composition

Hand butchering was accomplished by first splitting the crab in half, physically removing the carapace halves and scrubbing under running water to remove the gills and viscera (Figure 15). The finished product was body halves with legs and claws attached. For male golden crabs, the yield from whole, live weight is illustrated in Figure 16.

Halves include half of the body core with legs and claws attached. Sections (clusters) are halves with the claws removed. The larger male crabs yielded higher proportions than the females and the male claws accounted for nearly one-fifth of the entire body weight. Cooking of the whole crab resulted in a 12.3 percent weight loss. Total edible meat yield for steamed male crabs was 23 percent of the original whole live crab weight (Figure 17). In terms of the initial weight of the whole cooked crab, the edible meat yield after steaming was 27 percent. In commercial practice, cooked golden crab meat yield may vary from 16 to 20 percent depending on method of removal, cooking, and crab size. These yields are nearly twice that for blue crabs, (*Callinectes sapidus*) and compare favorably with other crab species (Table 16).

Likewise, the basic chemical composition from the raw and cooked golden crab is similar to other traditional crabs (Tables 17 and 18). Composition of the white, flaky meat is typical of a high protein, lof fat type of seafood. On a dry weight basis, steaming did not alter the original total content of protein or fat, but decreased the moisture and elevated the percent of edible protein.

Table 15. Percent mortality of golden crabs harvested from the Gulf of Mexico and stored under refrigeration in three separate conditions.

		Percent Mortality					
Hours	Reps	Open Basket		Burlap Bag		Iced	
		M	F	M	F	M	F
	(1)	72	40				
24	(2)	100	48				
	(1)			56	52		
48	(2)			28	12		
	(1)					64	11
72							
96							
102	(1)					91	56

M – males; F – females

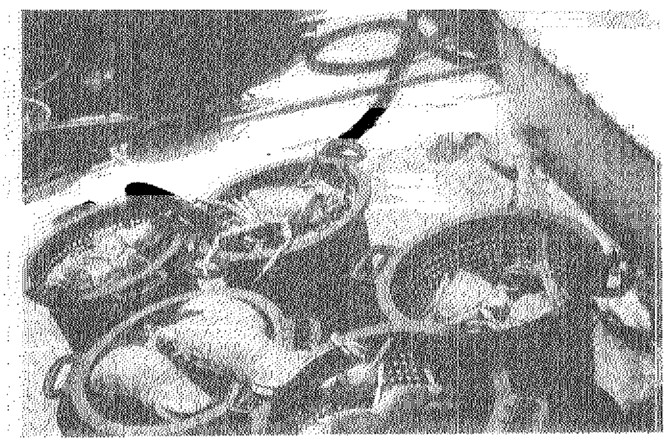

Figure 14. Storage of whole, live crabs on ice (left) assured the crabs were upright and not buried, otherwise iced storage would kill the crabs. Storage in open baskets (right) was convenient and easy to handle, but only six to ten crabs would fit in one basket and handling caused leg loss. Note the basket of large isopods, Bathynomus giganteus (on left of right picture).

 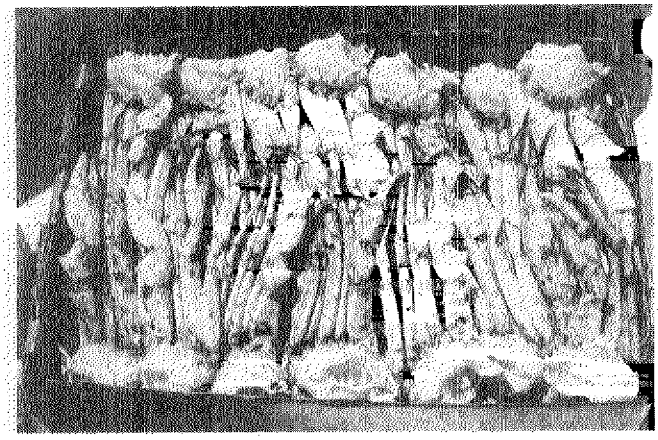

Figure 15. Hand butchering of the whole live golden grabs (left). A simple lobster splitter was used to divide the crabs into halves with claw attached. The halves were washed, viscera and gills removed, then packed in boxes (right).

MALE CRABS (10)

Live Body Weight – Mean 1169g (2.58±0.30 lbs.)
Range 959-1331g (2.11-2.93 lbs.)

Whole Crab (100%) → Halves (59.7±1.7%) → Legs and Cores (Sections) (40.3±1.8%); Claws (19.1±1.2%)

FEMALE CRABS (10)

Live Body Weight – Mean 461g (1.01±0.12 lbs.)
Range 378-522g (0.83-1.15)

Whole Crab (100%) → Halves (47.2±1.6%) → Legs and Cores (Sections) (33.2±1.0%); Claws (13.4±1.0%)

Figure 16. Butchered yields for whole, live male and female golden crabs caught in the Gulf of Mexico.

Melanosis (Black Discoloration)

Black discoloration of the soft tissue and meat in the crab is a problem which must be controlled before the potential of this new fishery can be realized. The crab tissue began turning black after the crabs died or were butchered (Figure 18). The discoloration was noted after two days iced storage. In whole crabs the discoloration begins on the gills and progresses to the muscle tissue. This discoloration tainted the shell color. On butchered sections and claws, discoloration begins on soft, exposed surfaces and joints. Freezing delayed the reaction but did not alter it in the thawed product.

The black discoloration is probably due to a polyphenol oxidase enzyme system similar to the enzyme oxidizing reactions which cause blackening on bananas and black spot on shrimp (Marshall et al, 1984). The reaction is enhanced in the presence of oxygen, thus explaining the initial discoloration of gills and exposed surfaces. The probable substrates are phenolic compounds from the hemocyanin (crab blood). The product is the formation of melanins (black pigments).

For comparison, work has shown that multiple forms of the polyphenol oxidase enzyme do exist in red crabs (Constantinides and Chang, 1976). Black discoloration occurs on raw red crabs within 48 to 72 hours on ice

MALE CRABS (4)

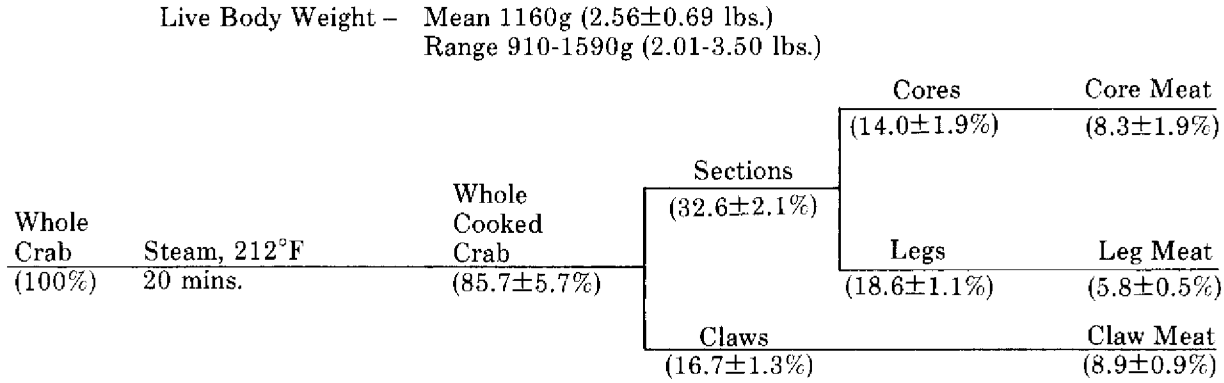

Figure 17. Cooked body parts and meat yields expressed as a percentage of the whole, live crab weight for male golden crabs caught in the Gulf of Mexico.

Table 16. Edible meat yield for common commercial crabs. Percent yields are based on the original live weight of the respective crabs.

Crab	Picked Meat (%)	Type of Meat (%)	Source
Blue Crab *(Callinectes sapidus)*	11-14	Lump & Flake (9-11) Claw (2-3)	[1]
Dungeness *(Cancer magister)*	20-25	Box (10-12) Claw & Leg (10-13)	Allen (1971) & Babbitt (1984)
King Crab *(Paralithodes camtschatica)*	18-26	Body-shoulder (6-9) Merus (6-9) Propodus-carpus (3-4) Claws (2-3)	Krzeczkowki et al. (1971)
Red Crab *(Geryon quinquedens)*	18-22		Mead & Gray (1973)
Snow Crab *(Chionoecetes)*	30.7	Body-shoulder (11.7) Merus (13.0) Claws (6.0)	Krzeczkowski & Stone (1974)

[1]Yield data for blue crabs is based on numerous informal conversations with commercial firms.

(Meade and Gray, 1973). They reported the melanosis could be inhibited for 19 days by dipping butchered parts into a 1.0 percent sodium bisulfite solution for 10 seconds. The bisulfite is a reducing agent used to control the oxidase enzyme reaction. Use of citric acid dips or a 10-minute blanch at 180°F was ineffective. Commercial practice has found that more thorough heat treatments or cooking can alter the enzymes causing melanosis. Currently red crab vessels are equipped for onboard butchering and dipping (sodium bisulfite) or cooking to prevent melanosis.

Initial dip studies using solutions of sodium bisulfite indicated concentrations greater than 1.0 percent would be needed to prevent melanosis in the golden crab (Table 19). These studies used fresh, raw body halves butchered from live crabs, then dipped for 20 seconds in 0.25, 0.50 or 1.0 percent sodium bisulfite. The control and dipped halves were stored (35°F) in plastic bags to eliminate the influence of direct icing. The effect of these dips was monitored on a subjective scale indicating the percent of crab halves which would be commercially unacceptable due to the development of black discoloration. These dips provided minimal protection and appeared least effective for the preferred male crabs. Without dips the control halves were discolored unacceptably in less than 48 hours.

Subsequent dip studies used the same methods but higher bisulfite concentrations and longer soaktimes (Table 20 and 21). Longer soaktimes in 1.0 percent sodium bisulfite appeared to increase acceptable refrigerated shelf-life from 5 to 8 days of storage. The higher dip concentrations (2.0 and 4.0 percent) provided additional prevention of melanosis, but strong, objectionable odors developed after 6 to 8 days refrigeration.

Table 17. Average basic chemical composition* (percentage) from six raw and six cooked male golden crabs harvested from the Gulf of Mexico. The cooked meat was produced from crab halves steamed (212°F) for 20 minutes.

	Leg	Core	Claw	Weighed Avg.
Raw Crab Meat				
Protein (N x 6.25)	15.5	17.1	13.7	15.4
Crude Lipid	1.3	1.6	1.0	1.3
Moisture	84.2	83.6	84.2	84.1
Cooked Crab Meat				
Protein (N x 6.25)	18.3	19.2	19.2	18.9
Crude Lipid	1.4	2.8	1.5	1.9
Moisture	81.5	80.9	81.2	81.2

*A.O.A.C. (1980) "Official Methods of Analysis," 13th Edition. Association of Official Analytical Chemist, Washington, D.C. Procedures for analysis done in triplicate per sample.

Table 18. Proximate composition reported for raw body meat from common commercial crabs.

Crab	Protein	Moisture	Fat	Ash	Source
	------------------	%	------------------	------------------	(Reference)
Blue Crab	16.4	78.8	0.8	2.1	(1)
(Callinectes sapidus)	15.9	80.3	1.3	1.9	(5)
	17.9	79.0	0.4	2.1	(5)
Dungeness *(Cancer magister)*	17.3	80.0	1.3	1.5	(5)
Jonah Crab	----	78.0	1.1	---	(3)
(Cancer borealis)	16.2	78.2	1.9	---	(4)
	17.3	80.0	1.3	1.5	(5)
King Crab	15.2	81.9	0.8	1.5	(5)
(Paralithodes camtschatica)	17.5	77.7	2.6	1.5	(6)
Queen Crab *(Chionoectes opilio)*	15.6	81.5	1.0	1.9	(5)
Red Crab	----	81.6	0.9	---	(3)
(Geryon quinquedens)	15.1	80.9	0.9	---	(4)
	15.0	80.8	1.0	1.6	(5)
Snow Crab	18.4	79.7	1.3	1.2	(5)
(Chionoectes bairdi)	18.8	80.0	1.6	0.4	(2)

Sources: (1) Anthony et al. (1983)
(2) Krzeckowske and Stone (1974)
(3) Krzynowek et al. (1982)
(4) Lauer et al. (1974)
(5) Sidwell (1981)
(6) Simpson and Howe (1977)

The 8.0 percent dip was effective, but irritated the workers eyes and skin. In continuous use, especially in poorly ventilated areas, bisulfite concentrations greater than 2.0 percent could be uncomfortable and harmful to workers.

Final dip studies packed the dipped halves directly in ice (Table 22). The influence on melanosis was less effective, but the melting ice delayed the onset of odor problems until the 10th to 12th day of refrigeration. Apparently the melting ice provided odor protection by rinsing odorous bacteria and autolytic by-products from the surface. The earlier onset of black discoloration was unexpected. Melting ice is thought to provide protection from 'black spot' in shrimp by rinsing away the melanin precursors (Nickelson and Cox, 1977), but for the golden crab the melt water may have diluted the surface protection provided by the bisulfite residue. Thus safe concentrations (less than 2.0 percent) of

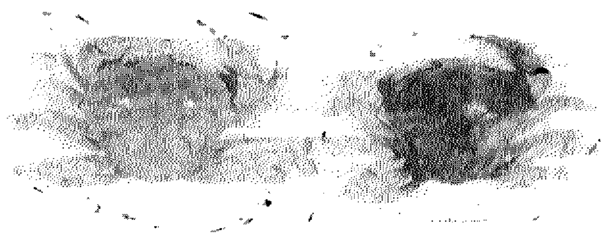

Figure 18. Melanosis in dead whole golden crabs (left) or in crab halves refrigerated less than 48 hours (right).

sodium bisulfite dip can only provide short term control of melanosis for butchered golden crabs. If refrigerated and/or iced storage is necessary for more than 6 days, cooking may be required to prevent melanosis. If a processor decides to dip the raw product, there should be no delay between butchering and dipping. A delay which would initiate the onset of melanosis would compromise any benefits derived from a sodium bisulfite dip.

Microbiology

A rinsing technique to enumerate total bacteria on whole and butchered golden crabs suggests the fresh product is highly susceptible to bacterial spoilage (Table 23). Although the total counts from the deep-sea crabs were initially low, the microbial rinse technique indicated that after 7 days of storage (40°F) surface counts on the butchered and dipped product approached levels commonly associated with spoilage. As previously noted (see Melanosis) spoilage odors became evident on the 6th through the 8th day of storage. Although a longer shelf-life would be expected at lower storage temperatures (less than 35°F), the rapid growth of bacteria on golden crab is typical for many seafoods harvested from cold, deep-sea habitats. Further bacterial work confirmed the rapid bacterial growth despite the use of more concentrated sodium bisulfite dips and direct packaging in ice (Table 24). Thus if vessel operations include primary onboard processing, a fishing schedule should be planned in reference to the limited shelf-life of raw, butchered halves.

Cooking

The golden crab can be cooked with steam or boiling water. Cooking with pressurized steam was selected to demonstrate the time-temperature combinations necessary to eliminate melanosis. All pressure cooking was done in a pilot plant vertical retort. Only body halves were used in the cooking studies. Whole crabs would require extra time and produce more waste materials.

The results indicate cooking halves at 212°F for 15 minutes or at 230°F for 10 minutes are the minimum cooking periods sufficient to eliminate melanosis during subsequent storage (Table 25). These cooking periods correspond to an internal temperature of 190° to 200°F as measured by internal probes placed in halves while cooking in the retort. Cooking at 250°F was too severe and produced 'burnt' aromas and flavors. For all cook temperatures and times the buff colored shell did not turn pinkish or red.

All cooked halves were cooled in refrigeration (40°F). As expected, higher temperatures and longer cook times decreased product yield (Table 26) due to dehydration (Table 27). The recommended cooking method, 230°F for 10 to 12 minutes retained 82 percent weight of the original butchered halves which yielded 38.8 percent edible meat with 20.4 percent protein. The yields and cook times should vary depending on the condition (body weight) and size of the crabs.

Boiling is a more common method for cooking crabs, but current Florida regulations prohibit boiling blue crabs (DNR Department Rules, Section 16B-28). These regulations may apply to golden crabs as well. For comparison, boiling blue crabs tends to soften the meat and produces a wetter product which is more prone to bacterial spoilage. King crab and snow crab processors believe boiling produces a better product which is firmer and easier to remove from the shell. International standards recommend boiling king crabs for 20 minutes. Meade and Gray (1973) recommended boiling red crabs for 25 to 30 minutes (whole crabs) or 4 to 10 minutes (sections). A 6-minute boil was the initial method for cooking red crabs in New England. Currently, red crabs are processed by a dual cook procedure to facilitate removal of the meat with automated, roller extraction. The precook of the sections is a mild 'blanch' to firm the meat for extraction. The shucked meat is finally steamed to complete the cooking process (Simpson and Howe, 1977). Further cooking studies with the golden crab may indicate more favorable conditions relative to yield or production rate, but the methods recommended from this study yielded a high proportion of delicate meat which did not stick to the shell and had an appealing flavor.

Table 19. Percent of golden crab halves that developed melanosis to the degree such that the raw product would be commercially unacceptable. Each percentage per storage time and dip treatment represents the results for ten halves packed in plastic bags stored in refrigeration (35°F).

Days Storage	No Dip		Sodium Bisulfite Dip (20 sec.)			
			.25%	.50%	1.0%	
	F	M	M	M	F	M
0	0	0	0	0	0	0
1.1	0	0	0	0	0	0
2.1	50	80	10	0	0	0
3.0	70	90	10	0	0	0
4.2	70	90	10	0	0	0
5.2	100	100	50	10	10	60
6.1	100	100	60	20	30	60
7.1	100	100	100	20	50	80

M – males; F – females

Table 20. Percent of male golden crab halves which developed melanosis to the degree that the raw product would be commercially unacceptable. Each percentage per storage time and dip treatment represents the results for ten halves packed in plastic bags stored in refrigeration (40°F).

Days Storage	No. Dip	Sodium Bisulfite Dip, %/(soaktime, sec.)								
		1.0%			2.0%			4.0%		
		(60)	(120)	(240)	(60)	(120)	(240)	(60)	(120)	(240)
0	0	0	0	0	0	0	0	0	0	0
2	100	0	0	0	0	0	0	0	0	0
4	100	0	0	0	0	0	0	0	0	0
6	100	0	0	0	0	0	0	0	0	0
8	100	10	10	10	0	0	0	0	0	0
10	100	70	70	50	0	20	0	0	0	0
12	100	100	100	100				0	0	0

Table 21. Percent of male golden crab halves which developed melanosis to the degree that the raw product would be commercially unacceptable. Each percentage per storage time and dip treatment represents the results for ten halves packed in plastic bags stored in refrigeration (40°F).

Days Storage	No. Dip	Sodium Bisulfite Dip, %/(soaktime, sec.)								
		2.0%			4.0%			8.0%		
		(60)	(120)	(240)	(60)	(120)	(240)	(60)	(120)	(240)
0	0	0	0	0	0	0	0	0	0	0
2	20	0	0	0	0	0	0	0	0	0
4	60	0	0	0	0	0	0	0	0	0
6	100	0	0	0	0	0	0	0	0	0
8	100	20	0	0	0	0	0	0	0	0
10	100	50	70	90	0	40	30	0	0	0

Taste Test

A sensory comparison of golden, king, red and snow crabmeats was conducted to determine how average consumers would perceive the golden crabmeat. Duplicate samples were presented individually to an untrained panel of 20 members over a two-month period. The panelists were asked to rate each sample using a 9-point hedonic scale where 1 equalled "dislike extremely" and 9 equalled "like extremely." Appearance, aroma, tex-

Table 22. Percent of male golden crab halves which developed melanosis to the degree that the raw product would be commercially unacceptable. Each percentage per storage time and dip treatment represents the results for ten halves packed in **ice** stored in refrigeration (40°F).

Days Storage	No. Dip	Sodium Bisulfite Dip, %/(soaktime, sec.) 2.0% (60)	2.0% (120)	2.0% (240)	4.0% (60)	4.0% (120)	4.0% (240)	8.0% (60)	8.0% (120)	8.0% (240)
0	0	0	0	0	0	0	0	0	0	0
2	30	0	0	0	0	0	0	0	0	0
4	100	0	0	0	0	0	0	0	0	0
6	100	0	10	0	0	0	0	0	0	0
8	100	50	60	50	40	0	0	0	0	0
10	100	80	90	70	90	50	20	20	10	0
12	100	80	90	90	90	80	40	40	40	30

Table 23. Total aerobic plate counts (microbial organisms/ml) determined for golden crabs and butchered halves using a rinse technique.* The butchered halves were stored on ice in a cooler (40°F).

Golden Crab		APC, 25°C
Whole, live male crabs		2.4×10^2
Butchered, halves from males		7.3×10^3
Dipped (2% sodium bisulfite-120 sec.)		6.1×10^2
Dipped crab halves stored (40°F) in ice;	1 day	9.2×10^3
	2 days	5.0×10^3
	7 days	4.3×10^7
	14 days	2.0×10^8

*Rinse technique—equal weights of sterile diluent added to crabs or halves in sterile bags, then massaged one minute prior to sampling, dilution and plating on nutrient agar.

Table 24. Total aerobic plate counts* (microbial organisms/ml) for golden crab butchered halves dipped in sodium bisulfite solutions and stored (40°F) in plastic bags (dry) or directly in ice (wet).

Bisulfite Dip (60 sec.)	Packing	Initial	APC, 25°C Storage Days 6	12
No Dip		3.2×10^4		
	dry		7.3×10^7	3.2×10^8
	wet		1.7×10^7	2.7×10^7
2% solution		3.9×10^4		
	dry		1.2×10^8	3.2×10^8
	wet		1.0×10^7	4.2×10^7
4% solution		2.5×10^4		
	dry		1.5×10^8	9.1×10^7
	wet		2.0×10^7	4.0×10^7

*Rinse technique—equal weights of sterile diluent added to crabs or halves in sterile bags, then massaged one minute prior to sampling, dilution and plating on nutrient agar.

ture, flavor and general likeability were the parameters rated. The mean responses are presented in Table 28. Golden crabmeat was rated slightly lower than king crab, but higher than both snow and red crab meats.

To determine how frozen storage of golden crab halves affected sensory attributes, picked meat from

Table 25. Number of male golden crab halves which developed melanosis after retort steaming. Six cooked halves per storage and cook time were stored in plastic bags at 40°F.

Days Storage	Cook Temperature and Time (mins.) 212°F (5)	212°F (10)	212°F (15)	230°F (5)	230°F (10)	230°F (15)	250°F (5)	250°F (10)	250°F (15)
0	0	0	0	0	0	0	0	0	0
2	1	0	0	1	0	0	0	0	0
4	3	0	0	1	0	0	0	0	0
6	5	2	0	3	0	0	0	0	0
8	6	2	0	3	0	0	0	0	0
10	6	2	0	4	0	0	0	0	0
12	6	2	0	5	0	0	0	0	0
14	6	3	0	5	0	0	0	0	0
16	6	4	0	5	0	0	1	0	0

Table 26. Average yields per six male golden crab halves cooked in a steam retort. Cooked halves were cooled (40°F) overnight prior to hand picking to remove the meat.

	Cooktime (min.)	Cook Temperature 212°F	230°F	250°F
		------Mean yields, % (std. dev.)------		
Halves	5	87.4 (1.3)	84.0 (2.2)	79.4 (3.0)
	10	84.4 (1.8)	82.0 (2.3)	73.3 (3.4)
	15	79.6 (3.2)	74.5 (2.6)	74.5 (2.8)
Meat	5	40.8 (4.3)	41.3 (3.8)	38.4 (3.3)
	10	41.4 (2.9)	38.8 (2.3)	33.8 (2.1)
	15	37.4 (2.2)	34.2 (2.2)	36.2 (2.0)

Table 27. Crude protein and moisture composition of golden crabmeat hand picked from six male halves cooked in a steam retort.

Cooktime (min.)		Cook Temperature 212°F	230°F	250°F
		------Mean yields, % (std. dev.)------		
5	Protein	18.5 (0.2)	21.0 (0.3)	19.7 (0.5)
	Moisture	79.1 (0.5)	78.4 (0.8)	76.5 (2.3)
10	Protein	19.0 (0.2)	20.4 (1.2)	20.8 (0.5)
	Moisture	78.4 (0.3)	77.2 (0.2)	77.0 (0.1)
15	Protein	20.6 (0.1)	22.2 (0.6)	22.3 (0.2)
	Moisture	78.1 (0.4)	77.2 (0.1)	76.1 (0.5)

halves stored six months at −30°F was presented to a sensory panel side by side with picked meat from halves cooked the same day. The results showed that no differences could be detected between the two samples (Table 29).

Table 28. Mean panelist responses for duplicate evaluations of king, golden, snow and red crabmeats served individually. Mean ratings include 20 panelists scores relative to a nine point hedonic scale on which 9.0 indicated "like extremely" and 1.0 indicated "disliked extremely."

	Appearance	Aroma	Texture	Flavor	General Likeability
King	8.0	6.9	7.8	8.0	8.0
Golden	6.8	6.9	7.2	7.0	6.8
Snow	5.6	6.0	5.6	6.2	5.6
Red	4.6	3.7	4.2	4.2	3.7

Table 29. Mean panelist responses for frozen (6 month at −30°F) and fresh golden crabmeat presented side by side. Mean ratings include 20 panelist scores relative to a nine point hedonic scale on which 9.0 indicated "like extremely" and 1.0 indicated "dislike extremely."

	Fresh	Frozen
Appearance	7.3	7.0
Aroma	6.5	6.4
Texture	7.0	7.0
Flavor	7.4	7.2
Gen. Likeability	7.4	7.4

Conclusions

The golden crab is a highly perishable seafood and since harvest extends far from shore, special onboard handling requirements must be considered before entering this fishery. Also processing schedules and methods must be prepared to prevent a pronounced melanosis problem. With proper handling and processing, the crab provides a relatively high yield of tasty meat with a favorable basic composition.

1. The amount of gear used and method of deployment should be planned in reference to necessary onboard handling considerations. The plan should permit unloading, culling, packing and storage of crabs within 30 minutes after a trap comes aboard.
2. Survival after harvest is expected to be poor, especially during warmer seasons. Sophisticated methods such as refrigerated seawater systems, open sprays, etc. must be used in order to maintain

live crabs. These techniques have been abandoned, however, due to continued losses in the established red crab fishery which occurs in cooler climates of New England. Preference is for onboard processing to avert crab mortalities and to land a better quality product. If the product is to be landed fresh, then controls must be used to prolong shelf-life and prevent melanosis. If the product is landed cooked and refrigerated, then fishing time must consider the shelf-life on ice. If landed cooked and frozen, then further processing and marketing must consider acceptable market forms, and/or thawing for further processing.

3. Microbial assessments with rinse techniques and the development of off-odors suggest the maximum iced shelf-life of raw crab halves butchered and dipped (sodium bisulfite) is 6 to 8 days at 40°F. Lower storage temperatures would extend the shelf-life. Direct icing extended shelf-life to 10 to 12 days.
4. Butchering methods and yields are provided. Raw crab halves represented approximately 60 percent of the whole, live body weight. These figures may vary with location fished and size of crab landed, but based on reference to the similar crab in New England, a 16 to 20 percent cooked meat yield could be expected from whole, live golden crabs.
5. The golden crab has a high protein, low fat content typical for most nutritionally favorable seafoods.
6. Melanosis (black discoloration) will rapidly occur in dead, butchered or thawed golden crabs. This problem seems to be more pronounced than noted for other commercial crustaceans. Use of sodium bisulfite dips can only provide partial control of this problem. The recommended dip is 2.0 percent for one minute. This dip can provide up to six days of control on ice. (Note use of sodium bisulfite on *Geryon* crabs has no prior sanction from the U.S. Food and Drug Administration. This situation may require closer regulatory scrutinization.)
7. Cooking prevents melanosis. For crab halves the recommended cooking times and temperatures using pressurized steam are 230°F for 10 minutes or 212°F for 15 minutes. These schedules represent an internal temperature within crab halves of 190° to 200°F.
8. The golden crab must be cooked before freezing to provide better meat texture.
9. In taste tests the golden crab compares favorably with most traditional crab meats.

MARKETING ATTRIBUTES

The golden crab is suitable for any traditional market for whole crab, crab parts, or crab meat, but certain physical and sensory attributes unique to this crab must be considered before initiating new market ventures. Although this crab will not be an exact substitute for king crab nor an economic alternative to blue crab, it does offer distinct attributes which should appeal to most crab buyers and consumers. Marketing efforts must recognize the favorable attributes and establish a new, distinct crab identity.

Marketing of whole crab could be the least favorable ploy. Survival problems and subsequent melanosis after death complicates wholesale handling. Use of bisulfite dips only offers temporary controls and would promote use of dead crabs which is inconsistent with prevailing regulations for more traditional crabs. Cooking can prevent melanosis, but this assumes consumers are willing to tackle large inedible body portions and wastes.

Unfortunately, the golden crab shell does not turn red nor pinkish color when cooked. Crab consumers may notice and object to the buff colored cooked crab. Likewise, shell damage and wounds evident as black spots and scars resulting from subsequent bacteria growth are aesthetically displeasing. This form of discoloration is evident on live crabs and differs from melanosis previously described. Although similar shell damage is common among most crabs, this discoloration is more obvious on the light colored shell of the golden crabs. Usually reddening of cooked crab shell helps mask any surface discoloration, but this discoloration remains obvious on cooked golden crabs. Thus culling for the 'cleaner' crabs with less shell damage and fewer barnacles is recommended prior to selling whole golden crabs.

Selling cooked body halves, sections and claws would eliminate most of the waste handling problems for buyers, averts some of the surface discolorations, and requires minimal processing for a finished product. No doubt the large, delicious claws could demand a separate, higher market value per pound of edible meat. The remaining sections would have to be trimmed for easier handling. The core and merus section (upper leg) contain enough meat worthy of a hand picking effort. Consumers would need some advice on picking. Although the basic process is similar as for most crabs, the merus leg is more pliable and could present difficulty. Proper trimming to provide a wide opening on the end of the merus will facilitate removal.

Cooked golden crab meat is delicate, white and has a distinct appealing crab flavor and texture. The meat could be marketed in a variety of forms relative to body portions and size of pieces, i.e., leg, body or claw meat, chunks or mince, various mixtures, etc. The golden crab does not have true lump meat common in swimming crabs, but larger pieces and sections can be recovered from the body and legs. The white color is appealing and versatile in recipes. The delicate, moist texture has appealing mouthfeel, but may tend to fragment with further cooking and agitation. This character must be considered in selecting recipes to include minimal heating, additional binders, (i.e. cheeses, stuffings, etc.) and less fluids.

Regardless of the market form, the common nomenclature chosen to describe the crab should be attractive and distinct from existing, traditional crabs. As previously noted, there is no current scientific name for this crab. Likewise, it has no common and usual name. By Federal law, Title 21, Code of Federal Regulations Chapter 1, Part 102, a food must be labeled by its common and usual name. Thus this crab offers the unique opportunity for deriving a new name. Golden crab has been chosen for simplicity in this text. It does not mimic any existing commercial species. It offers appeal and product description, and denotes value. To market this crab as a mimic; i.e., Gulf king crab, could be illegal and cause consumer confusion. To describe it as a substitute; i.e., golden lump meat vs. blue crab lump, could cause more confusion and competes with an item which is subject to large value fluctuations per season. Most importantly the crab should be marketed on its own merits.

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