Literature Cited

ALLEE, B. J.
1974. Spatial requirements and behavioral interactions of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Ph.D. Thesis, Univ. Washington, Seattle, 160 p.

ALLEN, K. R.
1969. Limitations on production in salmonid populations in streams. *In* T. G. Northcote (editor), Symposium on salmon and trout in streams, p. 3-18. H. R. MacMillan Lectures in Fisheries, Univ. B.C., Vancouver.

DOBLE, B. D., AND D. M. EGGERS.
1978. Diel feeding chronology, rate of gastric evacuation, daily ration, and prey selectivity in Lake Washington juvenile sockeye salmon (*Oncorhynchus nerka*). Trans. Am. Fish. Soc. 107:36-45.

ELLIOTT, J. M., AND L. PERSSON.
1978. The estimation of daily rates of food consumption for fish. J. Anim. Ecol. 47:977-991.

HARTMAN, G. F.
1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 22:1035-1081.

HINCKLEY, T. M., AND H. D. KENNEDY.
1972. Fluctuations of aquatic and terrestrial invertebrates in drift samples from Convict Creek, California. Northwest Sci. 46:270-276.

HORN, H. S.
1966. Measurement of "overlap" in comparative ecological studies. Am. Nat. 100:419-424.

HYNES, H. B. N.
1970. The ecology of running waters. Univ. Toronto Press, Toronto, 555 p.

JOHNSON, J. H.
1980. Production and growth of subyearling coho salmon, *Oncorhynchus kisutch*, chinook salmon, *Oncorhynchus tshawytscha*, and steelhead, *Salmo gairdneri*, in Orwell Brook, tributary of Salmon River, New York. Fish. Bull., U.S. 78:549-554.

JOHNSON, J. H., AND N. H. RINGLER.
1980. Diets of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*) relative to prey availability. Can. J. Zool. 58:553-558.

KALLENBERG, H.
1958. Observations in a stream tank of territoriality and competition in juvenile salmon and trout (*Salmo salar* L. and *S. trutta* L.). Inst. Freshwater Res. Drottningholm Rep. 39:55-98.

MASON, J. C.
1966. Behavioral ecology of juvenile coho silver salmon (*O. kisutch*) in stream aquaria with particular reference to competition and aggressive behavior. Ph.D. Thesis, Oregon State Univ., Corvallis, 195 p.

MILNE, D. J.
1948. The growth, morphology and relationship of the species of Pacific salmon and the steelhead trout. Ph.D. Thesis, McGill Univ., Montreal, 101 p.

MORISITA, M.
1959. Measuring of interspecific association and similarity between communities. Mem. Fac. Sci. Kyushu Univ., Ser. E (Biol.), 3:65-80.

NILSSON, N. A.
1967. Interactive segregation between fish species. *In* S. D. Gerking (editor), The biological basis of freshwater fish production, p. 295-313. Blackwell Sci. Publ., Oxf.

PARKER, R. R.
1963. Effects of Formalin on length and weight of fishes. J. Fish. Res. Board Can. 20:1441-1455.

SAUNDERS, J. W., AND M. W. SMITH.
1962. Physical alteration of stream habitat to improve brook trout production. Trans. Am. Fish. Soc. 91:185-188.

TIPPETS, W. E., AND P. B. MOYLE.
1978. Epibenthic feeding by rainbow trout (*Salmo gairdneri*) in the McCloud River, California. J. Anim. Ecol. 47:549-559.

WINDELL, J. T., J. F. KITCHELL, D. O. NORRIS, J. S. NORRIS, AND J. W. FOLTZ.
1976. Temperature and rate of gastric evacuation by rainbow trout, *Salmo gairdneri*. Trans. Am. Fish. Soc. 105:712-717.

ZARET, T. M., AND A. S. RAND.
1971. Competition in tropical stream fishes: support for the competitive exclusion principle. Ecology 52:336-342.

JAMES H. JOHNSON

New York State Department of Environmental Conservation
50 Wolf Road, Albany, N.Y.
Present address: *Nez Perce Tribe of Idaho*
P.O. Box 365, Lapwai, ID 83540

EMILY Z. JOHNSON

Department of Environmental and Forest Biology
State University of New York College of
Environmental Science and Forestry
Syracuse, NY 13210

THE OCCURRENCE OF *CIROLANA BOREALIS* (ISOPODA) IN THE HEARTS OF SHARKS FROM ATLANTIC COASTAL WATERS OF FLORIDA

Extensive depredation of catch triggered the closing of the only large commercial shark fishery on the Florida east coast (at Cape Canaveral) in October 1978. Shark catches had been affected throughout a 403 km stretch of nearshore waters from St. Augustine to Fort Pierce, Fla., from between 29 and 56 km offshore, at depths of 20-43 m. The organism responsible was a marine isopod, *Cirolana borealis* (Bowman[1]).

The presence of isopods (thought to be worms by the fishermen) in the heart of a shark was discovered in October 1977, when the pericardial

[1]Thomas E. Bowman, Curator, Crustacea, Department of Invertebrate Zoology, National Museum of Natural History, Washington, DC 20560, pers. commun. September 1978.

cavity of a freshly caught sandbar shark, *Carcharhinus milberti*, was accidentally opened. From January through May of 1978, increasing numbers of sandbar sharks with isopods in the gills and heart were taken. By spring, infestation was noted also in tiger sharks, *Galeocerdo cuvieri*, including one living animal in which isopods had entered the peritoneal cavity by chewing through the musculature from the right pectoral fin axil. Moderate isopod infestation of the gills was seen in one individual of a third shark species (*Sphyrna* sp.) in August 1978. Scavenging by isopods of dead sharks on setlines also increased dramatically during this period.

Shark catch declined sharply in June 1978, and up to 60% of the animals that were taken were affected by *C. borealis* (an average of 12 out of 20 sharks caught/400 hook set). The incidence rose to 100% of catch by August 1978 (an average of 22 sharks caught/400 hook set). Some of the sharks retrieved alive with isopods in their hearts showed no obvious external damage. A short pilot study in October 1978 identified the problem in the shark fishery (Bird[2]). Investigation was undertaken from June 1979 through April 1980 on the occurrence of *C. borealis*, the possible species of fishes affected, and the potential threat that the isopod posed to fisheries on the Florida Atlantic coast.

Cirolana borealis is normally a deepwater isopod. Its distribution on both sides of the Atlantic Ocean (usually at depths of 55-1,478 m) is temperature and Gulf Stream related (Richardson 1904; Schultz 1969). (One individual, a male, was noted by Menzies and Kruczynski (in press) in the Gulf of Mexico in 1967 at a depth of 55 m.) The occurrence in 1977 and 1978 off the Florida east coast in depths as shallow as 20 m appears to be a record for the species in that area. *Cirolana borealis* is eminently carnivorous, an active swimmer, and reputedly a voracious scavenger and has been noted as an occasional parasite by Sars (1899), Richardson (1905), and Halvorsen (1966). The species was recorded by Moreira and Sadowsky (1978) as an ectoparasite of *Squalus* spp. and *Raja* spp.; it was also recorded in the peritoneal cavity of *Raja* spp. *Cirolana borealis* is a morphologically capable predator. The incisors are heavily sclerotized for biting; the first three pairs of pereopods are prehensile, and the posterior pereopods are ambulatory (modified natatory).

The life cycles of most isopods are unknown (Overstreet 1978). There are few studies on the genus *Cirolana* other than those by Davis (1964), Nielsen and Stromberg (1965), Tjonneland et al. (1975), and Johnson (1976a, b). Cirolanids are not considered endoparasitic.

Methods

Fishes examined for isopods during the course of the investigation included commercially caught *Lutjanus campechanus*, *Epinephelus morio*, and *Mycteroperca microlepis* and numerous inshore and offshore species (*Dasyatis sabina*, *Raja eglanteria*, *Paralichthys lethostigma*, *Centropristis striata*, *Rhomboplites aurorubens*, *Sphyraena barracuda*, *Coryphaena hippurus*, *Haemulon plumieri*, *Euthynnus alletteratus*, *Echeneis naucrates*, *Balistes capriscus*, etc.) from fishing tournaments, shore fishermen, research vessels, and personal collection. Swordfish, *Xiphias gladius*, longline operations covering offshore areas from north of Cuba to Georgia were accompanied and their coincidental shark catches inspected for *Cirolana borealis*. Twenty-three species of sharks were examined altogether, including *Carcharhinus milberti*, *C. falciformis*, *C. limbatus*, *C. obscurus*, *Galeocerdo cuvieri*, *Sphyrna mokarran*, *Isurus oxyrinchus*, and *Ginglymostoma cirratum*.

As an adjunct to sampling, four seasonal field trails were undertaken at sites where infested sharks had been collected on setlines in 1978. Sites were "baited" for isopods with living and dead sharks placed on weighted lines and in wire cages on the bottom. Additionally, bottom samples from the area were obtained from shrimp and scallop trawlers. They were subsequently treated with rose bengal to stain organic material and screened for isopods. Faunal records and recent and historic benthic surveys were scrutinized for *Cirolana borealis* occurrence. Historic water parameters, currents, and eddies of the Florida Atlantic continental shelf were studied in regard to normal patterns and possible deviations.

Five shark samples with intact isopods were obtained. All samples were initially frozen and transferred into 10% buffered Formalin[3] on receipt. Samples 1 through 4 represented isolated

[2]Bird, P. M. 1978. Report on infestation by *Cirolana borealis* in sharks caught commercially on the Florida east coast. Fla. Sea Grant Rep. 04-8-M01-76, 14 p. Florida Sea Grant College, 2001 McCarty Hall, University of Florida, Gainesville, FL 32611.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

sections from mature sandbar sharks collected by the fishery operator[4] from various sets in winter and spring 1978; he stated the animals were alive when retrieved from the lines. The samples consisted of: sample 1—ventricle complete with atrium, conus arteriosus, and short ventral aorta section; sample 2—ventricle as above and an epidermal section from the same animal; sample 3—ventricle as above within the pericardial chamber, intact with coracoid bar and transverse septum; sample 4—two branchial arches. Sample 5 was an entire male sandbar shark, 153 cm total length (TL), collected in July 1978; it was retrieved dead from the line.

Sample 1 was subsequently examined histopathologically; the entire specimen was serially sectioned and all sections studied microscopically. The material was paraffin embedded, cut to 6-7 μm thickness, and stained with hematoxylin and eosin.

Locations of isopods within the samples, sites of attachment, evidence of feeding, and morphological distinctions were noted on initial examination. Isopods removed during subsequent dissection were measured to the nearest 0.1 mm TL; length data were classed (2 mm classes) for frequency distributions. Species identification, sex, and stage of development were determined. Isopods were transferred into 70% isopropyl alcohol after detachment.

Results

Sampling

All teleost samples were negative for *C. borealis*. Those obtained during the pilot project in October 1978 were possibly within the chronological period of isopod occurrence in nearshore waters. Occurrences of other parasites and pathologies noted in the fishes (ectoparasitic crustaceans, cestodes, monogenetic and digenetic trematodes, nematodes, infections, etc.) were within normal levels. Reports from finfish processors and historic faunal records from the area are consistent with the finding that *C. borealis* are not a problem for teleostean fishes. Elasmobranchs collected in 1979 and 1980 were also negative for the isopods. No *C. borealis* were produced by the field trials.

Bottom samples were also negative. Historic faunal surveys revealed only one recent record of *C. borealis* (provisionally identified), taken in the South Atlantic Outer Continental Shelf Benchmark Study[5] that sampled continental shelf waters from Daytona Beach, Fla., through Georgia during 1977. The season and location in which the species was collected are unknown because Benchmark faunal lists are not yet keyed for retrieval of these data. The report would place *C. borealis* in Atlantic Shelf waters within the chronological period of shark infestation by the isopod.

Water Parameters

The currents and eddies off the Florida Atlantic coast are particularly dynamic. Recent data show that deep, cold, nutrient-rich Gulf Stream waters advect onto the continental shelf many times during the year (Atkinson et al. 1978). Spin-off eddies become larger north of Jupiter, and an established, persistent upwelling feature occurs to the north of Cape Canaveral. Lee et al. (in press) noted that eddy events appear in surface waters as warm, southward-oriented extrusions of the Gulf Stream, coupled to cold, upwelled cores. They documented an unusually strong eddy in April 1977; the eddy apparently coincided with the vertical stratification of the water, which strengthened the extrusion and brought it closer to shore. Water near the bottom (63 m depth) at the shelf break from St. Augustine south had the characteristics of water from depths of from 200 to 300 m. Its Gulf Stream origin was indicated by low temperature, salinity, oxygen content, and high nutrient concentration. The eddy, which was followed by a second strong eddy event, was 225 km long (parallel to the shelf) and approximately 35 km wide; upwelling of the cold core extended into the euphotic zone (45 m depth). Lee[6] stated that the coastal area from St. Augustine to Cape Canaveral in which *C. borealis* was found in sharks in 1977 and 1978 coincided with the area influenced by the especially strong eddies in spring of 1977.

[4]Joe D. Walker, P.O. Box 356, Cape Canaveral, FL 32920.

[5]South Atlantic OCS Benchmark Program, 1977 Report. 1979. Texas Instrument Contract AA550-CT7-2, Bureau of Land Management, Vol. 1-6. Bureau of Land Management, Department of the Interior, Federal Building, New Orleans, LA 70113.

[6]Thomas N. Lee, University of Miami, Department of Energy, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149, pers. commun. March 1980.

Isopods in Shark Samples

Cirolana borealis (129 total individuals) were present only in shark samples 1-5 taken in 1978. One individual of a different isopod species and one copepod were also noted in the samples. Table 1 shows the *C. borealis* population composition for each sample. No manca larvae or true juveniles were found; all had completed the molt to seven peraeonal appendages, although the last pair of pereopods were small in some individuals in the 5 mm class. No ovigerous females or females with remnant marsupia were seen. A morphological distinction between isopods was noted in that the pleopods of individuals from the conus and ventricle were consistently swollen, while about half of those from the pericardial chamber, and only two of the isopods from the gills, showed this condition. The distinction was present prior to preservation of the samples, and was possibly an osmotic response to the body fluids of the host. The distribution of *C. borealis* in the same samples pooled by site of occurrence is shown in Table 2 (note relationships between the groups, particularly in the male to female ratios).

TABLE 2.—Distribution of *Cirolana borealis* by morphological site of occurrence in pooled *Carcharhinus milberti* samples (see text) collected off the Florida Atlantic coast in 1978.

Site of occurrence	Total number	Mean TL (mm)	% Male	% Female	% undifferentiated	M/F ratio
Epidermis	2	6.6	0	100.0	0	—
Gill	41	10.1	34.1	56.2	9.7	1:1.6
Pericardial cavity	56	10.0	28.6	71.4	0	1:2.5
Ventricle	28	12.1	14.3	85.7	0	1:6
Conus arteriosus	2	15.8	0	100.0	0	—

Shark Pathology

Intact isopods in the isolated shark samples were observed free within the pericardial chamber; others had their mouthparts attached to the tissues of the atrium and ventricle. In two instances (samples 1 and 3), a single, large female was attached in the conus arteriosus, caudad-directed, anterior to the proximal semilunar valves. There was no sign of external entry into the conus or aorta. Abrasions were evident on the exterior of the ventricles, and holes extended into the lumen; large isopods with guts distended and dark from feeding were present in pockets of tissue in the ventricular walls (Figure 1). Areas of possible necrosis were noted in these samples. Much of the gill tissue was destroyed on the branchial arches, exposing the cartilaginous gill rays. The epidermal section was abraded.

Two free isopods were in the pericardial chamber of the intact shark (sample 5). A small hole (chewed) through the coracobranchial musculature led into the chamber from the left posterior-most gill. No isopods were present in the interior of the ventricle, conus, or circulatory system. The tranverse septum was entire (as was that of sample 3). Two isopods were attached at the cloacal opening, and both claspers showed minor surface injury. The hide was deeply pitted at the axil of the pectoral fins and the soft areas at the median fin bases.

Histopathology of the Shark Heart

Histopathological examination of heart sample 1 showed several *C. borealis* in the atrium near the atrioventricular opening; the adjacent endocardium and myocardium surrounding one of the organisms had areas of necrosis, determined by observation of basophilic degeneration of myocardial fibers and loss of nuclei (Figure 2). No inflammation was evident. Isopods were present in the lumen of the ventricle. Isopod mouthparts

TABLE 1.—Population composition of *Cirolana borealis* present in five *Carcharhinus milberti* samples (see text) collected off the Florida Atlantic coast in 1978.

Item	1 Heart	2 Heart and epidermis	3 Heart	4 Gill	5 Intact shark	Pooled samples
Total number	7	30	47	38	7	129
Mean TL, mm	9.0	10.8	10.9	10.5	11.3	10.9
Male/female ratio	1:2.5	1:2.3	1:5.7	1:1.8	1:0.75	1:2.7
Number of males	2	9	7	12	4	34
TL range, mm	8.6-11.5	6.6-16.7	10.9-16.3	5.8-17.7	13.6-16.0	5.8-17.7
Mean TL, mm	10.1	11.3	13.6	11.5	14.7	11.6
Number of females	5	21	40	22	3	91
TL range, mm	5.4-15.9	5.5-18.8	5.4-19.4	5.3-18.3	6.5- 9.8	5.3-19.4
Mean TL, mm	9.0	10.8	10.2	11.3	7.7	10.5
Number undifferentiated	—	—	—	4	—	4
TL range, mm	—	—	—	4.8- 5.2	—	4.8- 5.2
Mean TL, mm	—	—	—	5.05	—	5.05

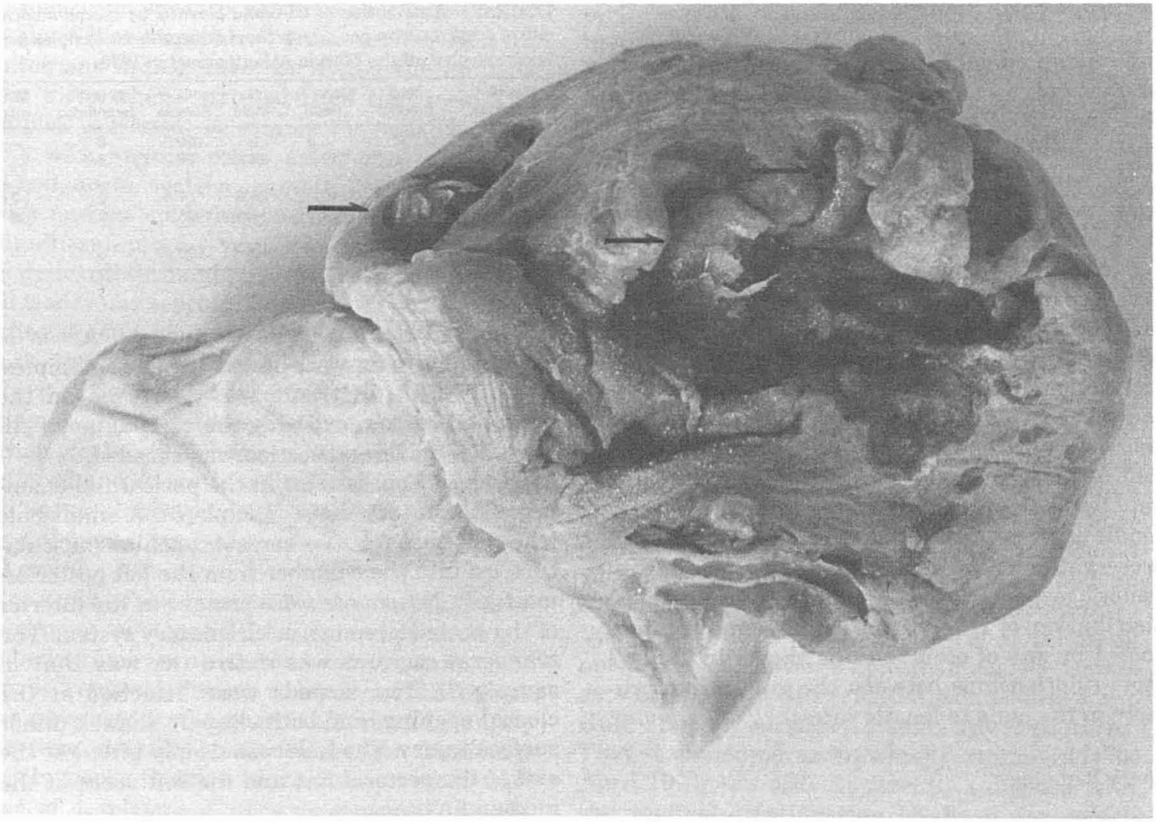

FIGURE 1.—Heart of a mature sandbar shark, *Carcharhinus milberti*, taken off the Florida Atlantic coast in 1978. Note *Cirolana borealis* enpocketed in the tissues of the ventricle.

were attached to the myocardium and on the endocardial surface of the ventricle; one area of the ventricle showed signs of endocardial and myocardial degeneration. The ventricular valves appeared morphologically normal (thus, the isopod in the conus in this sample had not entered from the ventricle). Isopod mouthparts were also attached on the pericardial surface, and there were foci of mononuclear cell infiltrate in the pericardium, indicating mild inflammation.

There was remarkedly little inflammation in the heart sample, but it is well documented that sharks demonstrate a surprising lack of inflammatory response to trauma (Sigel et al. 1968; Bird 1978). The pathologist[7] dated the time of necrosis development in the shark heart muscle as 18-24 h before death, because of the lack of inflammatory cells (as would be true in a human heart). He stated the lesion should be older, however, because of the loss of nuclei from the affected muscle cells.

Discussion

The occurrence of *C. borealis* in nearshore Atlantic waters and in the hearts of sharks appeared to be an unusual phenomenon. This is indicated by the absence of the species in historic records of faunal surveys and fishery operations in the area. The large shark fishery at Salerno, Fla., operated from 1935 to 1950 with no observed depredation of catch by *C. borealis* (Springer[8]). The occurrence in 1977 and 1978 might have passed unnoticed, however, had it not been for its effect on the Cape Canaveral fishery and the serendipitous opening of the heart cavity of a shark. It is probable that the isopods were

[7]William H. Luer, Department of Pathology, Tulane University, School of Medicine, 1430 Tulane Avenue, New Orleans, LA 70112, pers. commun. April 1980.

[8]Stewart Springer, Senior Research Associate, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577, pers. commun. October 1978.

FIGURE 2.—Paraffin section of *Carcharhinus milberti* atrium; hematoxylin and eosin (100×); bright field illumination. Necrosis of heart tissue demonstrated by basophilic degeneration of muscle fibers and loss of nuclei. Note *Cirolana borealis* (delineated by darkly stained exoskeleton) directly below necrotic tissue.

carried near shore by an event (or repeated events) of particularly strong upwelling, possibly the eddy of April 1977. Gulf Stream intrusions are known to exert major influences on populations of shelf biota (Atkinson et al. 1978). The isopods were not observed in the area by 1979, however, and may not have been able to survive as a species in coastal waters subject to extremes of temperature, light, and salinity, parameters which remain uniform in the deepwater environment.

Factors indicate that the *C. borealis* population in nearshore waters was aberrant: the depths were shallower than previously recorded for the species in American waters; large-scale predation on living animals was heretofore unknown. Additionally, the shark samples containing isopods were collected during three seasons (winter, spring, and summer) in 1978; and while the life cycle of *C. borealis* is unknown, it was surprising to not find a few juveniles or females with remnant marsupia in any of the samples.

Opportunistic feeding by *C. borealis* occurred when isopods and sharks were concurrently inhabiting nearshore waters. Both groups of animals may have been drawn to common areas as a response to the olfactory stimuli of baited setlines. Dead sharks on the lines were extensively scavenged, but living animals on the lines were attacked as well. Predation by isopods on active sharks on the lines would have been facilitated by the restricted avoidance capabilities of the hooked fishes. A deliberate preference by the isopods for the heart of the shark is strongly indicated, both in its predatory and scavenging activities.

The pathologies observed in the shark hearts suggest that *C. borealis* might have attacked some free ranging sharks while in nearshore waters. Shark setlines were retrieved by the fishery within 10-12 h of set because prompt recovery of catch was essential in order to maintain the quality of shark meat marketed for human consumption (Walker[9]). Yet, necrosis in heart sample 1 developed at least 18-24 h prior to the death of the

[9]Joe D. Walker, P.O. Box 356, Cape Canaveral, FL 32920, pers. commun. October 1978.

animal and perhaps longer (as indicated by the loss of nuclei in the affected muscle cells). Also, additional time would have been required for the isopod to penetrate the body wall of the shark and into the heart, and for the heart tissue to become necrotic. The disparity between the number of hours the shark could have been on the line and the length of isopod residence time in the heart muscle as shown by the well-developed necrosis would, therefore, indicate that the shark was attacked by *C. borealis* before it was hooked. Field tests in 1979 and 1980 could not, unfortunately, resolve this possibility (because *C. borealis* was not found in nearshore waters by that time) and it must remain speculative.

There is no evidence that *C. borealis* contributed to the sudden decline in shark catch in 1978, although it certainly affected utilization of catch adversely. A coincident decline in commercial catches of snapper and grouper that occurred in the area also appears unrelated to the isopods per se, particularly as no association was noted between *C. borealis* and teleosts in regard to catch depredation or predation. Probabilities are strong, however, that populations of sharks, teleosts, and isopods were all influenced by common water parameters. Upwellings have historically been associated with declines in fish catch (Jones et al.[10]) and were shown by George and Staiger[11] to be dominant in inducing shifts in benthic invertebrate and demersal fish populations in the South Atlantic Bight.

The Cape Canaveral shark fishery might not have closed in 1978 had the nature of the isopod problem been known at that time. The operator thought the shark flesh was contaminated by the isopods and was afraid to sell it, thus needlessly lost his profitable market for the meat. This, combined with reduced profits from the pitted hides and the decline in shark catch, caused undue financial hardship. The encounter with a totally new problem, of an unknown future duration, doubtlessly contributed to the disillusionment of the operator. Occasional occurrences of *C. borealis* in shallow waters should not be considered a deterrent to the establishment of commercial shark fishing operations in Florida, however. The phenomenon, if it recurs, should be of comparatively short duration; knowledge of this should aid fisheries to budget realistically during the interim. Isopods in sharks do not constitute a hazard to human health and their presence does not render shark flesh unmarketable. More frequent collection of setlines and experimental sets to define areas of less isopod prevalence would help alleviate problems of shark fisheries during possible future occurrences of *C. borealis* in nearshore waters.

[10]Jones, R., R. Gilmore, Jr., G. Kulczycki, and W. Magley. 1975. Studies of the fishes of the Indian River region. *In* Indian River Study, Harbor Branch Consortium, Annual Rep., 1973-74, Vol. 1, p. 110-183. Harbor Branch Consortium, North Old Dixie Highway, RFD 1, Box 196, Fort Pierce, FL 33450.

[11]George, R., and J. Staiger. 1979. Epifauna: benthic invertebrate and demersal fish population of the South Atlantic/Georgia Bight. *In* South Atlantic OCS Benchmark Program, 1977 Report, Vol. 3, p. 237-279 (see footnote 5).

Acknowledgments

This research was funded by the Florida Sea Grant College with support from the National Oceanic and Atmospheric Administration, Office of Sea Grant, U.S. Department of Commerce, #04-8-M01-76. I greatly appreciate the enthusiastic help in the field given by my student research assistants and the support from Sea Grant Agent Joe Halusky. Special thanks are extended to William Luer for his efforts in histological examinations and to Thiele Wetzel for his great contribution of time, effort, and boat facilities. The aid from William Tiffany in evaluating histopathological results is deeply appreciated.

Literature Cited

ATKINSON, L. P., G. PAFFENHÖFER, AND W. M. DUNSTAN.
1978. The chemical and biological effect of a Gulf Stream intrusion off St. Augustine, Florida. Bull. Mar. Sci. 28:667-679.

BIRD, P. M.
1978. Tissue regeneration in three carcharhinid sharks encircled by embedded straps. Copeia 1978:345-349.

DAVIS, C. C.
1964. A study of the hatching process in aquatic invertebrates. IX. Hatching within the brood sac of the ovoviviparous isopod, *Cirolana* sp. (Isopoda, Cirolanidae). X. Hatching in the fresh-water shrimp, *Potimirim glabra* (Kingsley) (Macrura, Atyidae). Pac. Sci. 18: 378-384.

HALVORSEN, O.
1966. Isopoder i torskerogr. Fauna, Oslo 19:90-91.

JOHNSON, W. S.
1976a. Biology and population dynamics of the intertidal isopod *Cirolana harfordi*. Mar. Biol. (Lond.) 36:343-350.
1976b. Population energetics of the intertidal isopod *Cirolana harfordi*. Mar. Biol. (Lond.) 36:351-357.

LEE, T., L. ATKINSON, AND R. LEGECKIS.
In press. Detailed observations of a Gulf Stream spin-off

eddy on the Georgia continental shelf, April, 1977. Deep-Sea Res.
MENZIES, R., AND W. KRUCZYNSKI.
In press. Isopod crustacea (excluding Epicaridia). Mem. Hourglass Cruises.
MOREIRA, P. S., AND V. SADOWSKY.
1978. An annotated bibliography of parasitic Isopoda (Crustacea) of Chondrichthyes. Bol. Inst. Oceanogr. 27(2):95-152.
NIELSEN, S., AND J. STRÖMBERG.
1965. A new parasite of *Cirolana borealis* Lilljeborg belonging to the cryptoniscinae (Crustacea Epicaridea). Sarsia 18:37-62.
OVERSTREET, R.
1978. Marine maladies? Worms, germs and other symbionts from the northern Gulf of Mexico. Blossman Print. Co., Inc., Ocean Springs, Miss., 140 p.
RICHARDSON, H.
1904. Contributions to the natural history of the Isopoda. Proc. U.S. Natl. Mus. 27:1-89.
1905. A monograph on the Isopods of North America. U.S. Natl. Mus. Bull. 54, 727 p.
SARS, G. O.
1899. An account of the Crustacea of Norway. Vol. II Isopoda. Bergen Mus., Bergen, Norway, 270 p.
SCHULTZ, G. A.
1969. How to know the marine isopod crustaceans. Wm. C. Brown Co., Publishers, Dubuque, Iowa, 359 p.
SIGEL, M., W. RUSSELL, J. JENSEN, AND A. BEASLEY.
1968. Natural immunity in marine fishes. Bull. Off. Int. Epizoot. 69:9-10.

PATRICIA M. BIRD

Mote Marine Laboratory
1600 City Island Park
Sarasota, FL 33577

A FLUSHING-CORING DEVICE FOR COLLECTING DEEP-BURROWING INFAUNAL BIVALVES IN INTERTIDAL SAND

In planning a study on the population dynamics and annual secondary production of deep-burrowing infaunal bivalves, a device was required which could take samples in shallow intertidal sand. Though many grabs or coring devices described in the literature (Brett 1964; Hopkins 1964; Maitland 1969; Kajak 1971) might have been suitable for taking short cores (20-30 cm deep) in intertidal or even subtidal areas, none were found suitable for taking large numbers of quantitative samples to a depth of 65-70 cm below the sediment surface. A device similar to one described by Van Arkel and Mulder (1975) was built to achieve this goal.

Materials

The device (Figure 1) was built according to the specifications outlined in Table 1. All materials are obtainable from either hardware or plumbing supply houses and are interconnected using polyvinyl chloride (PVC) cement, nuts, and bolts.

Operation

When intertidal samples are taken, the site is visited at high tide or when the water over the site

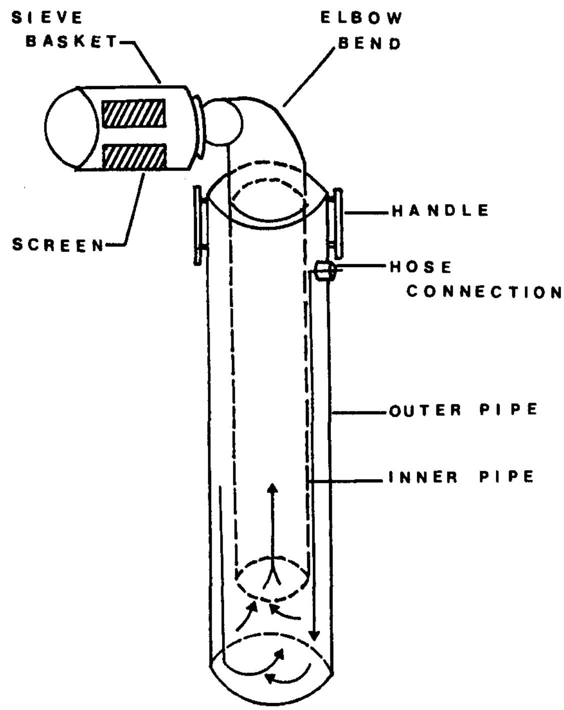

FIGURE 1.—Flushing-coring sampler. Arrows indicate direction of waterflow. Centrifugal water pump, gasoline engine, and water hoses are not shown.

TABLE 1.—Dimensions and materials used in the construction of the flushing-coring sampling system.

Item	Dimension (cm) Diameter	Length	Material
Inner pipe	10.2	100.0	Polyvinyl chloride
Outer pipe	16.0	115.0	Polyvinyl chloride
Hose connection to sampler	5.1	5.1	Polyvinyl chloride
Elbow bend	10.2	—	Polyvinyl chloride
Sieve basket	16.0	30.0	Polyvinyl chloride
Side handles	2.54	20.3	Aluminum
Screen mesh (2 per sieve basket)	—	12.7	Aluminum
Hose (pump[1] to sampler)	5.1	1,000.0	Plastic
Hose (water supply to pump[1])	5.1	610.0	Heavy plastic

[1]High-pressure (22 m^3/h) water pump and 3-hp gasoline engine.