# MEETING NOTES
# FEBRUARY 19, 1998

**DRAFT Meeting Summary**
**February 19, 1998**

AGENDA
I. Presentation on Thin-Layer Disposal by Susan Rees, Ph.D
II. Crab Study Update and Discussion
III. Additional Candidate Sites Discussion (with presentation by Dale Beasley)
IV. Closing

MEETING NOTES

## I. Presentation on Thin-Layer Disposal by Susan Rees, Ph.D

**Kim Larson (Corps)** introduced **Dr. Susan Rees** to the group. He noted that Dr. Rees is the Chief of the Coastal Environment Section for the Mobile District and has been involved in thin layer disposal program since its inception in 1985. He reviewed her background including her Ph.D in marine science, her prior experience as an assistant professor at the University of Alabama, and her work on NEPA projects.

Presentation Opening

Dr. Rees opened her presentation explaining that she intended to provide an overview of the Mobile District thin layer disposal project. She stated that Mobile District was taking a different approach than the approach taken on the Columbia. She went on to describe projects along the coasts of Alabama and Mississippi. She explained that on the Alabama coast they use a combination approach of upland on beach, within bay and ocean disposal and have a new site in progress for beneficial use of fine grain material. On the Mississippi coast, they have several small projects for which they also use a combined approach of upland, within bay, and ocean disposal as well as beneficial use sites.

She said that the Mobile District manages disposal "based on different goals." For example, they mound where they have a very flat mud bottom to create submerged structures to attract fish and redirect waves that impinge on Islands. In contrast, she explained that the within bay goal is not to allow mounding because the bay has very shallow water and they want to avoid environmental impacts, so they use thin layer disposal. Therefore, because they have different goals than the Columbia River she "cannot say its the same, but the theory is applicable."

History of Thin Layer Disposal Study

Dr. Rees presented a short history of projects and thinking leading up to the thin layer disposal study. She summarized two earlier projects from the late 1970s and the mid 1980s. One of these included a project to facilitate Shrimp Boat Movement in Mobile Bay. They tried thin layer disposal after the State indicated that it would deny water quality re-certification. Because they had no definition for "thin layer" they varied the disposal from 6 inches to 2 ½ feet. The conclusion of this first experiment was that thin layer may work, but several questions remained. The remaining issues included: how to define thin layer; how long do impacts last; and how fisheries might be impacted. She indicated that the only fish that showed a reduction was catfish.

> **Question—Neil Richard (ODFW)**: Why was there a reduction in catfish?
> **Response—Dr. Rees (Mobile Corps):** I don't know why, but was not considered significant, the only difference seen was a "blip" in the data.

**Question—Dick Sheldon (Northern Fish & Oyster Inc):** Do you use hoppers?
**Response—Dr. Rees (Mobile Corps):** Yes we do, at Mobile Bay Congressional language directed the Corps to use hopper dredges and haul material up to 50 miles to the ocean. We had lots of complaints regarding shoreline erosion. In 1996 Congress authorized evaluation of Mobile Harbor for potential in-bay disposal. Now, I foresee a combination approach in the future: transport to the ocean; thin layer in the bay, and other beneficial uses.

**Question—Kathi Larson (USFWS):** What were the impacts at the site?
**Response—Dr. Rees (Mobile Corps):** The studies showed that the underwater structures attracted fish, decreased wave action, and impacted benthic cover, but the benthic cover recovered.

**Question—Ed Manary (WDFW):** What about Shellfish?
**Response—Dr. Rees (Mobile Corps):** There were oysters, shrimp, crabs, but the study was primarily geared to benthos and fish.

**Question—Edie Beasley**: How large were the sites?
**Response—Dr. Rees:** The sites varied in size (50sq. mi., 18 sq. mi. and 8 sq. mil.). We only used small portions of the larger sites but due to the competing uses (oil, navigation, gas) we designated a large area.

**Question—Neil Richard (ODFW)**: How do the sediment types compare?
**Response—Dr. Rees (Mobile Corps):** It was a sandy bottom covered with fine grain materials so very similar to here at the Columbia.

The Gulf Port Demonstration Project

According to Dr. Rees, Congress defined "thin layer" as 6 to 12 inches ("not more than 12 inches"), authorized a study team, and established a time-frame as part of Gulf Port Improvement Act. The study team objectives included looking at the following:

- Benthos (because they wanted an estimate of how long to recover)
- Seasonal aspects of disposal
- Different sediment types (clay over sand and sand over clay)
- Historical effects of thin layer disposal
- Water quality
- Longer term residual effects
- Fisheries (using surrogates -- Dr. Rees noted there was not enough money in the federal budget to detect fisheries impacts)

With respect to the fisheries they looked at larval and juveniles using a four prong approach:

1. feeding impacts
2. direct physical impacts and sub-lethal impacts on larvae
3. turbidity: the relation between TSS and ability of larvae/juveniles to feed
4. whether fish try to feed in sediments where there is not a lot to eat

Historical Effects

Dr. Rees presented information on the study of historical impacts. She noted that the Gulf Port study presented a unique opportunity to consider historical impacts. She noted that they looked only at benthos, because they believed that the benthos would indicate the health of the system and because there is quite a bit of information known about the benthos. The conclusion for this aspect of the study was that there were no long-term impacts. Dr. Rees put up several overheads showing taxa information and answered some additional questions.

> **Questions—Bob Burkle (WDFW):** Did you put the same size grained materials over the same size or coarser over fine materials?
> **Response—Dr. Rees (Mobile Corps):** We did all of those. And yes, finer is more productive so better to put finer over coarser rather than coarser over finer.

Seasonal Aspects

Dr. Rees also presented information on the seasonal impacts of thin layer disposal. They looked at three time periods: late summer, fall, and early spring. Dr. Rees discussed the method of thin layering and answered questions about the process. In response to questions by **Edie Beasley** and **Kathi Larson** about shellfish, Dr. Rees stated that oysters were in the area but they did not dump on the oysters because they cannot get up and move; however, they did dispose nearby within 500 feet. She stated that no impacts on the oysters were seen. In response to questions by **Dale Beasley** and **Neil Richmond**, Dr. Rees stated that other commercial species were present, including shrimp, oysters, and blue crabs. She answered that blue crabs were not a species of concern for the area, although it was a productive nursery area for these species and they do have economic value although she did not know the dollar value.

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**[BREAK]**

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After the break, Dr. Rees clarified several points of the presentation that might have caused confusion. She noted that flows were 50,000-250,000 cfs and that the distances to the disposal depended on where in the channel the material was coming from. She clarified that the disposal sites were ½ to 4 miles offshore but that from the farthest end of the channel to the site it is approximately 50 miles.

Dr. Rees then took some additional questions.

> **Question—Darrel Potter:** The conditions are different here from there.
> **Response—Dr. Rees**: Yes, that's why the results may not be directly applicable. Cannot take the study and flop over into Oregon. But, the theory can apply.
>
> **Question—Ed Manary:** What are the average water temperatures?
> **Response—Dr. Rees:** 50 to 80 degrees.

Fisheries Impacts

Dr. Rees then moved to a discussion of the fisheries results of the thin layer disposal study. Dr. Rees stated that they initially thought disposal would devastate the fish larvae due to physical impacts. The study was designed to look at physical and sub-lethal impacts. They conducted 4 sets of studies to the fishery. The general results, with the exception of 1 case, were that the species were healthy when recovered and there were no changes in feeding. The conclusion was that thin layer did not interrupt the life processes during disposal. Over time, some differences but not significant.

Dr. Rees put up overheads showing impacts and results regarding feeding experiments with caged species and answered some additional questions. Dr. Rees stated their conclusion that there was no difference in feeding during and after disposal as compared to the control. Dr. Rees discussed a lab test used to examine the physical effect of sediments raining down on species and possible sub-lethal effects. In response to a question about rates of deposition, Dr. Rees answered that they tested a wide range of rates and types of material. Dr. Rees described the results. They found that the percent survival was higher as to fine sand and, overall, the species were quite resistant. Dr. Rees answered a number of questions about these experiments. In response to a question from Arlene Merems, Dr. Rees answered that while the species discussed were not found on the bottom. In response to a question from Dick Sheldon about the differences between their study conditions and the conditions in the Columbia, Dr. Rees responded that the situations were different. Dr. Rees also discussed study results from experiments on flounder larvae. The results indicated that physical impacts were not as great as perceived and that sub-lethal impacts were not significant.

Dr. Rees also discussed another test concerning impacts associated with increased total suspended solids (TSS) and how TSS impacts the ability of fish to see and get prey. The tests considered total prey density, TSS and use of models. The tests on Spot did not show response to either increased TSS or decreased prey. However, flounder larvae did show a response to increased TSS and decreased prey. Dr. Rees presented their conclusions: although fish perceive prey differently, researchers can develop models that can predict response.

Dr. Rees next presented the last fisheries study. The study looked at whether the fish would feed on disposal site with different sediments and different productivity (an energy budget analysis). They tested a range of grains sizes from very coarse to very fine. The conclusion was that the tested fish spent efforts where the food was. Dr. Rees stated that the fish were "smarter than we thought they were."

Benthos

Dr. Rees presented information on three sites used for the benthos study (sites alpha, beta, and delta) and the resulting data. With respect to the alpha site (coarse over fine), Dr. Rees stated that the diversity declined immediately after disposal but after 2 months diversity increased. Dr. Rees stated that at the beta site (fine over fine) they saw a reduction and a 10 month period before recovery. She indicated that the reduction in numbers may have been due to the time of disposal (December). At the delta site (basically fine over fine), they had a significant increase in the number of individuals as compared with the control. Something made the site more attractive, but they don't know why. Dr. Rees answered several questions about these results.

Water Quality Experiments

Dr. Rees presented information relating to the water quality experiments conducted for the thin layer study. The results showed no increase in fecal coliform but there were increases in TSS and turbidity. In the long term, there was a tendency for re-suspension but not a significant increase.

Conclusion

In conclusion, Dr. Rees stated that the group should look at the specific issues for the Columbia River and that groups members could call or write her if they had further questions.

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[LUNCH BREAK]

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**Facilitator:** **Ms. Lee** reviewed the afternoon agenda and raised for discussion any additional comments or questions for Dr. Rees.

**Dr. Susan Rees (Corps):** Dr. Rees said that she heard concerns raised by several members of the group as to whether the Mobile study was applicable given differences in conditions. She suggested that the concepts and management approaches included in the Mobile study are applicable, even if the specific numbers might not be. She said that the group needed to determine their objectives and to establish a management plan based on their specific site and the specific concerns involved. She said her project aimed toward achieving navigational reliability; avoiding unacceptable impacts to resources; and using resources to the maximum extent practicable. She said she was not a proponent of redoing the benthic studies, but that she saw valid issues relating to crab responses to thin layer disposal. She said that it is important to first define the goals, then gather information to achieve the goals. She added that in some cases mounding might be acceptable and there are always trade-offs. She noted that the goal for ocean disposal in Mobile was to make the mound as high as possible while maintaining 20ft to the water surface and that this method was used for navigational and environmental reasons. She noted that the goal for estuarine waters was for thin layer disposal methods.

> **Question—Jim Nichols (Oregon Dungeness Crab Org)**: If not for the shallow water and that you can run an hour out, would you do mounding in the ocean?
> **Response—Rees (Corps):** We do mound in the ocean. If the dredge comes from the North end of the channel it is 50 miles to the disposal site, but if the dredge is from the South end of the channel it is only a ½ mile to the disposal site. We mound for environmental reasons. We make a great big mound on purpose because that is the goal of the community and costs less than thin layer in the ocean.
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> **Question—Ed Manary (WDFW)**: You said you mound for the environment, do you do any enhancement? Also, do the mounds attract commercial fishers or recreational users to the area?
> **Response—Rees (Corps):** There was an active artificial reef program, but they don't do it in the same sites as the disposal. There was so much going on it became unacceptable, so now artificial reefs are strictly limited with where they can go. The ocean sites are not where you want artificial reefs. Also, there is no enhancement of the mounds, but snapper congregate at mounds without enhancement. Oil rigs also make excellent fish habitat. I believe the level of commercial/recreational use has increased because of the mounds.
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> **Question—Neil Richmond (ODFW):** If mound disposal is used, do you go back?
> **Response—Rees (Corps):** We go back to maintenance locations all the time. With new work we don't go back.
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> **Question—Edie Beasley (CRCFA)**: What impact will or could the report to Congress have on navigation?

**Response—Rees (Corps):** The report could establish a framework for managing disposal. The report will discuss thin layer as an alternative that should be considered.

**Question—Arlene Merrems (ODFW):** What was the new work amount?
**Response—Rees (Corps):** 1 million yards; approximately 2 million yards maintenance materials.

**Question—Ed Manary (WDFW)**: I wouldn't be surprised that the report carries a lot of weight, will push Corps to look at applicability on expanded level.
**Response—Rees (Corps):** We caveated the beginning, the middle, and the end of the report.

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**Facilitator**: **Ms. Lee** suggested that the group move into a discussion of how the information relates to the current situation.

**Comment—Darrel Potter (Western Fishboat Owners Assoc.):** The scientific part is helpful, we can use the models, but we need to keep in mind thin layer disposal must consider safety issue due to the situation here—we must keep safety in mind for the mouth of the Columbia.

**Comment—Dick Sheldon (Northern Fish and Oyster):** I agree, mounds collect fish, like at Clatsop Spit, but that is now known as the graveyard of the pacific as a result of so many lost ships. The issue is safety, and the safety issue is passed over in the other studies; crab issues are also passed over. If we deal specifically with the crab issue, identify it, look at the commercial impacts, ok, but otherwise the process problem takes lead over the tangible science. We did all this process and we can go on, but the crab issue is buried into other information, lumped in, but we were here to talk about crabs and its being ignored. We are here about crabs. I don't see any problem with thin layer, but it covers more area and that impacts more crabs. There is more information on crabs in these studies (referring to papers on the table).

**Comment—Susan Rees (Corps):** Thin layer is an option, if studies showed no impact to crab and no safety issue. You need to address whether thin layer impacts crabs, that is the question you need to ask. You should answer that before you go any further or say you will take this to the moon. Let science say whether crabs can or cannot handle six inches. Otherwise there is no basis for either side for its position.

**Comment—Edie Beasley (CRCFA):** Crabs are too vital to put anything on them. Monitoring did not supersede the impacts; even with monitoring there were "dead zones." If we do a test project here, we will have to work on restoration rather than conservation. What I am saying is that we should look outside this area.

**Facilitator/Ms. Lee**—Are you saying Edie that you do not believe that anything useful, any useful information can be derived from crab testing?

**Comment—Edie Beasley (CRCFA): The** lab test can provide some helpful information, but it can't predict mother nature. It would be interesting what would be found but what's interesting does not apply to crab. We need to stay away from the resource, and we will do anything we can to do make sure of that.

**Comment—Steve Barry(WDFW):** What I heard from the presentation is that fishery biologists are stubborn—so are crab fishers—and also heard that "like on like" works; dispersive sites help; beneficial uses are possible and we can do that here; and we can protect vessel safety. These four things are something his agency is interested in.

**Comment—Bob Burkle (WDFW):** I heard that projects caused erosion problems, effects on shoreline, exactly like here; something that is increasingly a problem here. The study confirmed that when coarse on fine there is lowered productivity, but not like on like. What's more important is the concepts.

**Facilitator/Ms. Lee:** The facilitator asked for responses to comments that the lab study would not help.

**Steve Barry (WDFW):** Lab study can help, its not the same as mother nature, but controlled experiment is the only opportunity we have. Understand not natural setting but there are no alternatives.

**Facilitator/Ms. Lee:** The facilitator responded that Edie did present an alternative, staying out of the area. Is that your position Edie?

**Comment—Edie Beasley (CRCFA):** Yes, we like the idea of beneficial use, but want the corps to stay out of the area.

**Comment—Ben Meyer (NMFS):** Susan had a valid point, its a tool to utilize; we should look at thin layer disposal as a concept, evaluate it, and may reject it, but first need to decide where to put material, then we can consider this as a potential tool. We also need to consider impacts to crabs.

Another participant commented that one thing they got at is direct application re: juveniles. Mobile trying to use the best combination of approaches; Mobile willing to move some material 50 miles, and use very large sites with multiple options. Thin layer not new, used for cleanups in Puget Sound, at Eagle Harbor.

**Facilitator/Ms. Lee:** The facilitator went around the room for responses to the point that it provides some information to fisheries in the Columbia.

**Comment—Ben Meyer (NMFS):** Yes, but adds more questions, a magnitude of questions, Susan could be studying for a long time.

**Comment—Arlene Merrens (ODFW):** The Mobile study looked at 3 species but only one species was a bottom species. So, I have a hard time applying their study to this situation. There are lots of differences, water temperature, different species composition, shallow/high energy system, so I am not sure its comparable. The details do not apply. Need to know more about flat fish and some other issues. Because the thin layer here is "a lot of material" should be concerned with how we approach. I am impressed with pre- and post- evaluation studies and monitoring that was done. Unless further assessments unlikely that her agency would sign-off on it.

**Comment—Kathi Larson (USFWS):** There are differences, but they show, like other studies, still get recovery of particular benthos and fragile fish, so I hoped could extrapolate to crabs here. Now I am hearing the need for tons more studies, when I thought we could extrapolate with a smaller study. I don't believe we will learn a whole lot by new studies and I think we can extrapolate, but the others do not seem to be in agreement. Fragile fish were studied yet not so unreasonable to believe that impact to fragile crabs would be the same.

**Comment—Ben Meyer (NMFS):** With a little more information, I could agree that the study would be useful.

**Comment—Arlene Merrens (ODFW):** Given magnitude of area in study, not comfortable to sign off now, does not appear to be an option yet. With study it has merit.

**Comment—Ed Manary (WDFW):** I have a question for the Corps, do you want to do a study for possible reference, is it the Corps' intent to test thin layer disposal at the mouth of the Columbia?

**Comment—Eric Braun (Corps):** There are no plans to study in the field at this time, especially because unlikely to be feasible, that's the reason looking at a lab study.

**Comment—Kim Larson (Corps):** We are just looking at thin layer as an options because the raised safety as an issue, the Corps has no agenda, just trying to present an option for consideration.

**Comment—Dale Beasley (CRCFA):** I am not opposed to it [thin layer disposal] except in area of highest concentration of resource. The goal is to minimize impact on commercial species. Cannot go out and do it wholesale and when it doesn't work say "oops, we made a mistake" which is what happened with the mounds. We warned against doing it, but you did it anyway, and a problem occurred. I am willing to try, but only at a controlled site, not in highest resource area, you should not experiment with resource. My experience is that wherever disposal occurs, crabs do not come back.

**Facilitator/Ms. Lee:** The facilitator asked for a show of hands as to whether the study has a reasonable amount of helpful information; not all participants raised their hands. The facilitator then requested that the participants representing the crabbing and fishing industry share their thoughts regarding whether or not the crab study would provide useful information.

> **Response—Neil Richmond (ODFW):** No, but ...
> **Response—Jim Nichols**: No
> **Response—Dave (Oregon Commercial fisherman):** Don't know.
> **Response—Dale Beasley**: Would provide some information.
> **Response—Edie Beasley**: Would provide some information.
> **Response—Mike Desimone (Pacific County DCD):** Pass
> **Response—Bill Rhodes (CRCFA):** Yes
> **Response—Darrel Potter:** Some information, but just as a tool, not to say all-right, too many variables
> **Response—Dick Sheldon**: No

**Facilitator/Ms. Lee:** The facilitator opened this inquiry to the remainder of the group regarding whether a study would be viewed as a waste of money or would it depend on the study design.

> **Response —Susan Hinton (NMFS):** No idea, haven't seen the crab study, can have some information but I need to know what it is controlling.
> **Response—Arlene Merrens**: Provided design valid, and peer reviewed.
> **Response—Kathi Larson:** Some concern with design of study
> **Response—Bob Burkle**: It's essential, Menhadden completely different than crabs. We must study crabs to determine impacts.
> **Response—Ed Manary**: Why are we going backwards? It seems like all this decided before.

**Facilitator/Ms. Lee**: The facilitator asked Kim Larson to give a status report on the crab study.

**Comment—Kim Larson:** Why should we do the study when so many here don't think its worth anything? Why spend the money?

The group took a brief break with separate discussions continuing during the brief break.

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[Brief Break]

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## II. Crab Study Update and Discussion

Kim Larson presented a crab study update. He indicated that the design work was just getting started and that he would send out the information to everyone who was interested. He spoke about the proposed study design under consideration. The crab study would include 3 size groups (youth, sub-adults, adults), development of an apparatus, use of 5 gallon buckets, and evaluation at different depths. He indicated that he was reviewing last session's notes so that he could address all of concerns raised about the design, including using the same type of sediments as those being disposed, control of barometric pressure, as well as the other concerns noted. He agreed to include some flat fish if he could find a source. He stated that he was also open to incorporating any additional ideas.

There was some discussion of suggestions by the participants, about the size of containers, the location for the testing, and other issues. The facilitator requested volunteers to form the study group to work with Kim Larson on designing the study. The facilitator recommended to the group that they go forward with development of the study design and then decide on whether it was worth doing.

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[Break]

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Crab Study Design Working Group

After the break, the facilitator outlined the process for the crab study that would include development of a scope of work with working group input, incorporation of concepts, and then distribution to the wider group. The study working group would include Kim Larson, Neil Richmond, Steve Barry, Ben Meyer, Dale and Edie Beasley, Bill Rhodes, Jim Nichols, and Susan Hinton. The working group agreed to meet on **March 18th at 9am at NMFS's Hammond Office.**

**Kim Larson** outlined the process agreed upon. First a draft would be developed. The draft would be circulated to peer reviewers including Susan Rees. Then the study group would incorporate the comments and distribute.

Usefulness of Guidance Document and Crab Distribution Concerns

**Edie Beasley** raised a concern and noted her surprise that she had not been provided with a 1990 Corps' Guide Book with information about the process that they were involved with. She said that she had found many good ideas in the Guide Book and information about the process for what they were doing and she wanted to know why the group was not using the materials. She expressed frustration that she had asked for all materials, manuals, information, and guides having to do with the process and applicable laws at the start of the process and if she had had this earlier it would have helped explain a lot about the process and in establishing a "framework" for the group.

**Kim Larson** responded that they are using the process in the guidance materials and that all that has gone on so far is essentially the same as what is set out in those materials.

There was discussion of the materials, who knew about them, and what information they contained that might now be used in this process. **Dick Sheldon** said that portions of the manual set out a process that should be followed. He also said that all the process going on was not getting anything done.

The **facilitator** asked by how the materials might be used at this point in the process.

> **Response**: **Edie Beasley** indicated that she did not have specific recommendations at this time but stated that she believed that everyone should have the information.
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> **Response: Dick Sheldon** stated that the book suggested avoiding shellfish areas in site selection
>
> **Response**: Responding to Dick Sheldon's comment, **Kim Larson** noted that no site had yet been selected.
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> **Response**: **Dale Beasley** suggested that the group move on to discussion of additional candidate sites.
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> **Response: Dick Sheldon** noted that he wished the group had started out on a different foot. He indicated that the Guide book lays out criteria to choose sites that the group had not really used. He thought that they would find out the economics of disposal—what is the economic impact. He added that a lab study would not say whether the crabs will stay out there. He said that crabs don't like the mounds and don't stay there and that thin layer disposal would mean an even larger area that the crabs don't like. He stated that the key issues were economics and safety including issues of navigation time. He said that even if no deaths and the crabs just move that would be "as big a concern."
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> **Response**: **Dale Beasley** stated that there were ten occasions in which this impacted his bottom line.

The **Facilitator** sought to clarify whether the concern raised was the economic impacts resulting from re-distribution of crabs.

> **Response: Dale Beasley** stated that he was talking about a year's salary.

The **Facilitator** then asked if the concern was economic impacts stemming from distribution changes rather than biological effects.

> **Response: Dick Sheldon** answered Yes.
>
> **Response: Darrel Potter** clarified that the 10 days noted by Dale Beasley was 50% of the season and thus was "a whole heck of lot" of impact.

The **Facilitator** again asked for clarification as to whether the issue was the distribution of the crabs that made the economic impact and not the biological impact.

> **Response: Dick Sheldon** indicated that it was a distributional issue. For this reason, he stated that it would be ok to drive crabs out of places where crabbers don't crab because then they could get them.

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## II. Additional Candidate Sites Discussion (with presentation by Dale Beasley)

**Dale Beasley** gave a presentation of information relating to his proposal for an additional candidate site. In the first part of his report he presented data from studies conducted in the 1970s in the area North of site B relating to TOC information. He noted that this data supported what he had been trying to say for quite awhile—that TOC is important. He suggested that biomass calculations showed areas of highest calculations due to a correlation between biomass and crab and fish. Dale Beasley also summarized 1993 Sediment Migration data produced by NOAA concerning benthic infauna and sediment characteristics. He also summarized 1996 data relating to grain sizes in sediments and sediment migration from area B.

Next, **Dale Beasley** put up an overhead locating his proposed candidate site. He noted that reasons favoring the site included

- the site was deep enough so that no safety problems existed
- the site was not usable by crabber boats
- the site could be designated for beneficial uses

Dale Beasley stated that the key reason for the site selected was that it was not utilized by any of the user groups. However, he stated that the site, located 1-2 miles out, may be somewhat farther out than the Corps would like. He also stated that a drawback of the site would be that the sand would not available for other uses.

Participant Comments on Dale Beasley's Presentation:

**Thron Riggs (Columbia River Bar Pilots)** agreed that he did not have a problem with the site. He stated that anywhere in the area would present conflicts with traffic and so the absence of conflict was not an issue. He noted that anywhere selected, including this proposed site, would be better than inside the sea buoy marker. **Ben Meyer** asked about how the proposed site overlapped with the skirt area overlay and the skirt overlay was placed over the proposed site. **Arlene Merems** commented that not all the overlays are to scale so hard to compare the information. She also stated that she had a concern that at least 50% of the proposed site overlapped with areas of concern for ground fish. **Edie Beasley** noted that the benefits of this site were that it supports overlay data; sediment compatibility; less environmentally sensitive; minimal damage to commercial marine resources; minimal interference with commercial & recreational fisheries; minimal impact to local economies; minimal interference with navigation; beyond breeding and spawning areas; beneficial use site; and other reasons [See Attached Information Sheet submitted by CRCFA showing proposed site and listing proposed site benefits]. **Kim Larson** responded that not all of the stated benefits were proven, noting in particular that the site was not proven to be beyond breeding and spawning areas.

Discussion of Proposed Site as a Candidate Site

After some additional questions and responses to the presentations, the **Facilitator** went around the room to determine whether there was consensus on the inclusion of the new site as a potential candidate site under consideration. Everyone agreed that the site could be included as a candidate site for further consideration with the exception of **Arlene Merems** who did not want to include the site at this time due to potential conflicts with commercial fishing areas.

State Park Problem

**Bob Burkle** raised a concern regarding conditions at a State Park where restrooms and roads had been lost. He noted that if conditions continued there would not be any park left. He stated that there is a need for something to be done and that the receding shoreline may contribute to navigational problems at Peacock Spit.

**Rod Moritz** noted that the land portion did not exist before jetties put into place and may be a transient problem even though its seems as if its been there a long time. He noted that the situation was similar to the problem raised by Dr. Rees concerning Dolphin Island and the use of "feeder" materials placed offshore/nearshore for washing onto beach.

## III. Closing

The meeting was brought to a close by the facilitator.

Laura and Valerie

Attached is the best I could do to reconstruct what I presented. I think I have covered everything – maybe not exactly the overheads that were used but close. I am currently revising the report and it will go final in the next couple of weeks. Will send you copies when it is reproduced.

Good Luck and do not hesitate to call

Susan


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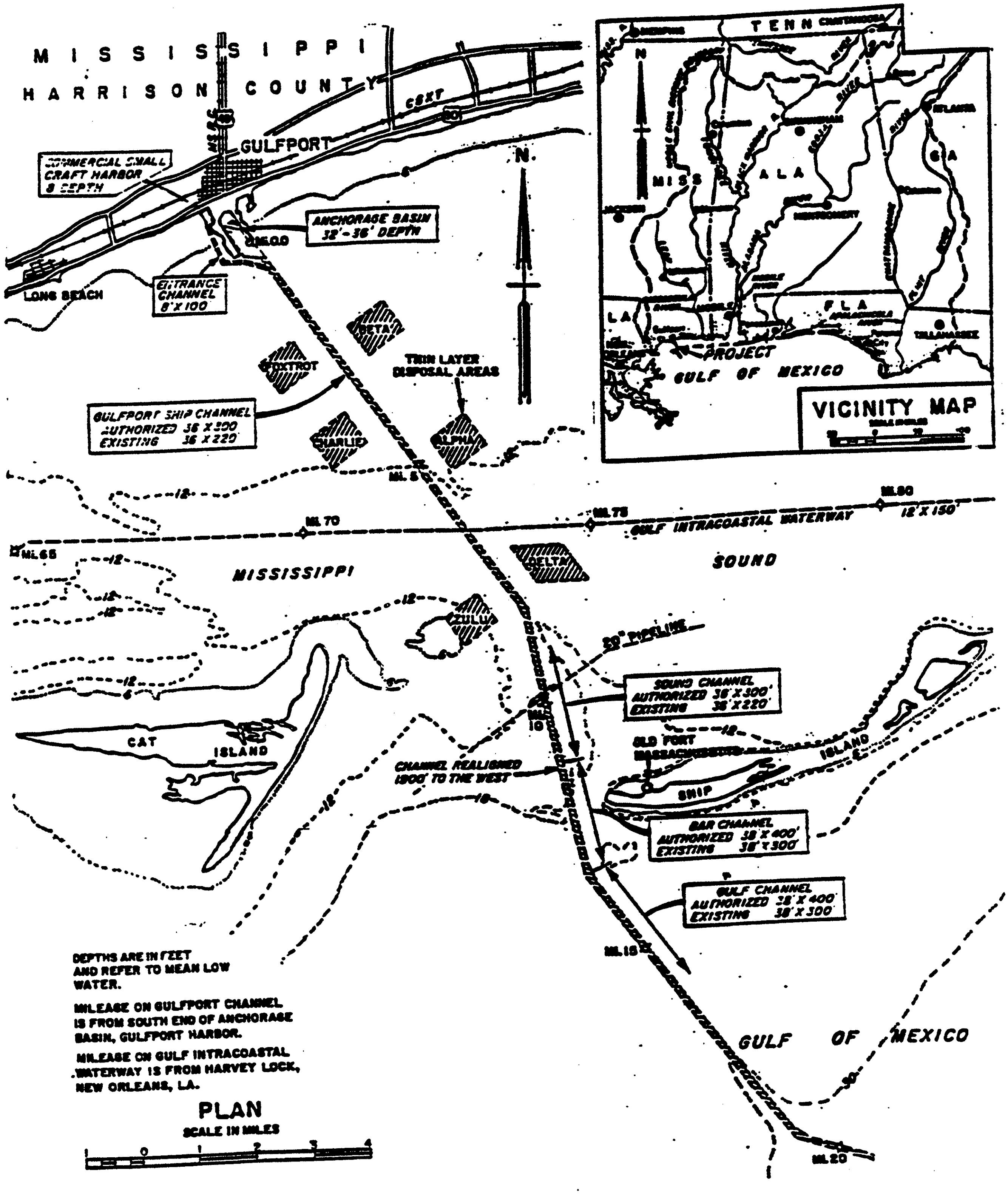



Figure 1. Gulfport Harbor Federal Navigation Project.

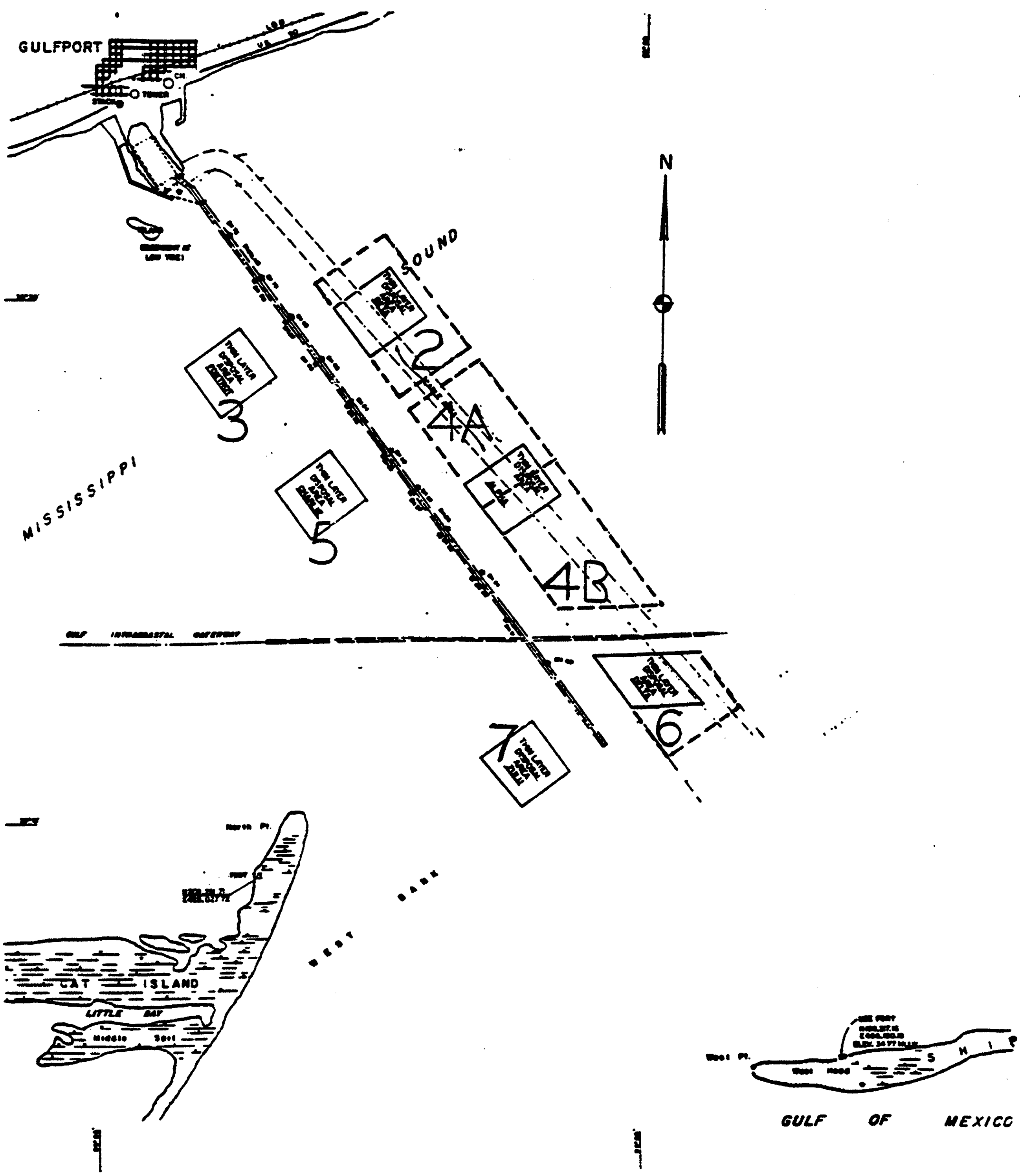



Figure 2. Thin-Layer Dredged Material Disposal National Demonstration Program Study Areas.

length of time the barge would remain at any one spot within the disposal lane and deposit 12 inches or less of material. This pattern was input into the computer system onboard the barge. The system would then direct the dump foreman to adjust the winch system moving the barge along the disposal arc and within the discharge lane.

TABLE 1. Thin-Layer Disposal Schedule And Study Parameters

| Disposal Area | Material Type | Disposal Dates | Monitoring Parameters |
|---|---|---|---|
| ALPHA | New Work | 3 - 14 Aug 1992 | LTB, Macroinfauna, Fishery, Bathymetry |
| CHARLIE | Maintenance | * | * |
| BETA | New Work | 26 Sept - 5 Oct 1992 | WQ, LTB, Macroinfauna, Fishery, Bathymetry |
| FOXTROT | Maintenance | 15 - 24 Sept 1992 | WQ, LTB, Fishery, Bathymetry |
| DELTA | New Work | 4 - 8 May; 11 - 25 May 1993 ** | WQ, LTB, Macroinfauna, Fishery, Bathymetry |
| ZULU | Maintenance | 20 - 27 March; 10 - 14 April 1993 ** | WQ, LTB, Fishery, Bathymetry |

WQ = Water Quality Studies; LTB = Studies on the long-term effects of thin-layer disposal; Macroinfaunal = Studies on the impacts of thin-layer disposal of new work material; Fishery = Fishery Studies; Bathymetry = Bathymetric Surveys

* The reach of the channel adjacent to the Charlie site did not contain any maintenance material requiring removal therefore disposal and subsequent monitoring of this site was not conducted.

** Consistent bad weather, problems with the dredge equipment, and slower than expected production by the dredge caused deviation from the planned 10-day duration disposal, subsequently disposal was reinitiated.

The discharge barge is free floating, anchored to a swivel barge by a pontoon dredge line. The barge has a real time positioning system operational at all times during the operation and is manned by both the barge foreman (winch operator) and a computer operator. The barge foreman has an enhanced color schematic of the predisposal survey visible at all times, with the computed minimum and maximum travel speed displayed as well as the position and actual speed of the barge traveling along the discharge arc. Additionally, the discharge barge is equipped with fore and aft trisponders reading data into the computer along with fore and aft lead lines for quality control. The discharge arc is changed by moving the swivel barge to the next predetermined position within the

| DATE | | Predisposal Sites | | Alpha | Alpha NC | Alpha SC | | Beta | Beta NC | Beta SC | | Delta | Delta C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.1991 | | BN, SED | | | | | | | | | | | |
| 8.1991 | | BN, SED | | | | | | | | | | | |
| 9.1991 | | BN, SED | | | | | | | | | | | |
| 10.1991 | | BN, SED | | | | | | | | | | | |
| 11.1991 | | BN, SED | | | | | | | | | | | |
| 12.1991 | | BN, SED | | | | | | | | | | | |
| 1.1992 | | BN, SED | | | | | | | | | | | |
| 2.1992 | | BN, SED | | | | | | | | | | | |
| 3.1992 | | BN, SED | | | | | | | | | | | |
| 4.1992 | | BN, SED | | | | | | | | | | | |
| 5.1992 | | BN, SED | | | | | | | | | | | |
| 6.1992 | | BN, SED | | | | | | | | | | | |
| 7.1992 | | | | BN, SED | BN, SED | BN, SED | | | | | | | |
| 8.1992 | | | | BN, SED | BN, SED | BN, SED | | | | | | | |
| 9.1992 | | | | BN, SED | BN, SED | BN, SED | | | | | | | |
| 10.1992 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 11.1992 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 12.1992 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 1.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 2.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 3.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | | |
| 4.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 5.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 6.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 7.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 8.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 9.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 11.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 12.1993 | | | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 1.1994 | | | | BN*,SED | BN*,SED | BN*,SED | | BN, SED | BN, SED | BN, SED | | BN, SED | BN, SED |
| 2.1994 | | | | BN* | BN* | BN* | | SAMPLE | SAMPLE | SAMPLE | | BN | BN |
| 3.1994 | | | | BN*,SED | BN*,SED | BN*,SED | | SED | SED | SED | | BN, SED | BN, SED |
| 4.1994 | | | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE |
| 5.1994 | | | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE |
| 6.1994 | | | | BN* | BN* | BN* | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE |
| 7.1994 | | | | | | | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE |
| 8.1994 | | | | | | | | SAMPLE | SAMPLE | SAMPLE | | SAMPLE | SAMPLE |
| 9.1994 | | | | | | | | BN* | BN* | BN* | | SAMPLE | SAMPLE |
| 10.1994 | | | | | | | | | | | | SAMPLE | SAMPLE |
| 11.1994 | | | | | | | | | | | | SAMPLE | SAMPLE |
| 12.1994 | | | | | | | | | | | | SAMPLE | SAMPLE |
| 1.1995 | | | | | | | | | | | | SAMPLE | SAMPLE |
| 2.1995 | | | | | | | | | | | | SAMPLE | SAMPLE |
| 3.1995 | | | | | | | | | | | | BN | BN |

BN = Benthic analysis completed    BN* = Benthc analysis partially completed
SED = Sediment analysis completed    SAMPLE = Samples collected, not analyzed

Table 2. Sampling dates for the Gulfport Thin-layer Disposal Demonstration Project, July 1991 through March 1995.

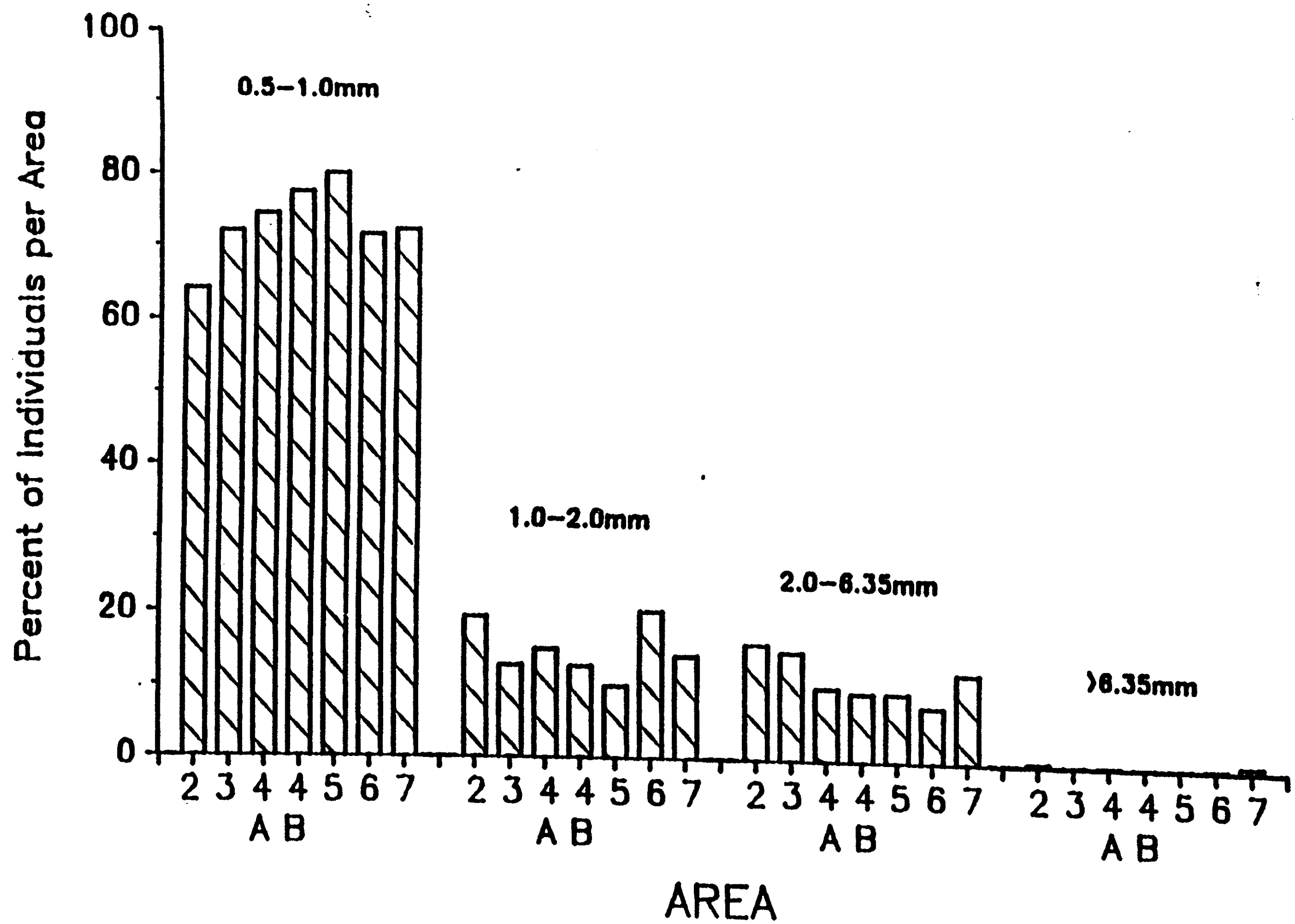
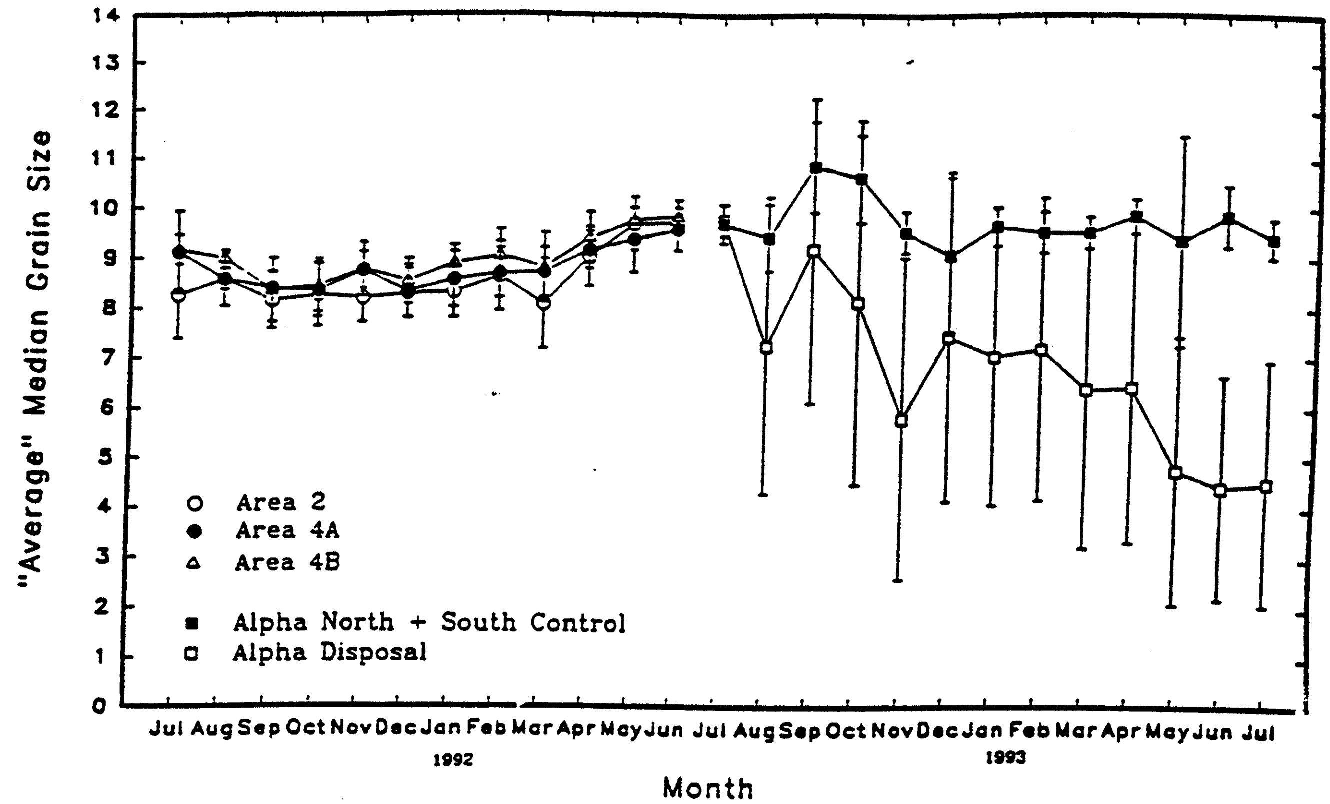



Figure 11. Bar graph of percent individuals by size class (all areas combined) for July 1991 through June 1992.

Table 9. Percent of individuals among major faunal groups from the 1986 disposal area. Pre-disposal (1986), post disposal (1988), and current (1991-92) data are presented.

| FAUNAL GROUP | Dec 86 D-4-6 | Dec 86 D-5-5 | Jan 88 D-4-7 | Jan 88 D-5-5 | Dec 91 Area 2 | Jan 92 Area 2 |
|---|---|---|---|---|---|---|
| NEMERTEA | 11.17 | 7.58 | 28.64 | 20.87 | 6.01 | 10.41 |
| ANNELIDA - Total | 71.78 | 76.13 | 43.67 | 52.35 | 39.82 | 50.30 |
| Polychaeta | 71.06 | 75.85 | 41.88 | 49.08 | 39.82 | 50.30 |
| Oligochaeta | 0.72 | 0.29 | 1.79 | 3.27 | 0.00 | 0.00 |
| Misc. Annelids | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MOLLUSCA - Total | 4.19 | 2.90 | 15.70 | 16.67 | 10.03 | 9.61 |
| Gastropoda | 1.33 | 1.16 | 5.10 | 7.14 | 9.57 | 9.13 |
| Bivalvia | 2.86 | 1.74 | 10.60 | 9.53 | 0.46 | 0.48 |
| Misc. Molluscs | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ARTHROPODA - Total | 3.97 | 4.94 | 3.82 | 3.37 | 2.77 | 1.60 |
| Myodocopa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Podocopa | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cirripedia | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mysidacea | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.15 |
| Cumacea | 1.83 | 2.03 | 3.44 | 2.48 | 1.07 | 0.33 |
| Tanaidacea | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Isoposa | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.22 |
| Amphipoda | 1.12 | 1.45 | 0.13 | 0.79 | 1.22 | 0.70 |
| Decapoda | 1.02 | 1.46 | 0.25 | 0.10 | 0.18 | 0.20 |
| Insecta | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Misc. Arthropods | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ECHINODERMATA | 5.52 | 4.95 | 5.24 | 3.97 | 3.49 | 3.68 |
| HEMICHORDATA | 3.27 | 3.49 | 0.00 | 0.00 | 37.50 | 24.24 |
| VERTEBRATA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| MISCELLANEOUS | 0.10 | 0.00 | 2.93 | 2.77 | 0.39 | 0.17 |
| TOTAL | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

- Mean benthic macrofaunal densities increased from 480 organisms per $m^2$ (71 species) for the pre-dredging sampling (June) to 3,700 organisms per $m^2$ (total 124 species) for December post-dredging. The greatest changes occurred at the offshore disposal station (C-2W), which had a density of 520 organisms per $m^2$ for June and 11,434 organisms per $m^2$ for December. Species diversity (H') increased from pre-dredging to post-dredging. The increases in faunal density and diversity were attributed to seasonal variation and not as a result of disposal of dredge material. Re-population of the disposal areas was rapid and there were no discernible effects six weeks after the end of disposal operations.



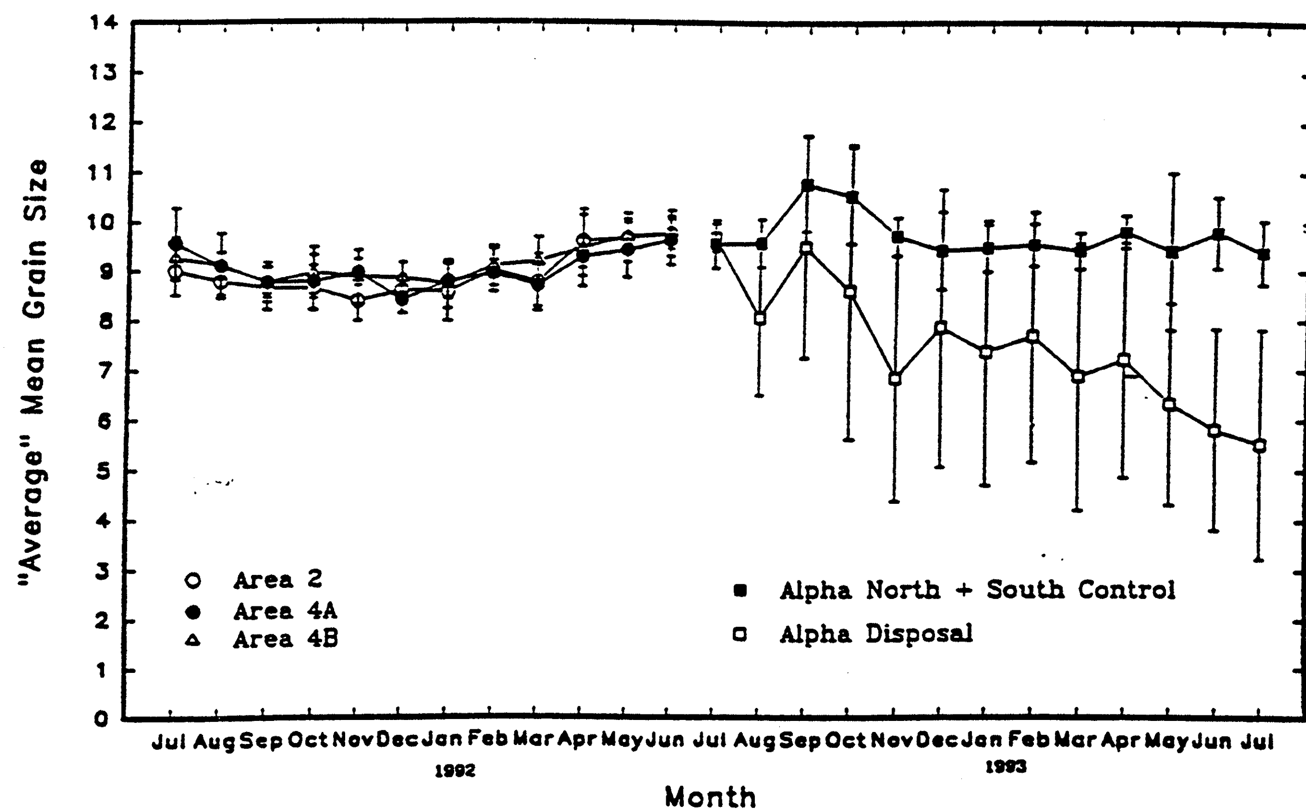




Figure 24. Average monthly mean and median grain size measurements for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Alpha Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for July 1992 through July 1993. Thin layer disposal was conducted in August 1992, prior to site sampling. Grain size is expressed as phi(ϕ) units.

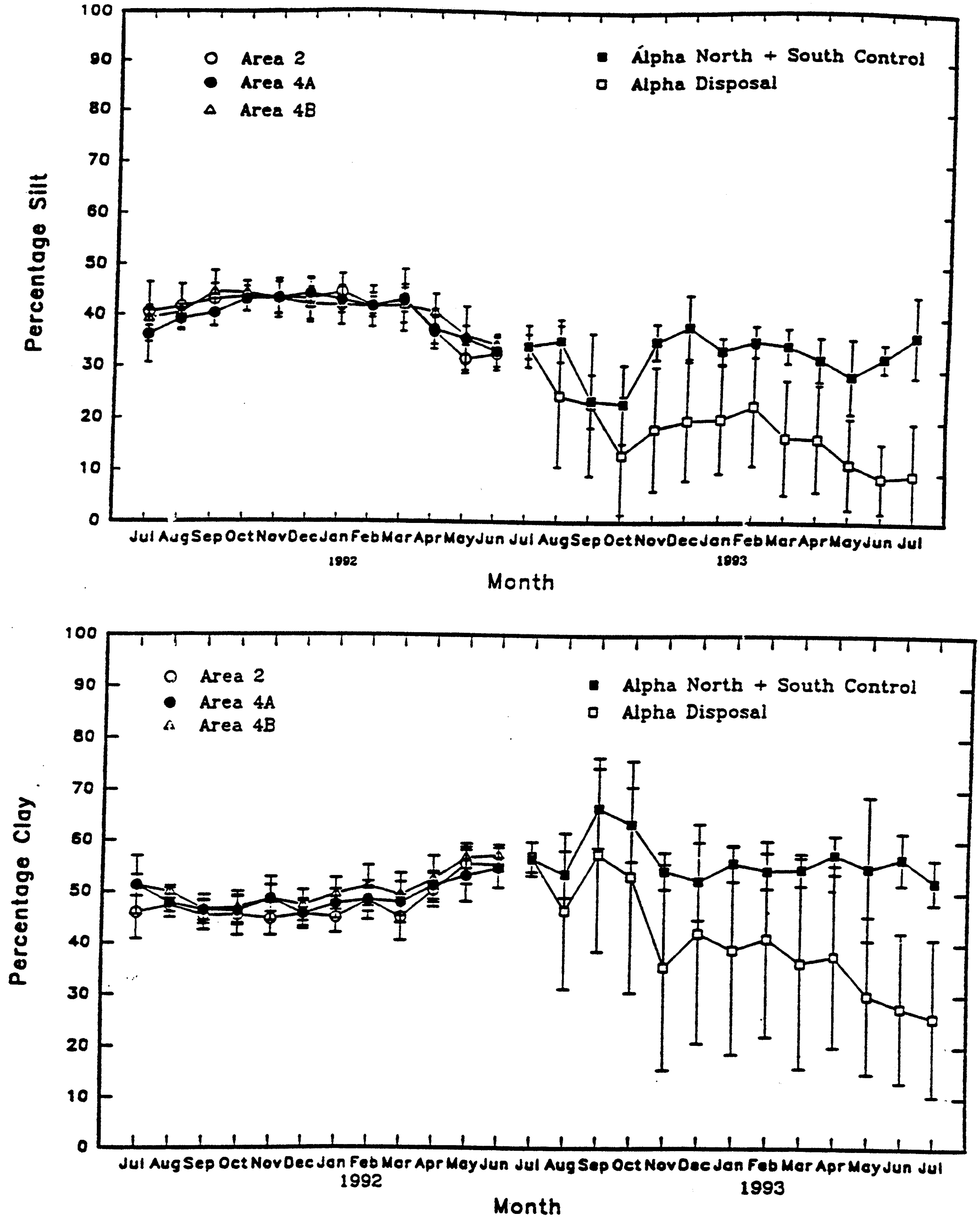



Figure 25. Average monthly percentage silt and clay of sediment samples for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Alpha Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for July 1992 through July 1993. Thin layer disposal was conducted in August 1992, prior to site sampling.

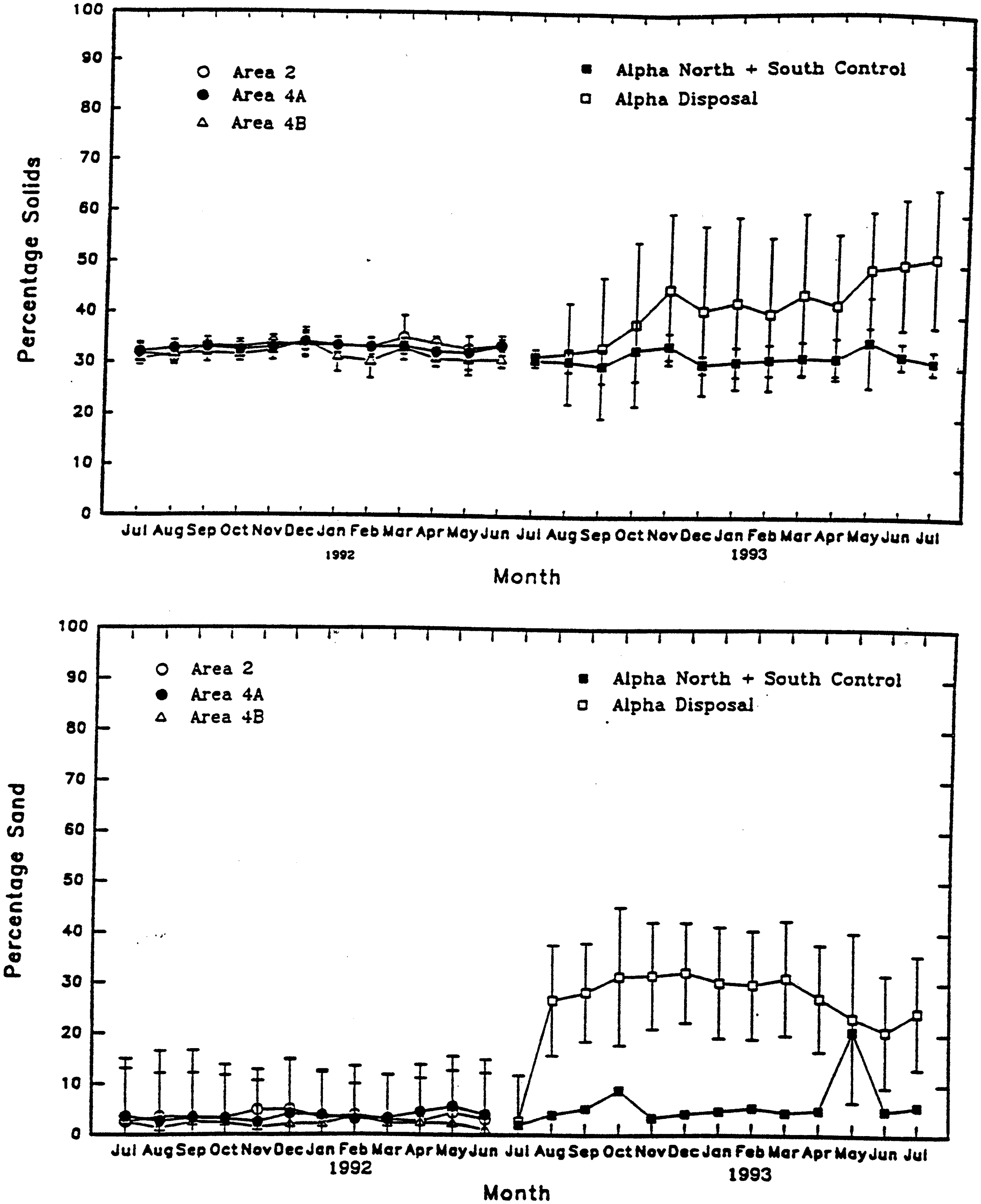



Figure 26. Average monthly percentage solids and percentage sand of sediment samples for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Alpha Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for July 1992 through July 1993. Thin layer disposal was conducted in August 1992, prior to site sampling.

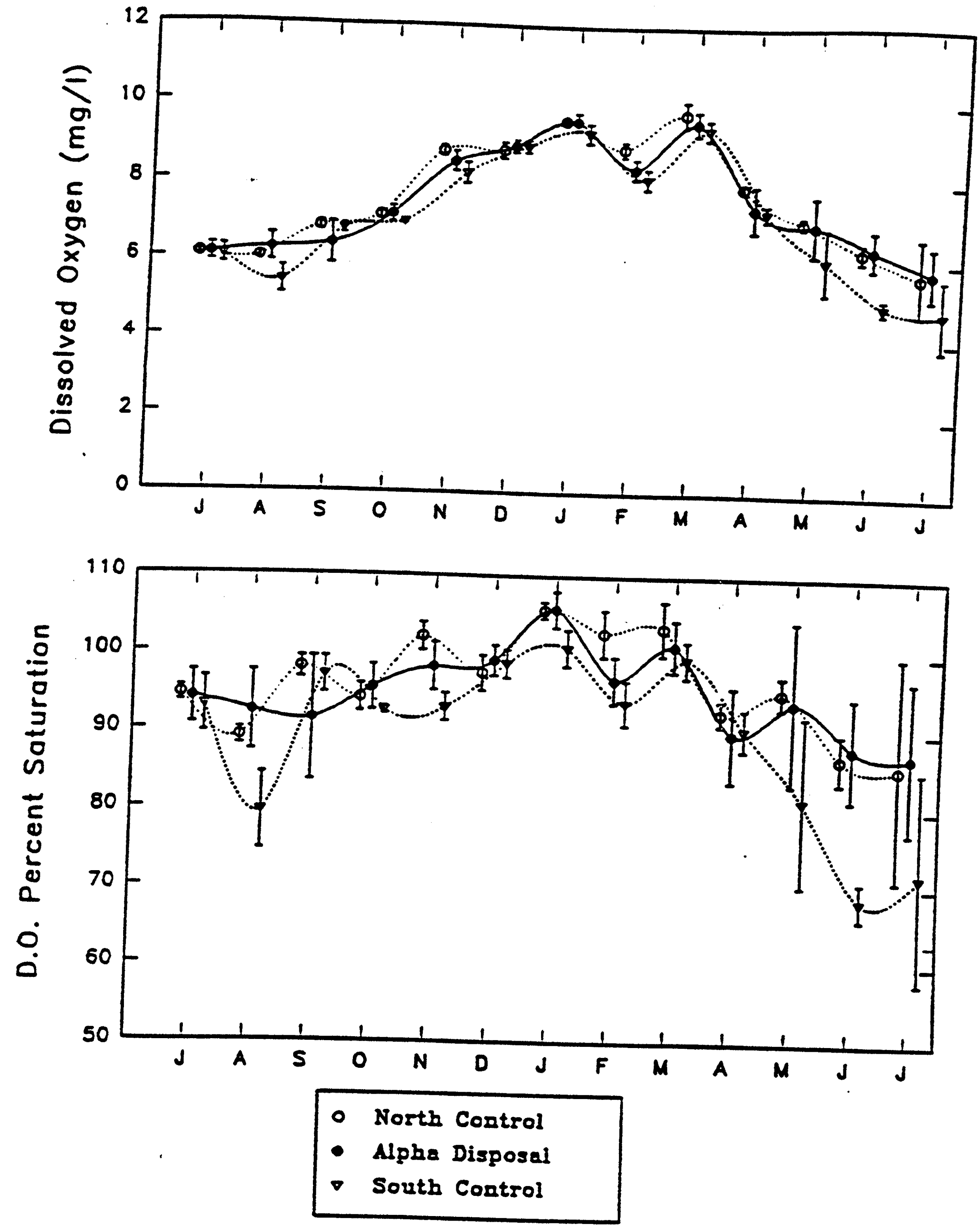



Figure 28. Monthly plots of near bottom dissolved oxygen as milligrams per liter and as percent saturation for Alpha Disposal and the North and South Control areas, July 1992 through July 1993.

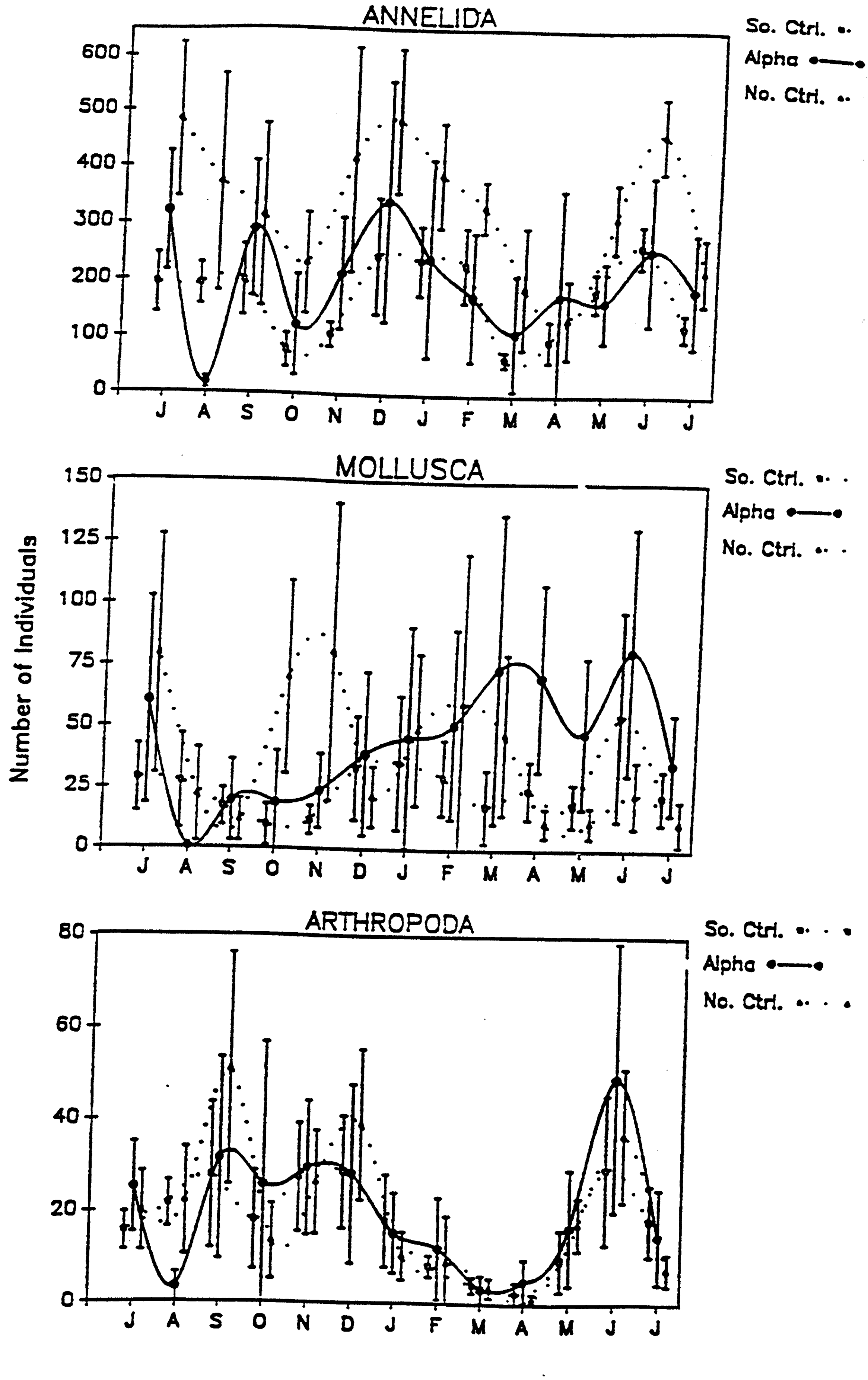



Figure 29. Mean abundance and standard deviation for three major faunal categories for Alpha Disposal and the North and South Control areas, July 1992 through July 1993.

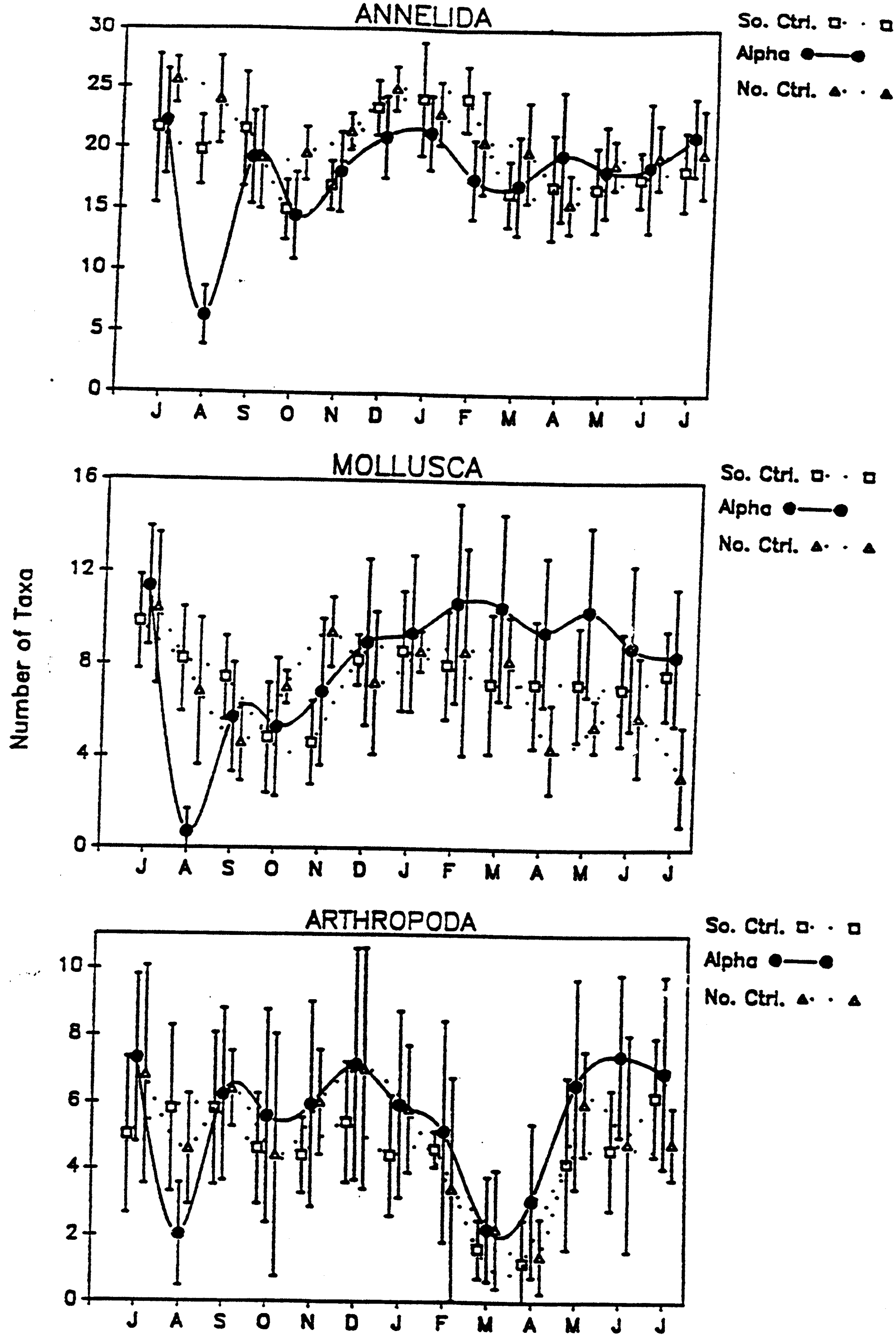
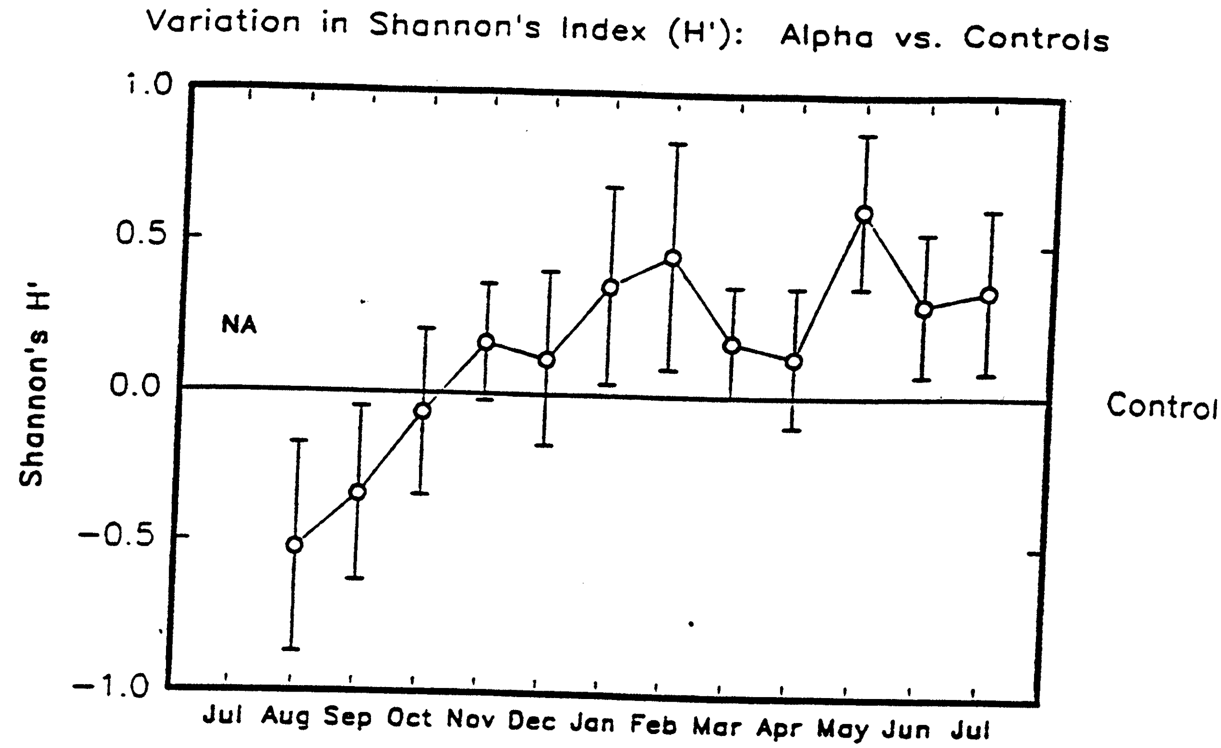



Figure 30. Mean number of taxa and standard deviation for three major faunal categories for Alpha Disposal and the North and South Control areas, July 1992 through July 1993.



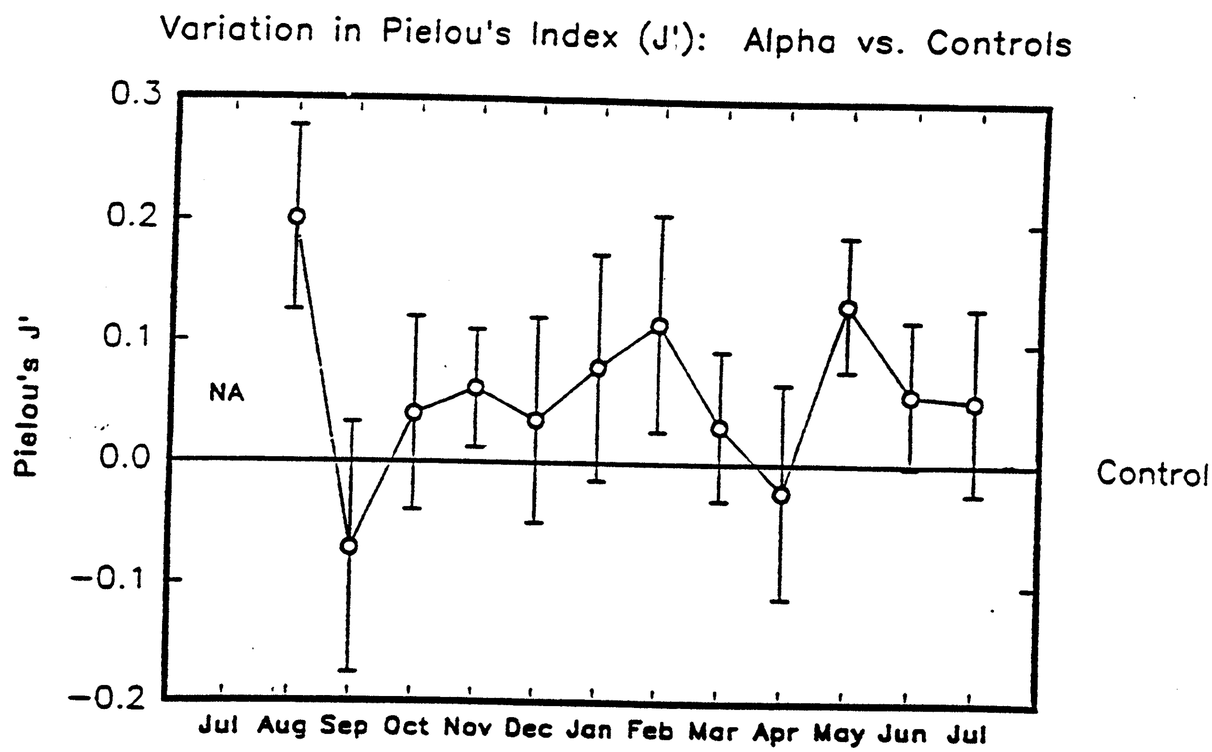
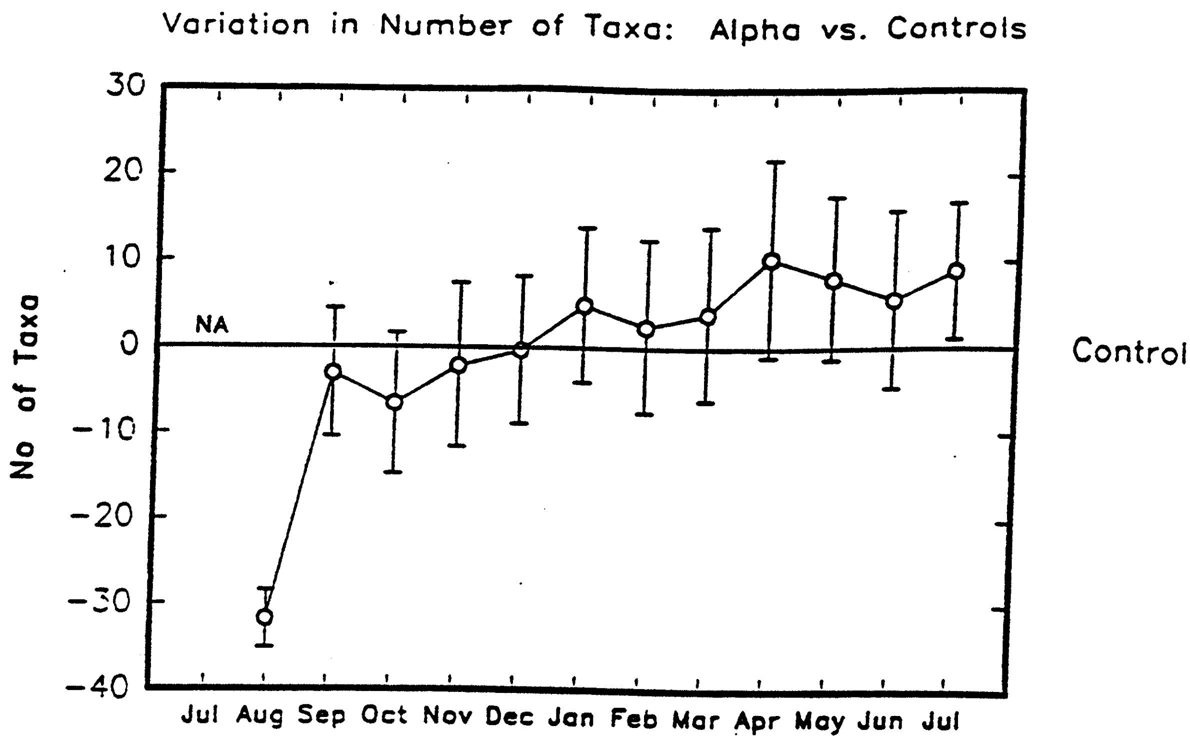




Figure 31. Comparisons of the variance of mean species diversity (H′, top) and equitability (J′, bottom) of Apha Disposal to the Control stations. The Control mean is represented as the zero line with Alpha Disposal deviations from the control mean plotted as open circles.



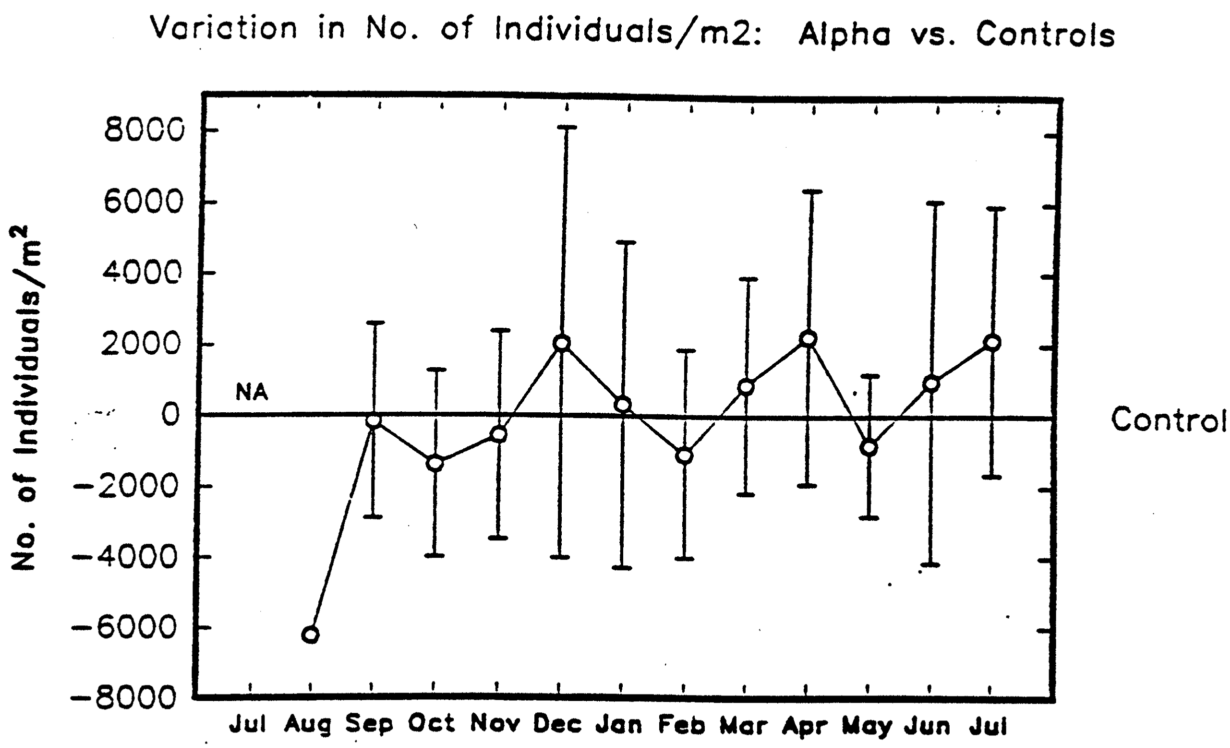
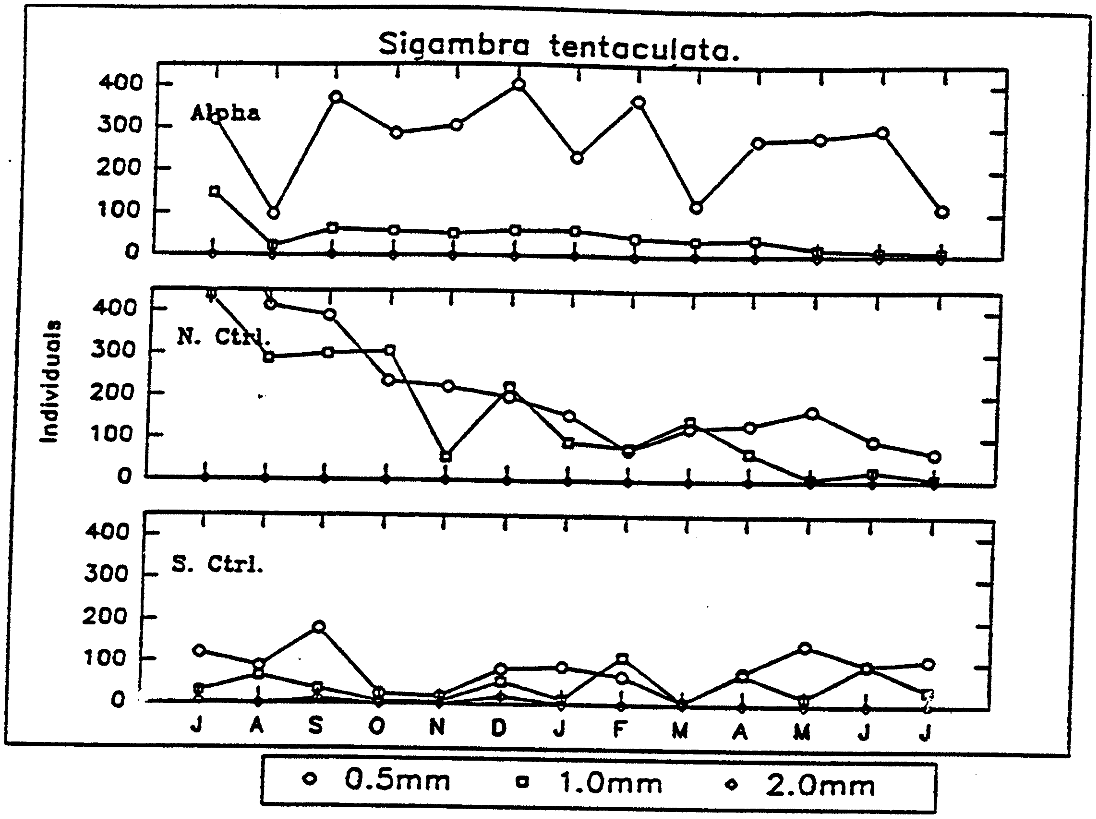




Figure 33. Comparisons of the differences in mean number of taxa (top) and mean number of individuals (bottom). The Control stations mean is represented as the zero line with Alpha Disposal deviations from the Control mean plotted as open circles.



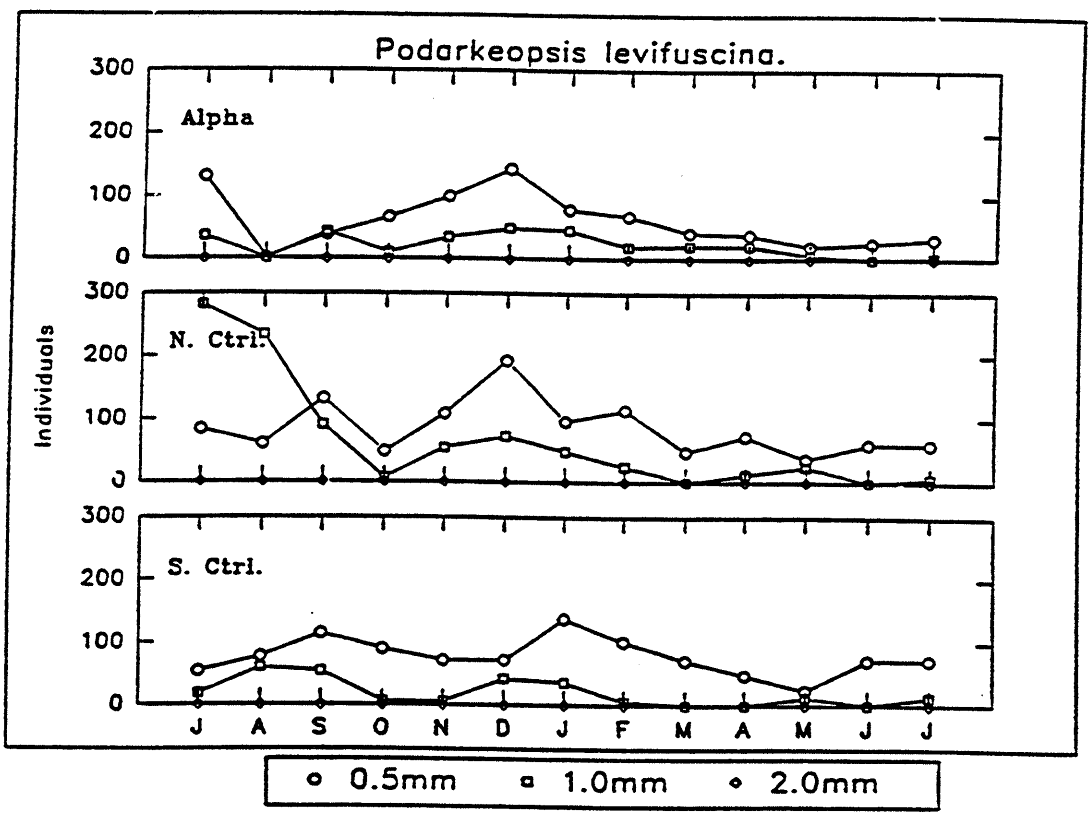




Figure 34. Monthly abundance size class distribution for Alpha Disposal and the North and South Control areas from July 1992 through July 1993.

dramatically between collections. For some months (August, March, April, May, June and July 1993) there appeared to be a central station cluster surrounded by an outer band of similar stations. This pattern indicates the possibility of two differentially impacted areas, or conversely differential recovery rates throughout the impacted area. The sediment data indicated a spatially heterogeneous thin-layer coverage with surface characteristics changing through time. It would be expected that a temporally changing substratum would result in complex faunal community. The faunal analyses indicate a complex changing fauna, generally different from both Control areas. Sediment analysis results showed that the surface grain size of Alpha Disposal was becoming more coarse through time. The continual sediment change should have also influenced the faunal composition.

The results of the cluster analysis are summarized as follows:

- North Control stations were most often most similar to other North Control stations
- South Control stations were most often most similar to South Control stations
- For pre-disposal, the South Control stations were more similar to Alpha Disposal stations than to North Control stations
- Post disposal North and South Control stations were more similar to one another than they were to Alpha Disposal stations
- For Alpha Disposal the patterns of similarity were complex and without obvious spatial relationships, particularly at the highest levels of similarity.

### 4.3 Conclusions

Thin-layer disposal on area Alpha resulted in an increase in mean grain size and variability. Coarse material deposited on Alpha Disposal increased heterogeneity of the sediments and an increase in sand composition. Over time, the sediments became more coarse unlike Control sediments which remained stable. In a strict sense Alpha disposal experienced "environmental impact" in that the post disposal faunal community was altered to a state different from it's original state and different from the Control sites. The meaning of this "environmental impact" however is unclear. Alpha Disposal showed a very rapid recovery following thin-layer placement. For many benthic invertebrates the spawning cycle initiates in the spring as the coastal waters warm. Summer and fall are peak benthic recruitment periods with planktonic larvae settling from the water column. The rapid recovery of Alpha may be due to the summer and fall recruitment period as there was evidence of both planktonic and adult recruitment at this area. Adult recruitment can be both by organisms which were occupying the site prior to disposal, survived the thin-layer placement, and burrowed to the surface, as well as by organisms which migrate into the site from adjacent areas. By the end of the first year, Alpha Disposal exhibited a greater faunal diversity and abundance than the Control areas and greater than the pre-disposal studies. The benthic community composition was also more complex and spatially heterogeneous than before. Classically diverse systems are considered 'healthy' and the more diverse a system, the more healthy and more resilient. Therefore, although the community has changed due to impacts from the thin-layer disposal, the changes are not considered

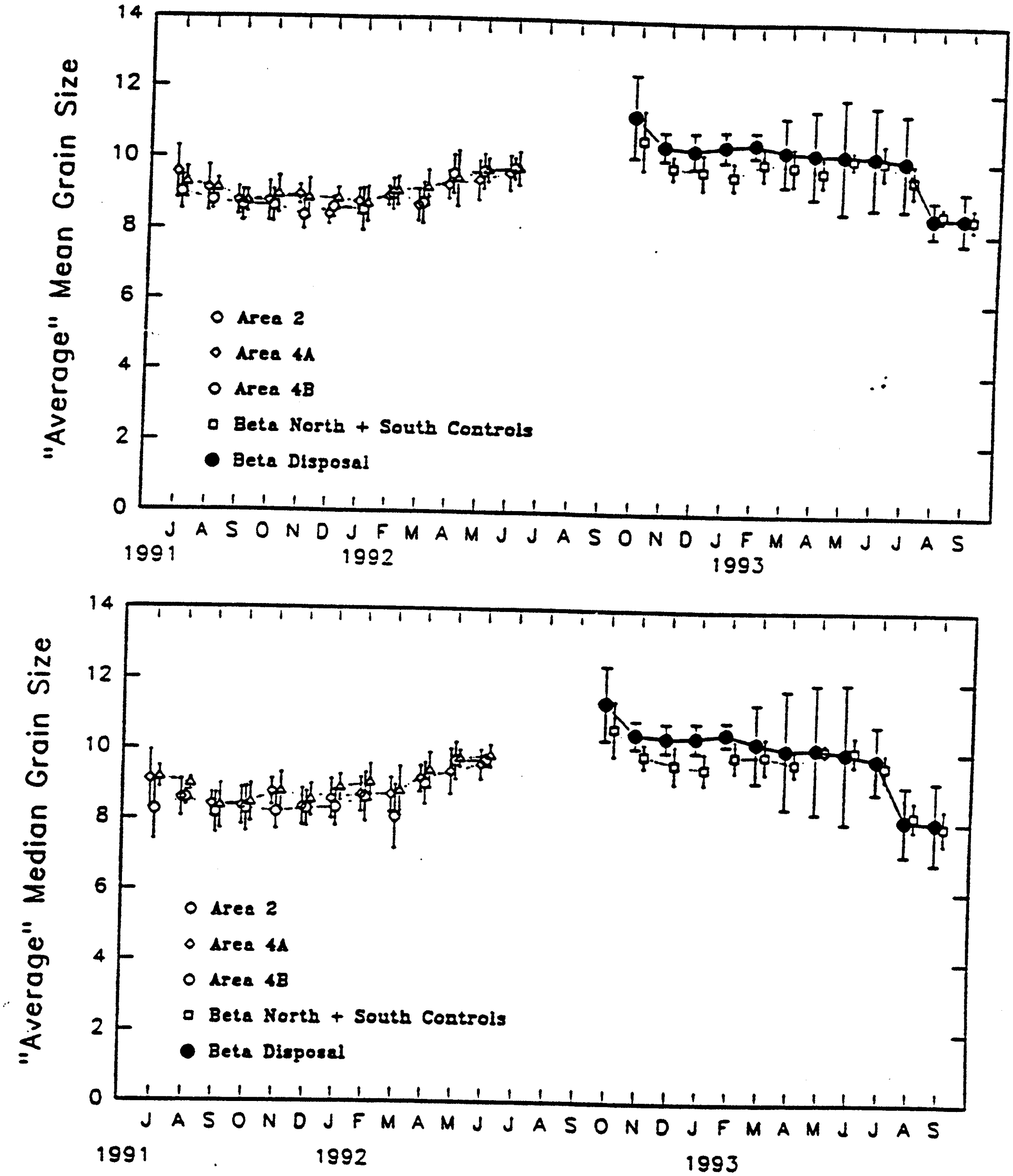



Figure 43. Average monthly mean and median grain size measurements for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Beta Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for October 1992 through September 1993. Grain size is expressed as phi (ϕ) units.

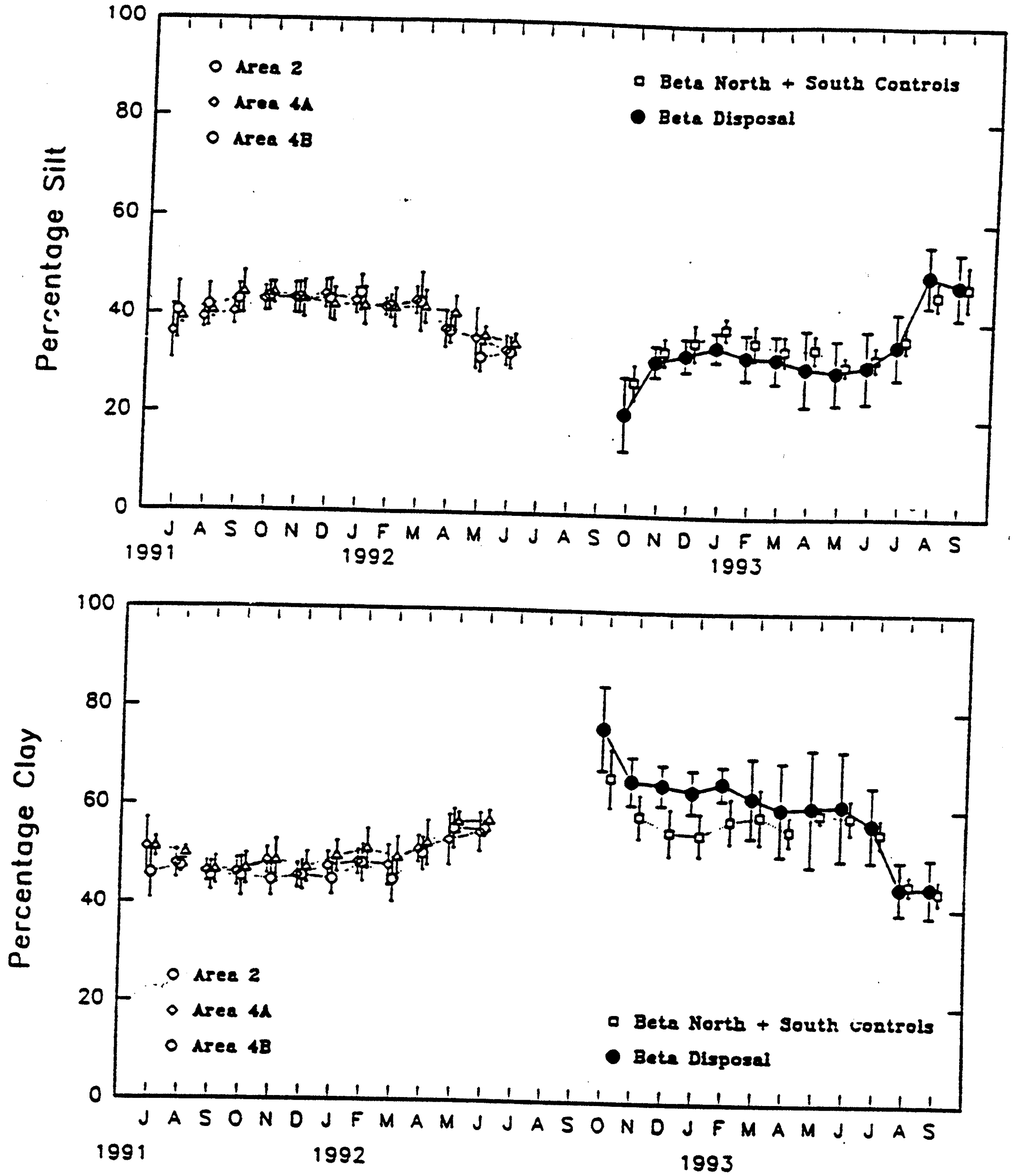



Figure 44. Average monthly percentage silt and clay of sediment samples for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Beta Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for October 1992 through September 1993.

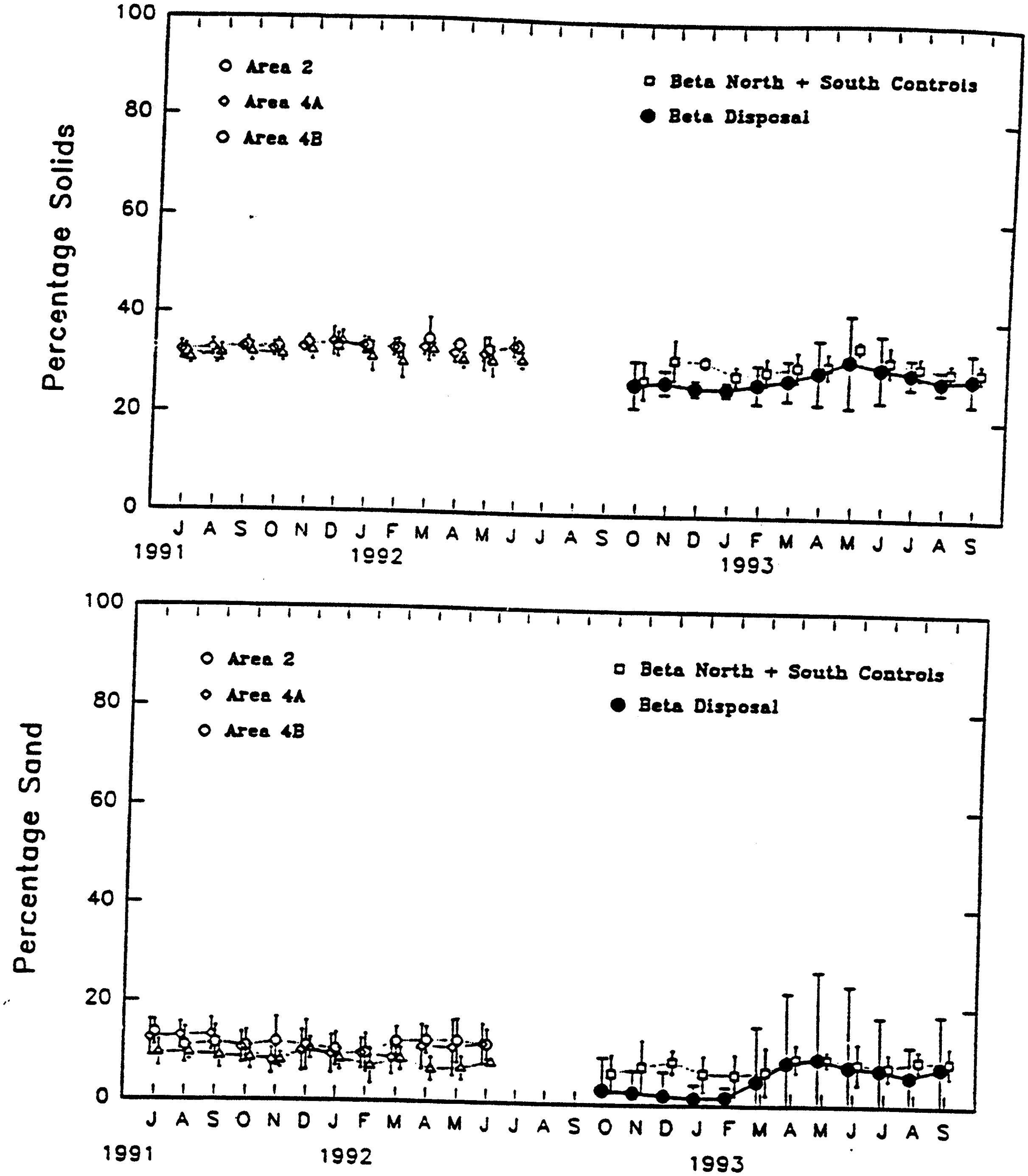



Figure 45. Average monthly percentage solids and percentage sand of sediment samples for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Beta Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for October 1992 through September 1993.

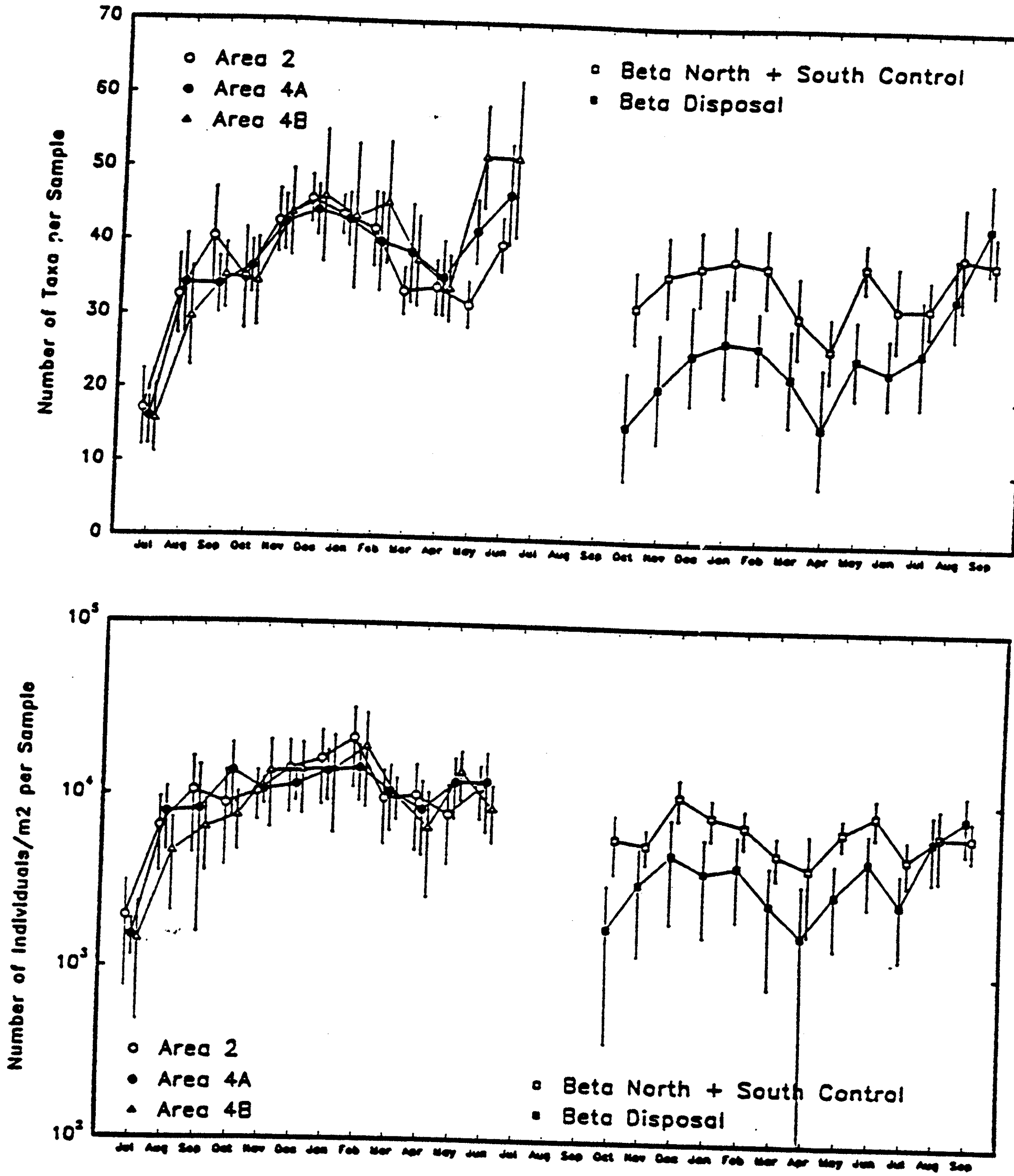



Figure 50. Average monthly number of taxa and individuals per sample for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Beta Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for October 1992 through September 1993.

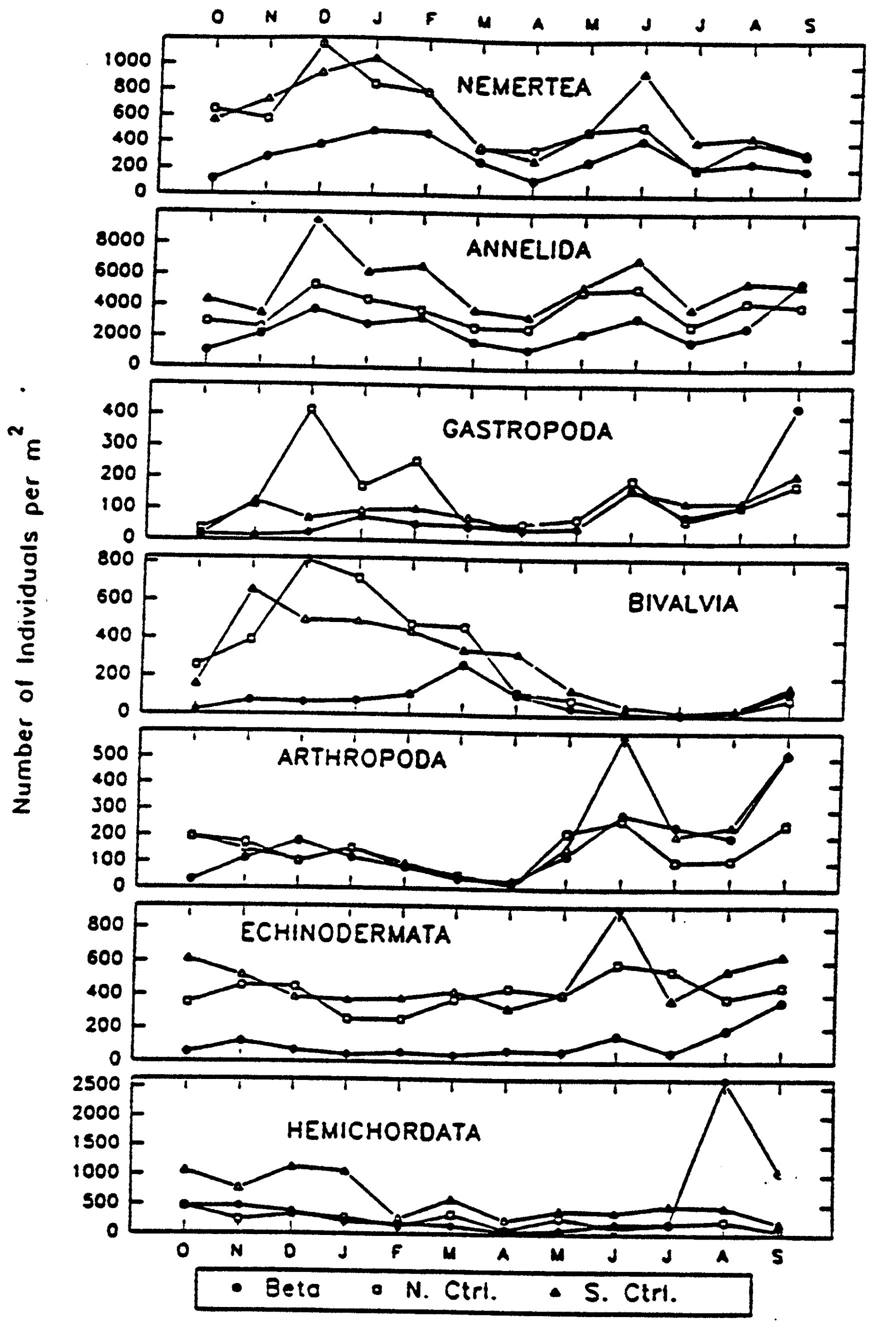



Figure 51. Mean abundance for major faunal categories for Beta Disposal, and North and South Controls. October 1992 through September 1993.

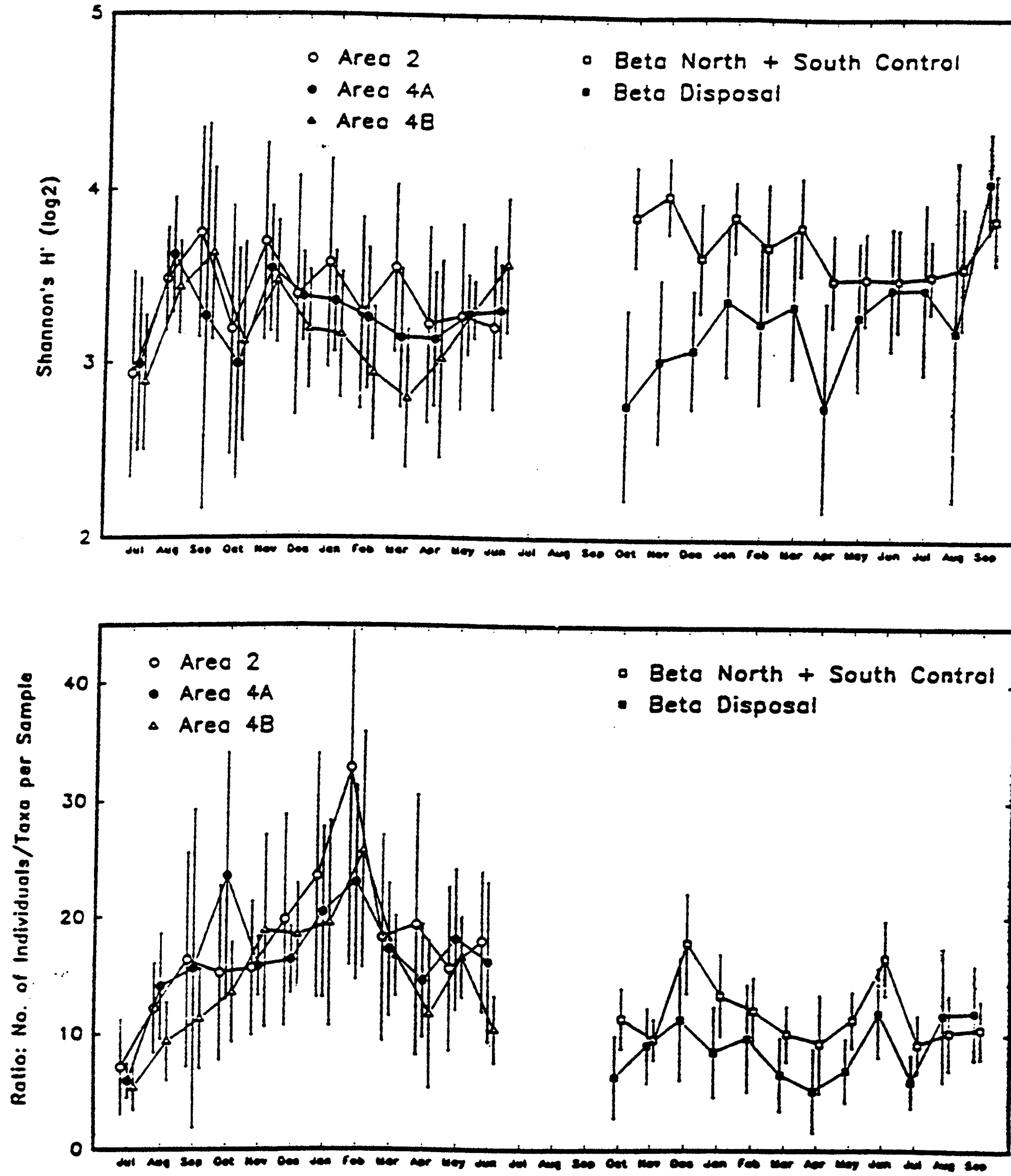



Figure 56. Average faunal diversity (H') and ratio of individuals/taxa for areas 2, 4A and 4B of the base year monitoring (n = 10 samples/area) and Beta Disposal (n = 30 samples/month) and North + South Controls (n = 10 samples/month) for October 1992 through September 1993.

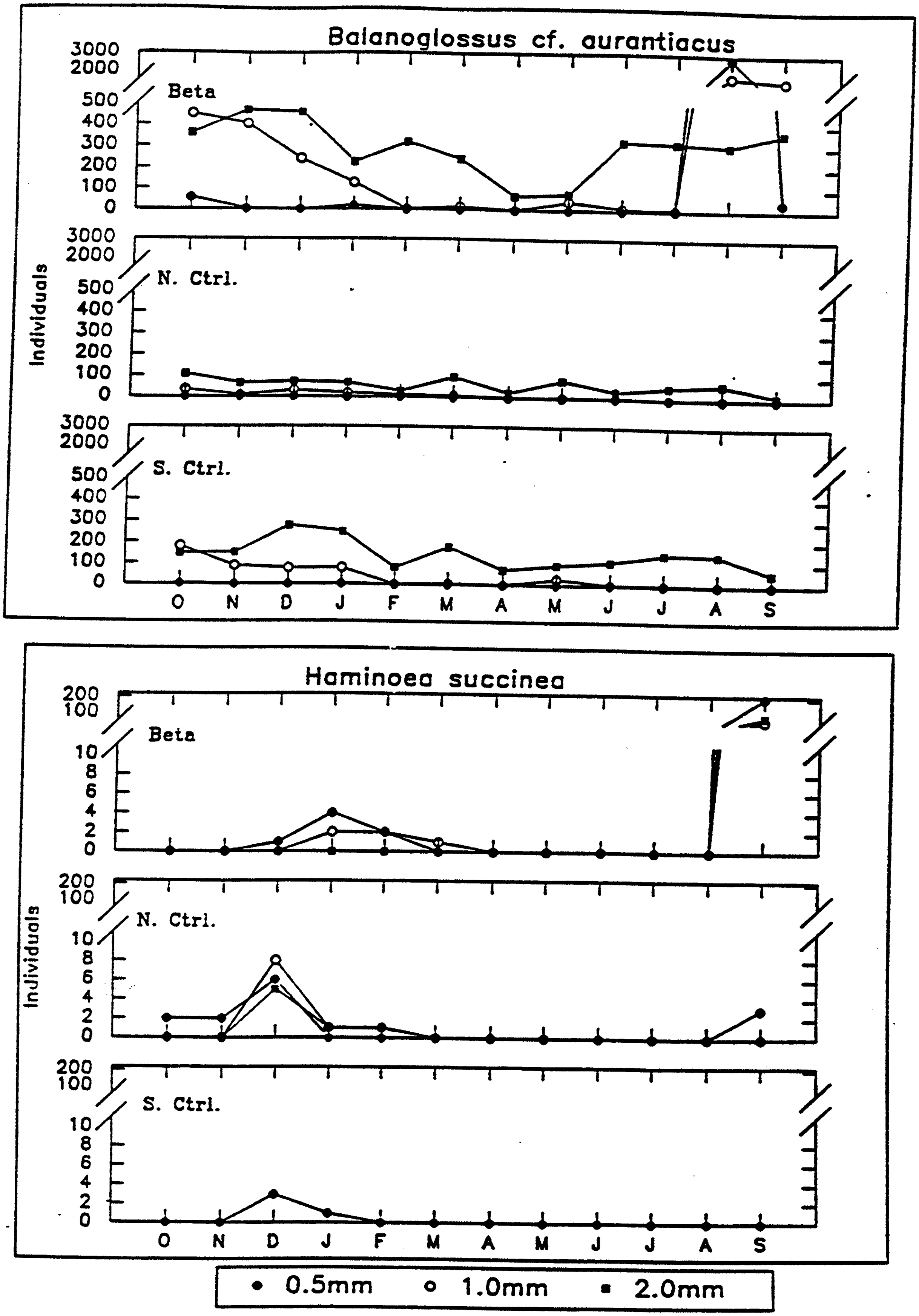



Figure 59. Monthly abundance size class distribution for Beta Disposal and the North and South Control areas from October 1992 theough September 1993.

## 5.3 Conclusions

As with Site Alpha, we again see an impact to area sedimentary parameters. In this case. however, finer grained sediments were placed on the site during the thin-layer placement. Theoretically the introduction of fine grained particles could have had a significant impact on macroinfaunal community structure and recovery by choking out filter feeders or making mobility by surface dwelling organisms more difficult due to the soft and shifting nature of the deposited sediments. This is not the case at area Beta since immediate recolonization by filter feeding surface dwelling organisms was observed. More than likely the length and cyclic nature of the recovery is due primarily to the temporal aspects of the thin-layer placement. As mentioned earlier, summer and fall are peak larval recruitment periods for macroinfauna and this is a major means for many species to repopulate, especially those considered to be representative of Stage I. Since disposal took place between late September and early October, it is possible that many of the fall recruitment class were buried by the thin-layer deposit and due to their small and fragile nature were not able to migrate upward through the dredged material. Recolonization by a number of species did begin immediately following disposal however this was likely due to migration from adjacent areas or possible upward migration through the dredged material of larger and more motile individuals. The basis for this is that similar recruitment events were not noted for these same species in the control areas therefore a large scale larval recruitment is an unlikely cause for the recolonization. Following the summer recruitment in May - June, which was seen at both the disposal area Beta and the control areas, the macroinfaunal community of the disposal area began to mimic that of the control areas, although neither area was compatible to that seen in the pre-disposal survey. Upward migration of at least one Stage III species, *Balanoglossus*, was noted to occur immediately following disposal. Other Stage III species, the echinoderms, were absent from the area, probably due to the increase in fine grained sediments since they are positively associated with sandier sediments. Only Ophiuroidea spp. and *Micropholis atra* had recovered to near control abundances by one year following placement. *Hemipholis elongata* abundance in the disposal area was more similar to those from the pre-disposal survey areas than the control areas.

# 6.0 DELTA RESULTS

Contract specifications required that the thin-layer placement at area Delta occur between March 15 and April 15, 1993, however equipment problems caused the initiation of placement to be delayed to 4 May 1993. Placement was interrupted on 8 May by bad weather and was resumed on 11 May. Approximately 330,000 cubic yards of new work dredged material were placed on the Delta site between 4 May and 25 May, 1993. The initial post disposal sampling of macroinfauna at Delta was scheduled to be completed 20 - 23 April. This sampling was completed on time and will serve as a check to the pre-

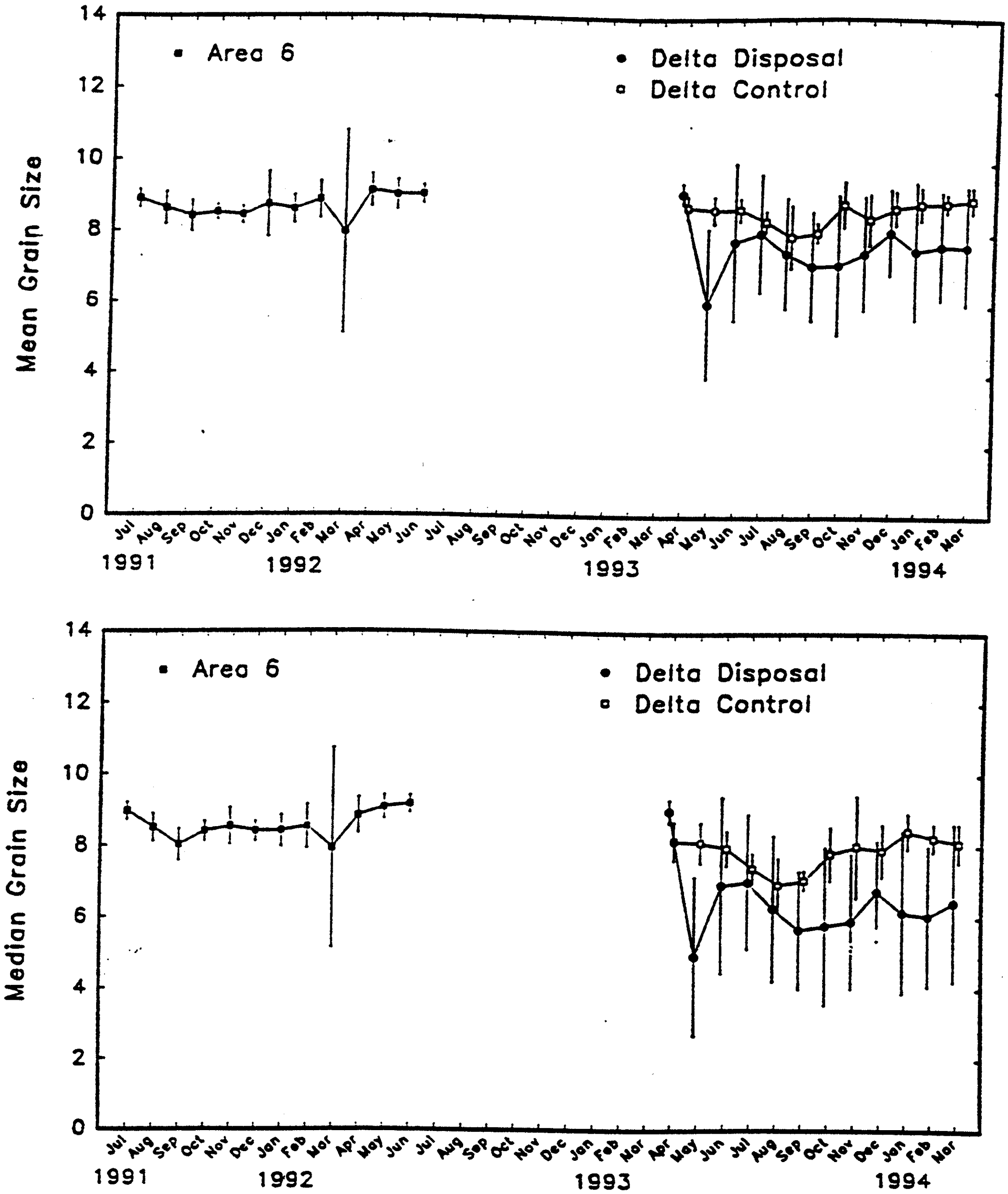
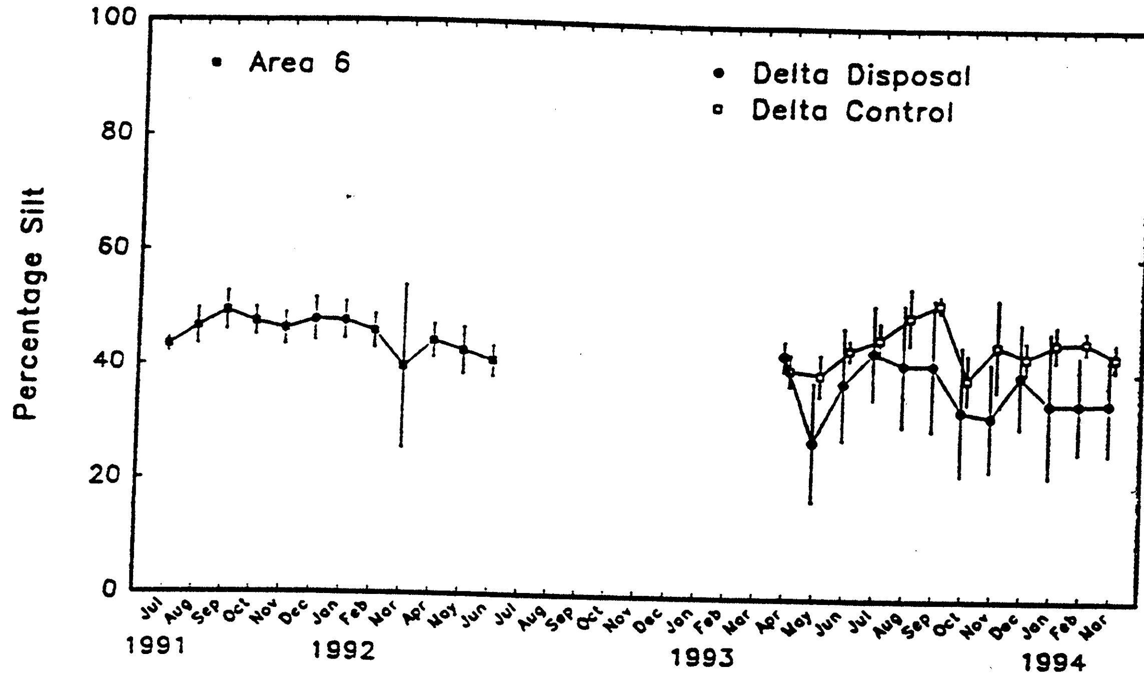



Figure 67. Average monthly mean and median grain size measurements for area 6 of the base year monitoring (n = 10 samples/area) and Delta Disposal (n = 30 samples/month) and South Control (n = 10 samples/month) for April 1993 through February 1994. Grain size is expressed as phi ($\phi$) units.



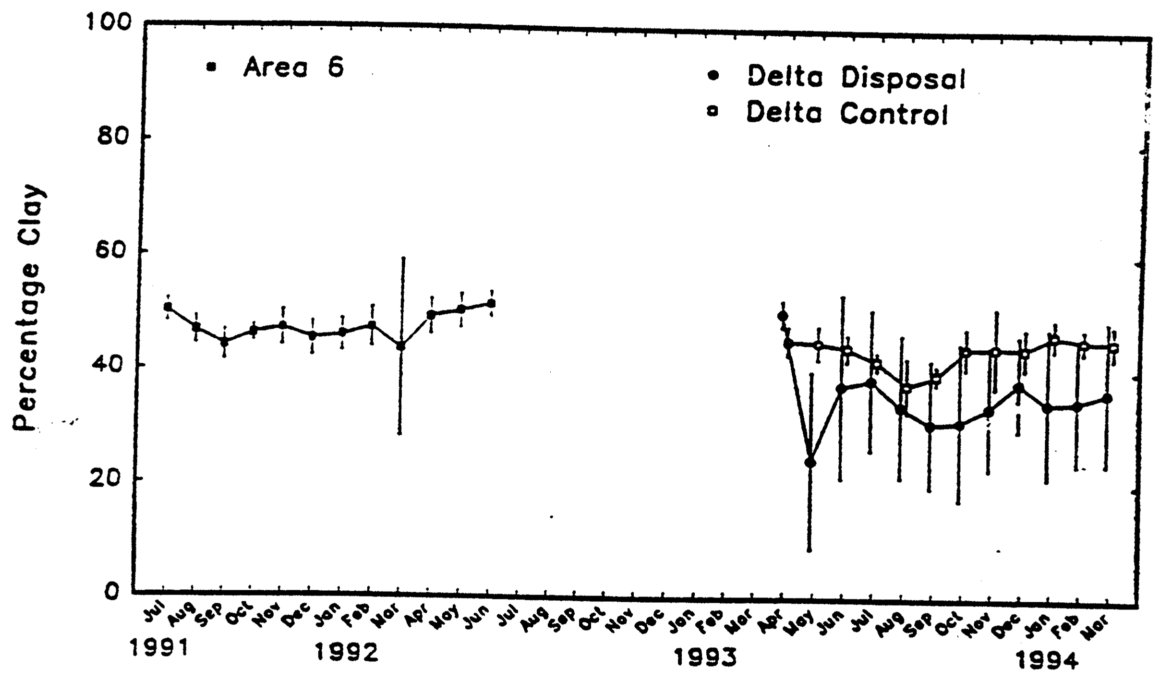
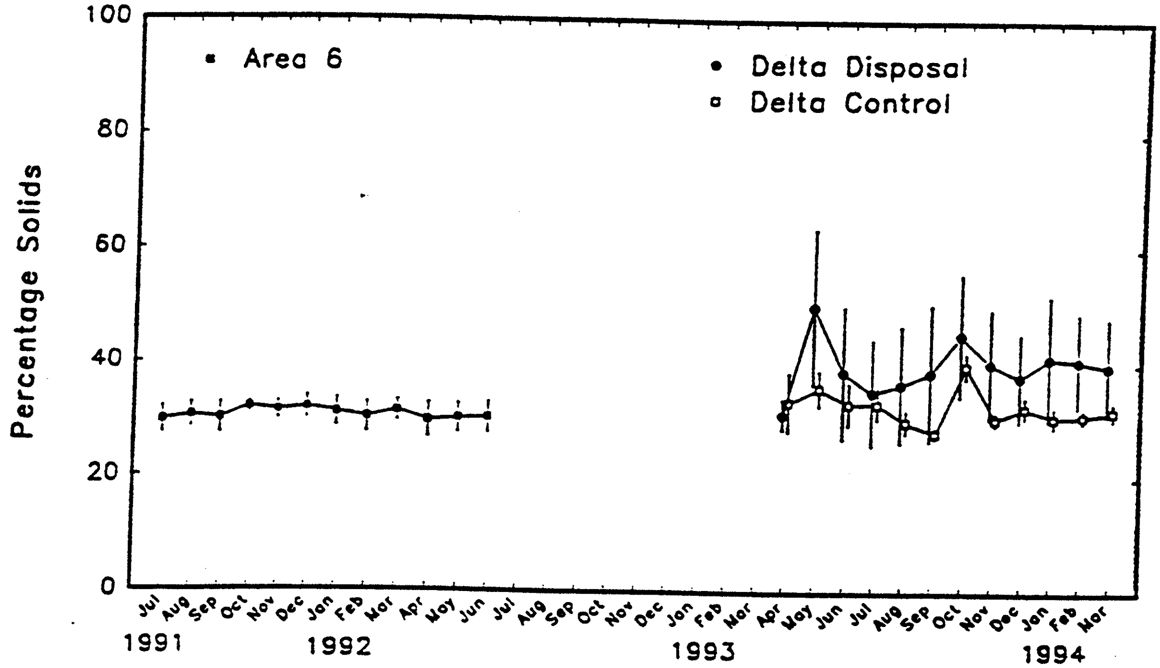




Figure 68. Average monthly percentage silt and clay of sediment samples for area 6 of the base year monitoring (n = 10 samples/area) and Delta Disposal (n = 30 samples/month) and Control (n = 10 samples/month) for April 1993 through February 1994.



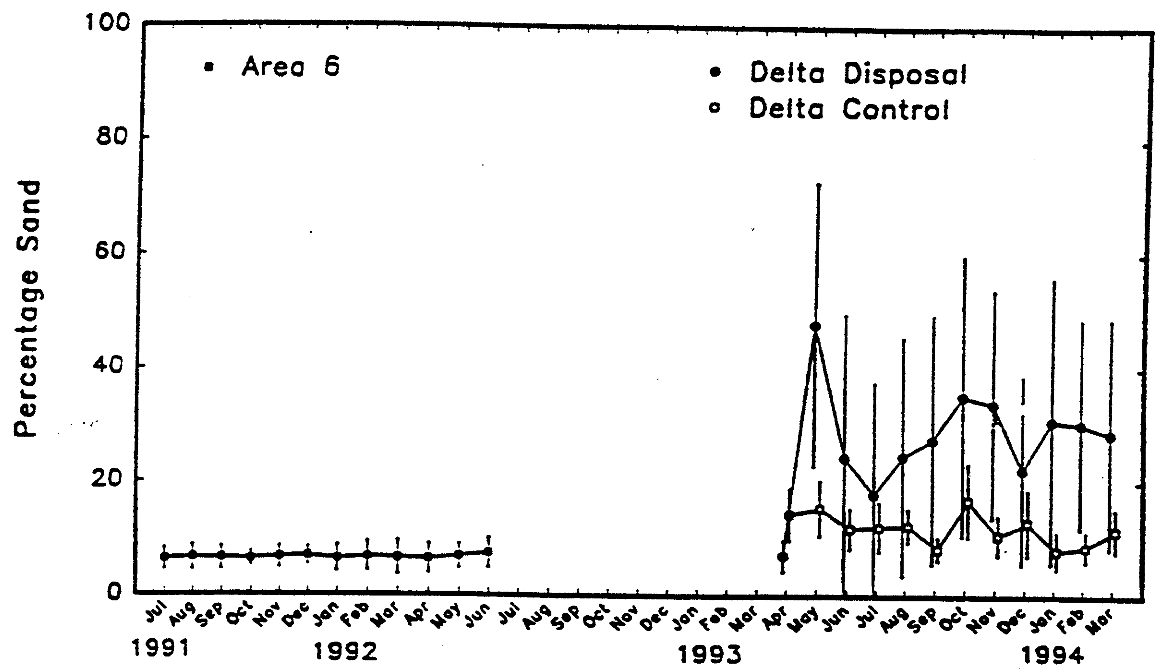
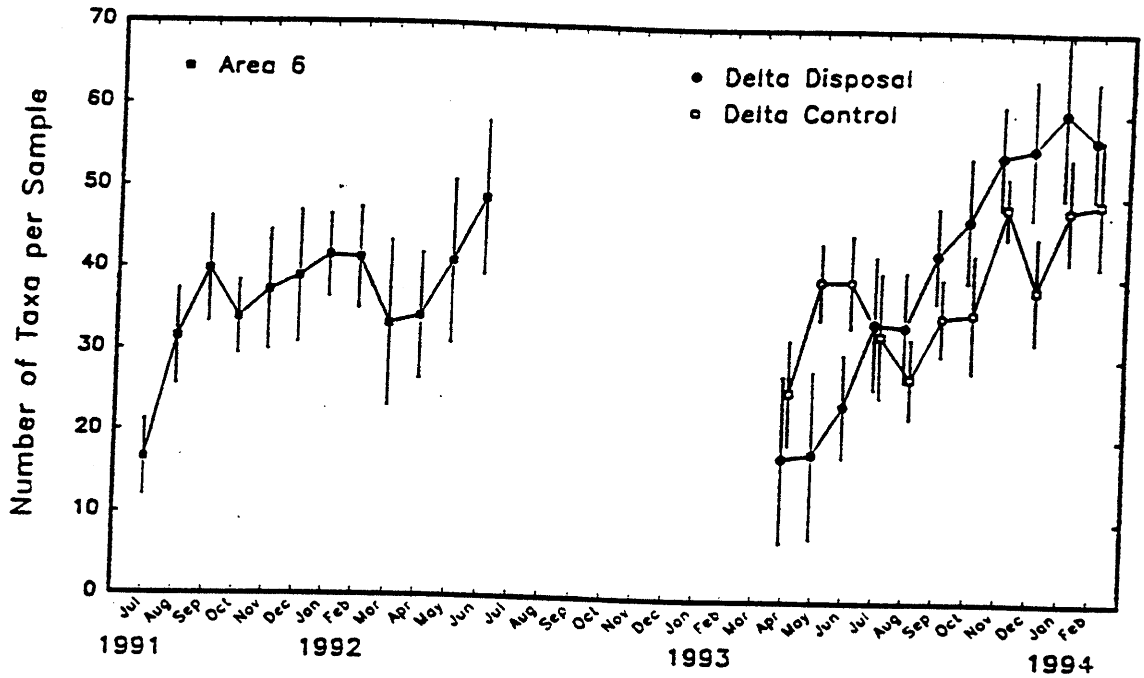




Figure 69. Average monthly percentage solids and percentage sand of sediment samples for area 6 of the base year monitoring (n = 10 samples/area) and Delta Disposal (n = 30 samples/month) and Control (n = 10 samples/month) for April 1993 through February 1994.



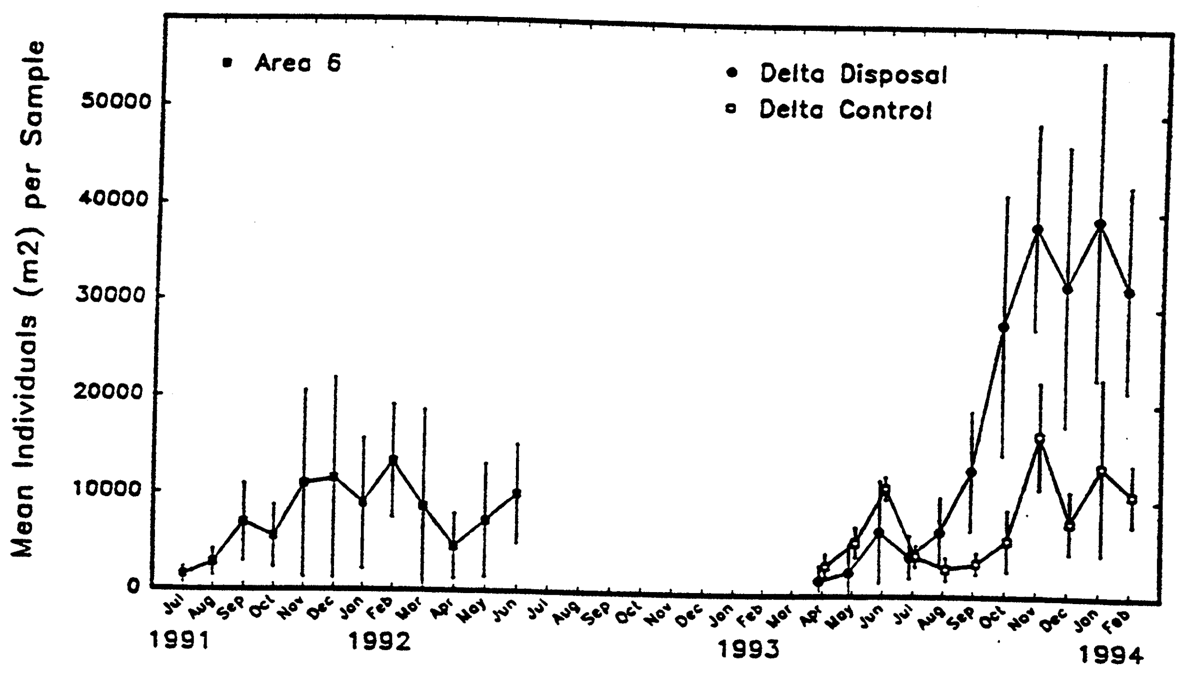




Figure 74. Average monthly number of taxa and individuals per sample for area 6 for the base year monitoring (n = 10 samples/area) and Delta Disposal (n = 30 samples/month) and Control (n = 10 samples/month) for April 1993 through February 1994.

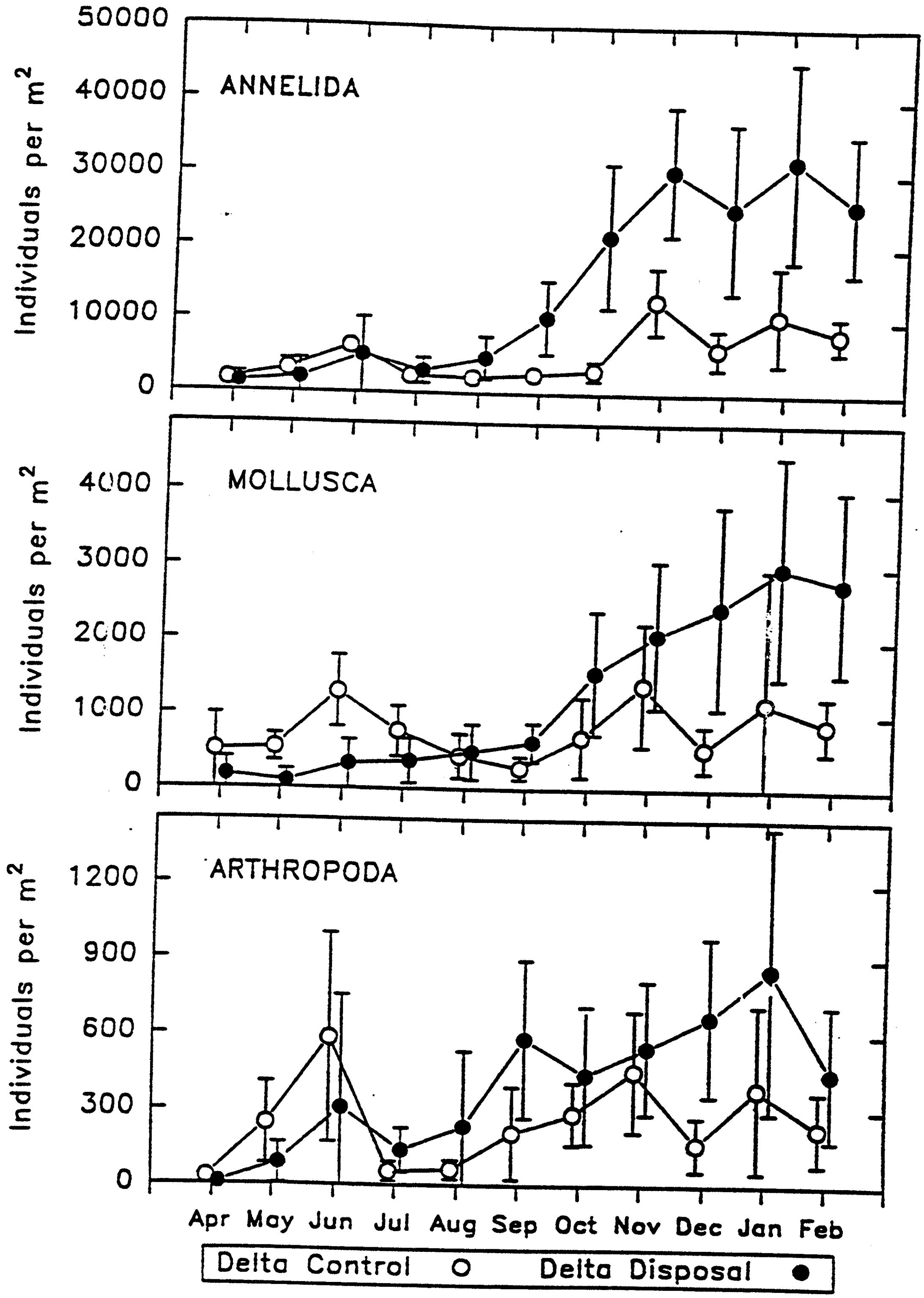



Figure 75. Mean abundance for major faunal categories for Delta Disposal and Control areas, April 1993 through February 1994.

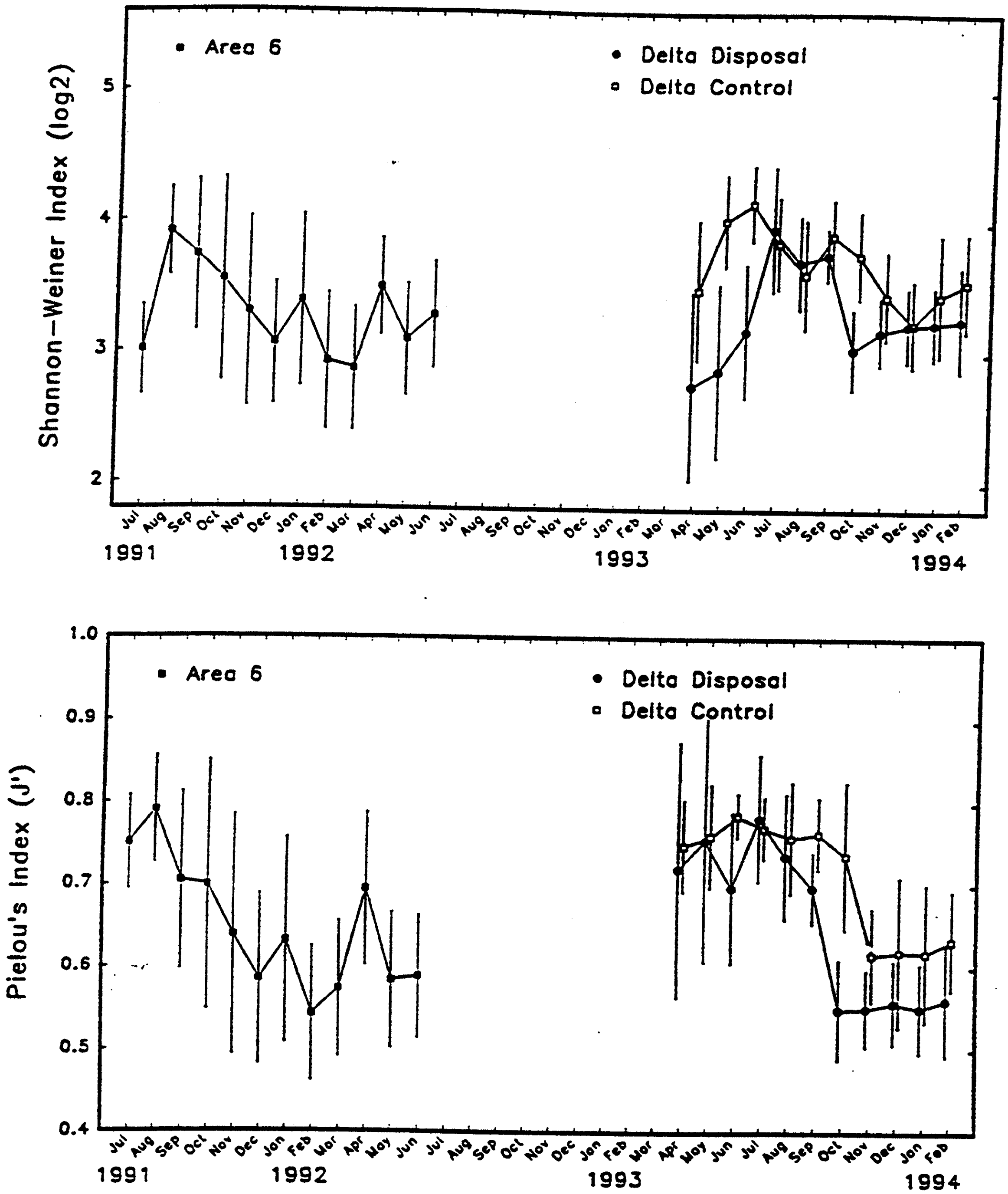



Figure 76. Average monthly faunal diversity (H', top) and equitability (J', bottom) for are 6 for the base year monitoring (n = 10 samples/area) and Delta Disposal (n = 30 samples/month) and Control (n = 10 samples/month) for April 1993 through February 1994.

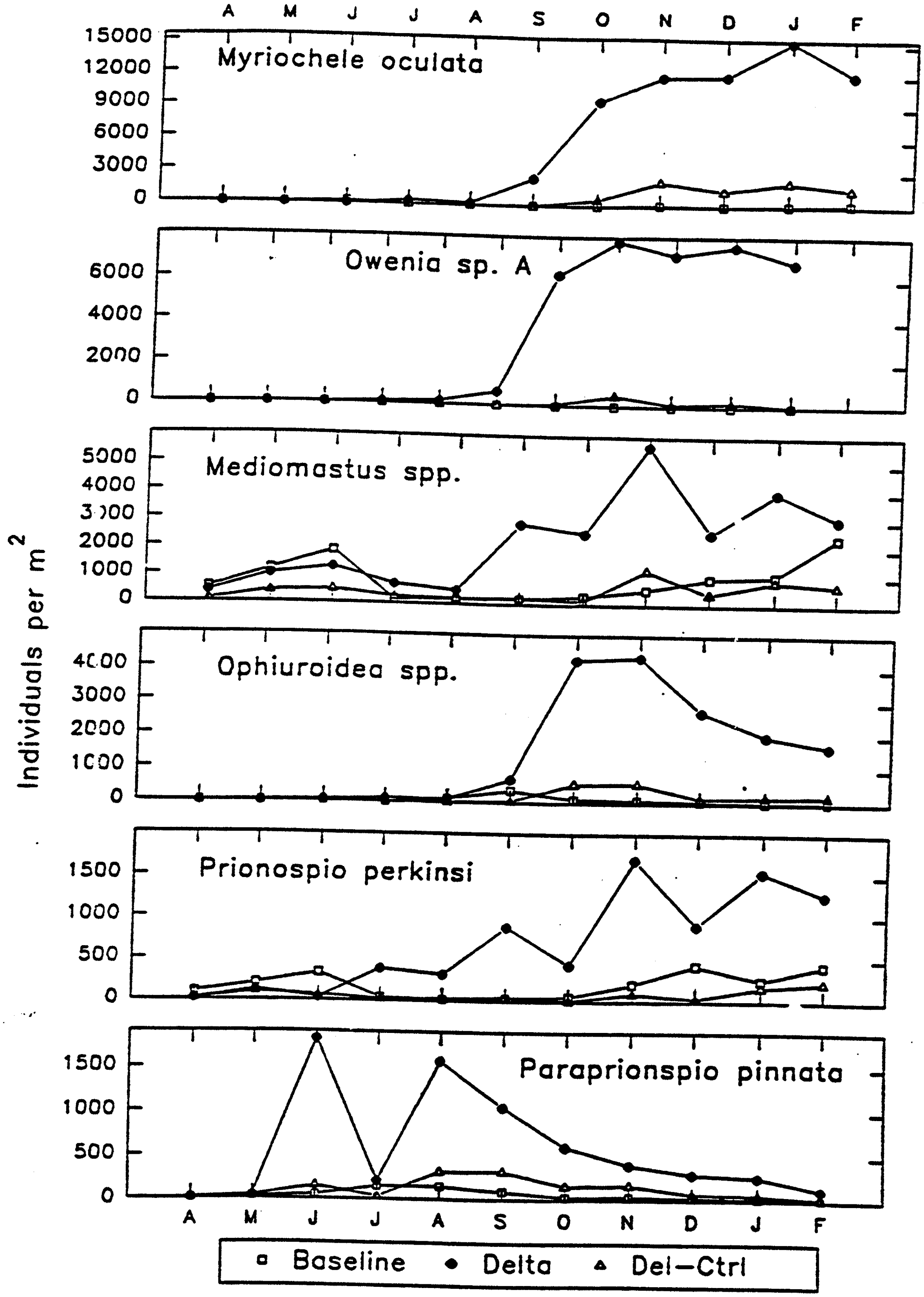



Figure 77. Comparison of abundance (#/$m^2$) of dominant fauna for the Base Year (1991 - 1992, area 6), Delta Disposal, and Control areas (1993 - 1994).

Throughout most of the sampling year, Control stations were more similar to other Control stations than Delta Disposal stations. This is evident for the area even before the thin-layer placement of dredged material began and it is characteristic of the variability of the benthic communities of an area. Among the Control stations, two groupings were noticed for most of the later sampling dates with one of the groups usually including one or more Delta Disposal stations. Overall, Delta Disposal stations showed signs of spatial separation, but no significant patterns were noticed. Over time, high similarity linkages became more common, signifying a more established community within the Delta study area.

## 6.3 Conclusions

Disposal operations at Delta brought on significant changes in sediment parameters. Sediments in Delta Disposal experienced increases in sand and in grain size while also becoming highly variable in composition. Over time, sediment characteristics began to return to pre-disposal levels with decreased grain size and sand content though high variability remained. Over time, more established benthic faunal species would produce a more homogenous sediment bed as seen in the pre-disposal survey. Thin-layer placement at Delta Disposal did not result in short or long-term impacts to the benthic community as measured by number of taxa, abundance of individuals, or diversity. In fact, Delta Disposal showed increases in each of these community parameters within two months from the time of disposal. Recovery was quick and ultimately the community of Delta Disposal was more diverse than the Control area with higher abundances and larger number of taxa. It appears that the thin-layer disposal which caused an increase in the heterogeneity of the sediments is responsible for these increases. Species composition underwent a significant change from silt to sand preferring species. This diversification of fauna provides opportunities for new niches to be developed while also creating a more 'healthy' system.

using a real-time positioning system, and trisponders mounted fore and aft continually monitored bathymetry. Accuracy of the trisponders were checked frequently with lead lines. The discharge barge was connected to a swivel barge by a pontoon dredge line. Tender boats and pulleys moved the discharge barge through an arc, and the swivel barge was relocated as needed. Thin-layer disposal occurred three times, July 1992, September/October 1992, and March/April/May 1993 and two disposal areas were used each time. Water quality was monitored during the latter two disposal events when approximately 300,000 cubic yards (229,000 cubic meters) of material were placed into each of four disposal sites.

## General Monitoring Plan

Four disposal events were monitored, and each event had a separate disposal area (Foxtrot, Beta, Zulu or Delta; Figure 2). The four disposal areas were grouped into two pairs (Foxtrot and Beta; Zulu and Delta), with one member of each pair used for maintenance material (Foxtrot and Zulu) and the other for new-work material (Beta and Delta). Each pair of disposal areas was used for one channel reach. Boundaries of channel reaches were set so removal of maintenance and new-work material should each require 10 days. Disposal occurred in Foxtrot and Beta during September/October 1992; disposal occurred in Zulu and Delta during March/April/May 1993.

The monitoring for each disposal area had four phases: predisposal, during disposal, short-term postdisposal, and long-term postdisposal. Table 1 outlines how sampling efforts were partitioned during each phase. Under the target plan, disposal would occur continuously at a site for 10 days. One set of predisposal sampling was targeted for the five days before the beginning of the 10-day period. Three sets of during disposal sampling were targeted for days 6-10 of the 10-day period. One set of short-term postdisposal sampling was targeted for the five days immediately after the disposal period. Six sets of long-term postdisposal sampling would begin a month after disposal ended and proceed at monthly intervals. Each monitoring set consisted of four cycles at least 6 hours apart. The Results Section discusses the degree to which each monitoring event adhered to this plan.

feeding fishes like Spot, would be less important than if they were unable to so effectively assess the food resources of their immediate environment.

## 7.7 WATER QUALITY

7.7.1 Introduction. The question posed by the Study Team to be answered by the water quality studies was:

- What changes in water quality occur as a result of the disposal operation and how long is the period of recovery to ambient conditions?

The water quality study plan included the thin-layer placement of dredged material at four areas, two sites located on the west side of the channel, which received maintenance material, and two sites located on the east side, which received new work material. This was done to analyze the differences between the two types of material when dispersed in a thin-layer over a vast area. To address possible temporal variability in thin-layer placement impacts to water quality, disposal was performed at two different times, the first during September/October 1992 on Beta and Foxtrot which were located closer to shore. Delta and Zulu were disposed on during March/May 1993.

The monitoring for each disposal area consisted of four phases: predisposal, during disposal, short-term post-disposal (2 - 4 days following disposal), and long-term post-disposal (monthly for six months). During the predisposal, during disposal, and short-term post disposal phases, the following parameters were measured at each station-by-depth combination: temperature, salinity, pH, dissolved oxygen (DO), turbidity, total suspended solids (TSS), total organic carbon ( TOC), total Kjeldahl nitrogen ( TKN), ammonia, nitrate, nitrite, total phosphorus, orthophosphate, sulfate, and chlorophyll a. During the long-term surveys, temperature, salinity, pH, DO and TSS were measured at each station-be-depth combination.

In addition to the above parameters, total fecal coliform bacteria was measured in surface and bottom waters during disposal monitoring at Foxtrot. Of the 76 samples taken, 70 observations were below the detection limit (1 MPN/100 ml). Each of the remaining 6 observations was 1 MPN/100 ml and included both surface (1) and bottom (5) water samples. Since there was no indication that thin-layer disposal was releasing fecal coliform bacteria, additional bacteria samples were not collected.

Both temporal and spatial references were used to judge whether thin-layer disposal affects water quality. Temporal references involved comparing predisposal results to during and post-disposal results. Spatial comparisons consisted of establishing reference sites relative to the disposal sites. Each pair of disposal sites had 3 reference areas (East, West, and South). Separate reference sites were needed for each pair because of differences in distance from shore and water depth.

7.7.2 General Comments on Water Quality Not Related to Thin-Layer Disposal. Before detailed discussions of differences between the thin-layer placement and the reference areas, a few general comments should be made about the water quality of Mississippi Sound during the study. There was little stratification of the water column at Foxtrot, Beta, and their surrounding reference areas because the waters were shallow and easily mixed by waves and currents. TSS was the exception to this general rule. TSS concentrations in bottom waters were often twice the values in surface waters, particularly during the long-term post disposal phases. Natural stratification was stronger at Delta, Zulu, and the 3 corresponding reference sites, because the deeper waters provided a greater potential for stratification and required higher current and wave energies to mix the water column. Surface salinity were generally 2-5 ppt lower than bottom waters during spring and summer, while usually isohaline during the fall. TSS concentrations were generally 2-4 times greater in bottom waters compared with surface waters during the entire study. DO concentrations were stratified during the spring and summer with hypoxic and near hypoxic conditions common in bottom waters during the summer at Zulu and Delta and their east reference site.

Although primary production was not measured during this study, indirect evidence suggests it was low throughout the study relative to other estuaries. Chlorophyll a measurements were higher in and near Foxtrot and Beta sites (4-8 μg/l) than offshore at Zulu and Delta (1-2 μg/l). Median values of 8 μg/l have been reported from Florida estuaries with 90% of all observations greater than 2 μg/l (Freidemann and Hand, 1987). TKN values were similarly low, typically on the order 0.2 to 0.8 mg/l at N. The TOC concentrations in Mississippi Sound were exceptionally low, typically 1 - 3 mg/l; 90% of the observations from Florida estuaries exceed 3 mg/l. Concentrations of DO (2 - 9 mg/l), total phosphorus (0.03 - 0.40 mg/l at P) , TSS (10 - 40 mg/l), levels of pH (7.70 - 8.10) and turbidity (2 - 20 NTUs) were representative of those from other Gulf of Mexico estuaries.

Average current speed was 0.6 ft/s and ranged from 0.0 to 1.8 ft/s. Most of the time, mean current flow was to the northwest, west or southwest (51%), with eastward flow representing 14% of the cycles; however during 29% of the cycles, no clear mean direction existed.

7.7.3 Effects of Thin-Layer Disposal on Water Quality. Thin-layer disposal resulted in changes in pH, DO, turbidity, TSS, TKN, ammonia, nitrate, and perhaps chlorophyll a. Most of these effects occurred during or soon after disposal and the differences were more significant with maintenance material than with new work.

pH was the most frequently affected parameter, but results were contradictory. Disposal apparently decreased pH at Foxtrot and Beta, but it increased pH at Delta and Zulu. Initially, the small pH reductions at Foxtrot and Beta made sense because dredging often exposes reduced materials to the water column, and their oxidation would reduce pH. However, preliminary calculations indicate the magnitude of the effects observed at Foxtrot and Beta cannot be accounted for by the estimated disposal rate and redox potential of the dredged material. Although the cause of the pH differences was not identified, the magnitude observed was within the natural annual variation of pH and therefore poses no ecological consequences.

DO concentrations were effected by the fall disposal event (Beta and Foxtrot) more than the spring disposal. Bottom waters were affected by a 10-20% reduction in DO compared to surface and middepth waters (5-10%).

Turbidity was affected by the disposal of maintenance material and though it affected the entire water column, the greatest effects were seen in bottom waters. Compared to reference sites, increases were less than 6 NTU for surface and middepth waters of Foxtrot and Zulu, but 19-27 NTU in the bottom waters of Zulu and 60-64 NTU for the bottom waters of Foxtrot. Increased turbidity is the most commonly reported effect from disposal plumes though the magnitude of the increases here are consistent with those caused by frontal storms.

TSS was also elevated in the bottom waters of disposal areas. Its limitation to the bottom waters suggest rapid settling rates of the material or low wave and current energy unable to resuspend sediments. Consistently higher TSS numbers were found at Foxtrot throughout the 8 month sampling period suggesting the possibility of channel water invading the disposal area. Bottom and slope sediments of recently dredged channels may resuspended easily and thus may be advected by strong currents. Further, dredging occurred in the channel and turning basin throughout much of the long-term post-disposal phase for Foxtrot and Beta, and suspended material from this work may have been transported by the channel onto Foxtrot and Beta.

Thin-layer disposal appeared to have elevated TKN, ammonia, and nitrate on a few occasions, all during the fall dredging and mostly during the maintenance dredging. Fine grained nutrient rich sediments seem to cause increases in nutrient levels and although Foxtrot's sediments were not significantly enriched, they consisted of fine maintenance material from nearshore waters. Nutrient levels were also elevated for the short term survey suggesting nutrients can leach out of disposal sediments for at least a week after disposal.

Thin-layer disposal appeared to elevate chlorophyll a concentrations by 40% in the bottom waters of Beta after disposal ceased. It would be premature to link this result to increased nitrogen levels seen at Beta during the same period. Generation times of phytoplankton are longer than the time required for water to move through the disposal area, so it is unlikely the phytoplankton were responding to the increased nitrogen levels.

7.7.4 Conclusions. In summary, thin-layer disposal clearly affected pH, DO concentrations, turbidity and TSS levels during disposal, and these effects were stronger when maintenance material was disposed than new work material. In general, these effects were limited to times when disposal was actually occurring. Ammonia and other forms of nitrogen may have leached from disposed material after one of the four disposal events, but the increase in nitrogen concentrations were small. TSS concentrations were elevated at one disposal site throughout the long-term post-disposal monitoring, but these elevations could have been caused by factors other than thin-layer disposal. Other than this potential increase in TSS concentrations, effects from thin-layer disposal on water quality were limited to the areas of the disposal sites and the times when disposal was occurring or soon after disposal stopped.

## 8.0 SUMMARY OF NATIONAL DEMONSTRATION PROGRAM RESULTS

Throughout these studies an attempt has been made to not only detail the possible negative impacts associated with the thin-layer disposal of dredged material but also to investigate ways to mitigate those impacts that do occur, and if possible to glean benefits from the management of the placement operation. The results of the research conducted during the Thin-Layer National Demonstration Program indicate that the disposal of dredged material in a controlled thin lift can be managed without causing negative environmental impacts and in fact can be managed to effect beneficial impacts to the estuarine system. Short term impacts to water quality, primarily increases in turbidity and total suspended solids, are shown to be restricted to the immediate vicinity of the placement operation and to the time of disposal and immediately (2 - 4 days) thereafter. Thin-layer placement of dredged material has surprisingly few direct physical impact to the even the most fragile forms of larval and post larval fishes. In addition, the increases in turbidity and total suspended solids appear to have highly variable impacts on the feeding ability of these forms. Feeding of Paralithid Flounder had the greatest tendency to be negatively impacted by increases in turbidity but since the increase in turbidity is shown to be very short term, it is highly unlikely that this impact would result in significant impacts to the Flounder resource of the estuary. The possible total loss of the benthic community as a result of thin-layer disposal (i.e. the community becomes azoic) did not result in impacts to the fishery resource in terms of wasted feeding effort at least for Spot, the only species tested. Since there was no evidence of thin-layer placement causing total defaunation of any of the disposal areas, the possibility of additional impacts through feeding effort of other species is reduced. The response of the macrobenthic community to thin-layer disposal is dependent upon the initial sedimentary characteristics and thus the existing community type, the sedimentary characteristics of the dredged material, and the time of the placement operation. At no time, however, did the thin-layer placement result in the total defaunation of the disposal area. Evidence of migration upward through the thin layer of material was evident in all studies. In addition, the 'environment' of the newly placed dredged material was suitable for recolonization by organisms migrating inward from adjacent areas as well as recolonization through larval settlement and growth. Placement of dredged material with different sedimentary characteristics from that of the disposal area may cause a shift in the faunal composition and depending upon the time of placement, recovery may be slow initially mediated by upward and inward migration of adult forms. This was evident when placement was accomplished in the fall and total recovery was not noted until after the spring larval

## EXECUTIVE SUMMARY

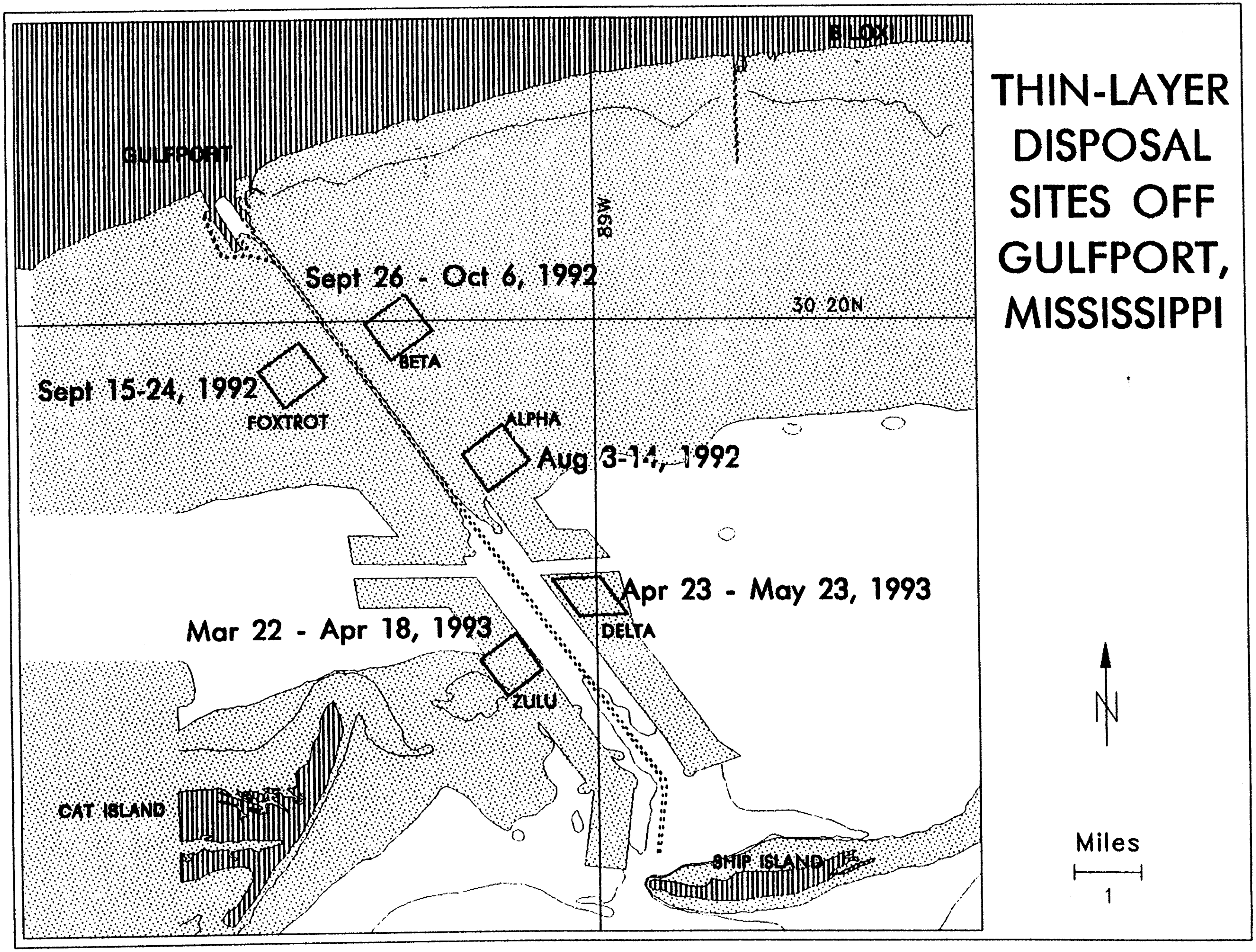
The document reports the results of research into potential effects of thin-layer dredged material disposal on fishery organisms. The research was sponsored by the Mobile District of the U.S. Army Corps of Engineers as a part of the environmental research associated with the National Thin-Layer Dredged Material Disposal Demonstration Project at Gulfport, Mississippi.

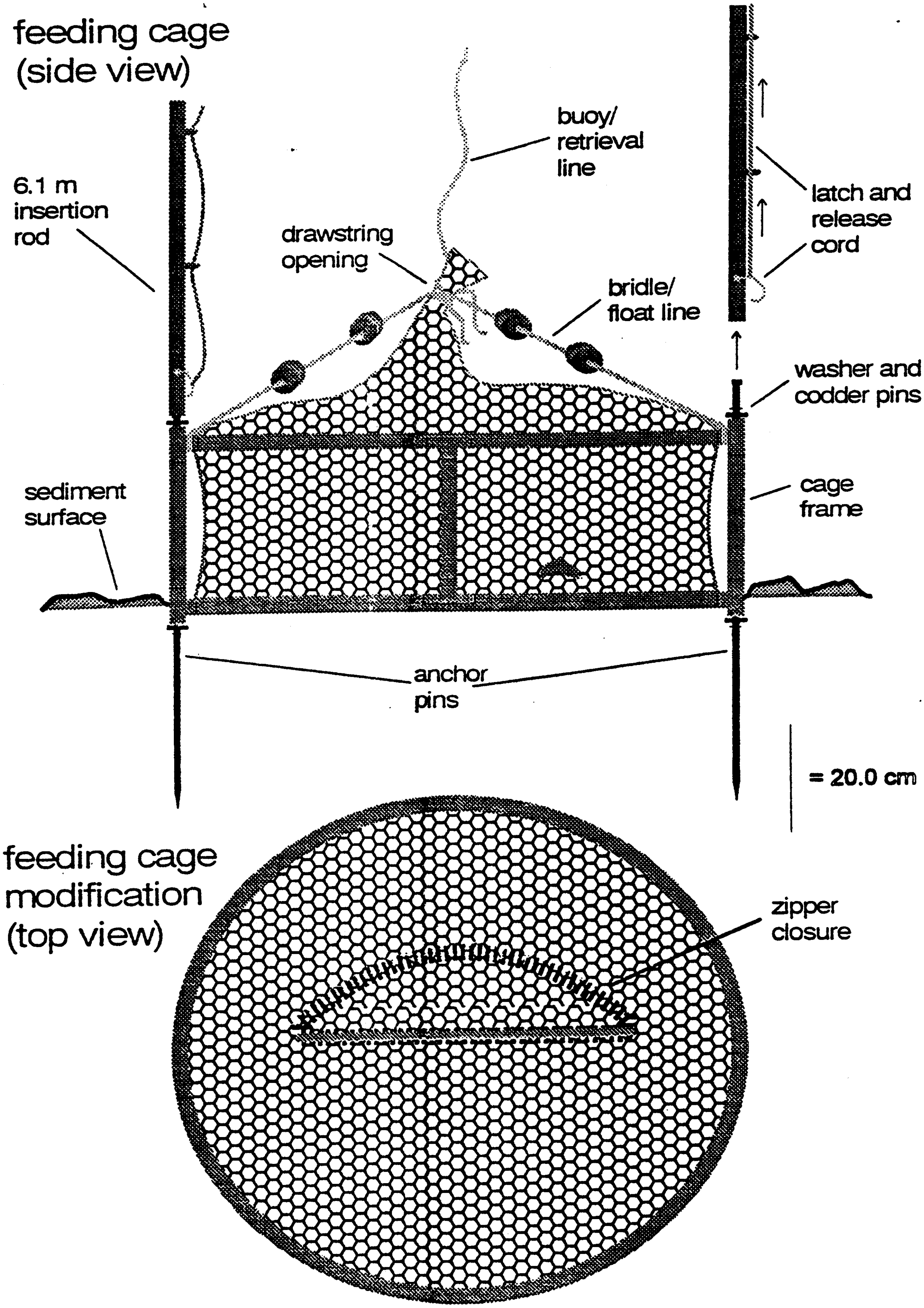
The research consisted of four projects, each addressing a different potential effect of thin-layer disposal on fishes. The first of these compared the feeding success of fishes deployed individually in cages upon either thin-layered sites or on adjacent areas of Mississippi Sound. The data obtained from 460 cage deployments of juvenile Spot, *Leiostomus xanthurus*, during 1992 and 1993 revealed that the fish were as likely to have fed if deployed on a thin-layered site, as they were if deployed on adjacent areas of the sea floor. Examination of their diet compositions showed that in the first few months following the thin-layer deposition, the feeding profiles of fish from experimental and control sites may differ, but that within about a year, they converge.

The second research project examined the survival of larval and juvenile fishes experimentally exposed to laboratory simulated thin-layer deposition. The purpose was to determine if direct physical effects of the falling sediments might cause significant mortality. The first phase of the experimentation employed factorial experimental designs in which sediment type and depth of the thin-layer were varied. The six sediments employed in the full design were five grain-size categories of sand, and kaolin clay. The depths employed were 10, 20, and 40 cm. In the second phase of the experimentation clay, coarse sand, and sand obtained from a local beach were employed with a single depth of 20 cm. The experiments revealed that even very fragile fish larvae were relatively robust to the simulated depositions and survivals were generally above 80 percent, frequently above 90 percent. A majority of the fish also fed successfully when offered brine shrimp after 24 hours, confirming that they were in relatively good health.

The third research project investigated the relative feeding success of larval and juvenile fishes used in a factorial experimental design in which turbidity and prey concentration were varied over four and three orders of magnitude respectively. In most of the experiments brine shrimp were used as prey, but experiments were also conducted using wild caught plankton as well. Logistic regression models were fit to the data for each species of fish tested and they provided a means of assessing the relative importance of the two factors in determining whether a fish had fed or not. Each species tested exhibited a different pattern of response, but a species' response to wild plankton tended to be similar to its response to brine shrimp. Some species such as Spot had a high probability of having fed over the entire range of turbidities. For others, such as Flounders, the probability dropped rapidly with increasing turbidity.

The fourth research project was designed to determine if juvenile Spot could readily distinguish differences in foraging profitability of different experimental sediments. In the first phase of these experiments a factorial experimental design was followed. Sediment grain size category and length of time the sediment had been exposed for colonization by meiofauna were the two factors. Later, in the second phase, natural sediments from an intertidal flat were used along with medium sand. The fish displayed relatively high foraging efficiency throughout the experimental series, with many entirely avoiding sterile sediments that were offered. The fishes' ability to assess the foraging value of the different sediments suggests that they would probably not linger over sediments largely devoid of food items, but would instead move on to more profitable environments. This, in turn, would tend to minimize the impact of thin-layer deposition and any attendant, if temporary, reduction in benthic prey, on production of fishery organisms.


THIN-LAYER DISPOSAL SITES OFF GULFPORT, MISSISSIPPI
GULFPORT
BILOXI
89W
30 20N
Sept 26 - Oct 6, 1992
BETA
Sept 15-24, 1992
FOXTROT
ALPHA
Aug 3-14, 1992
Apr 23 - May 23, 1993
DELTA
Mar 22 - Apr 18, 1993
ZULU
CAT ISLAND
SHIP ISLAND
N
Miles
1


feeding cage
(side view)
6.1 m
insertion
rod
drawstring
opening
buoy/
retrieval
line
bridle/
float line
latch and
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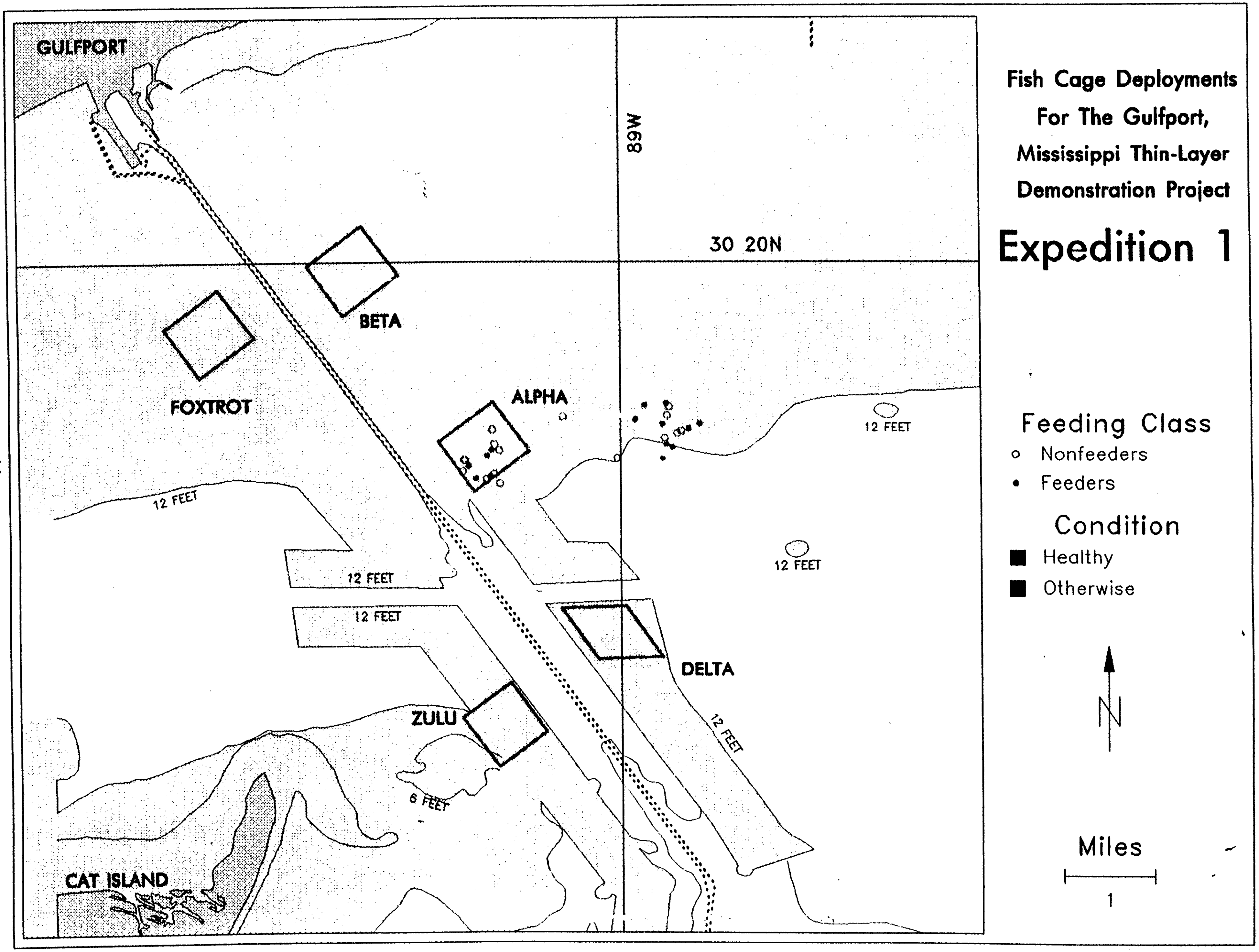
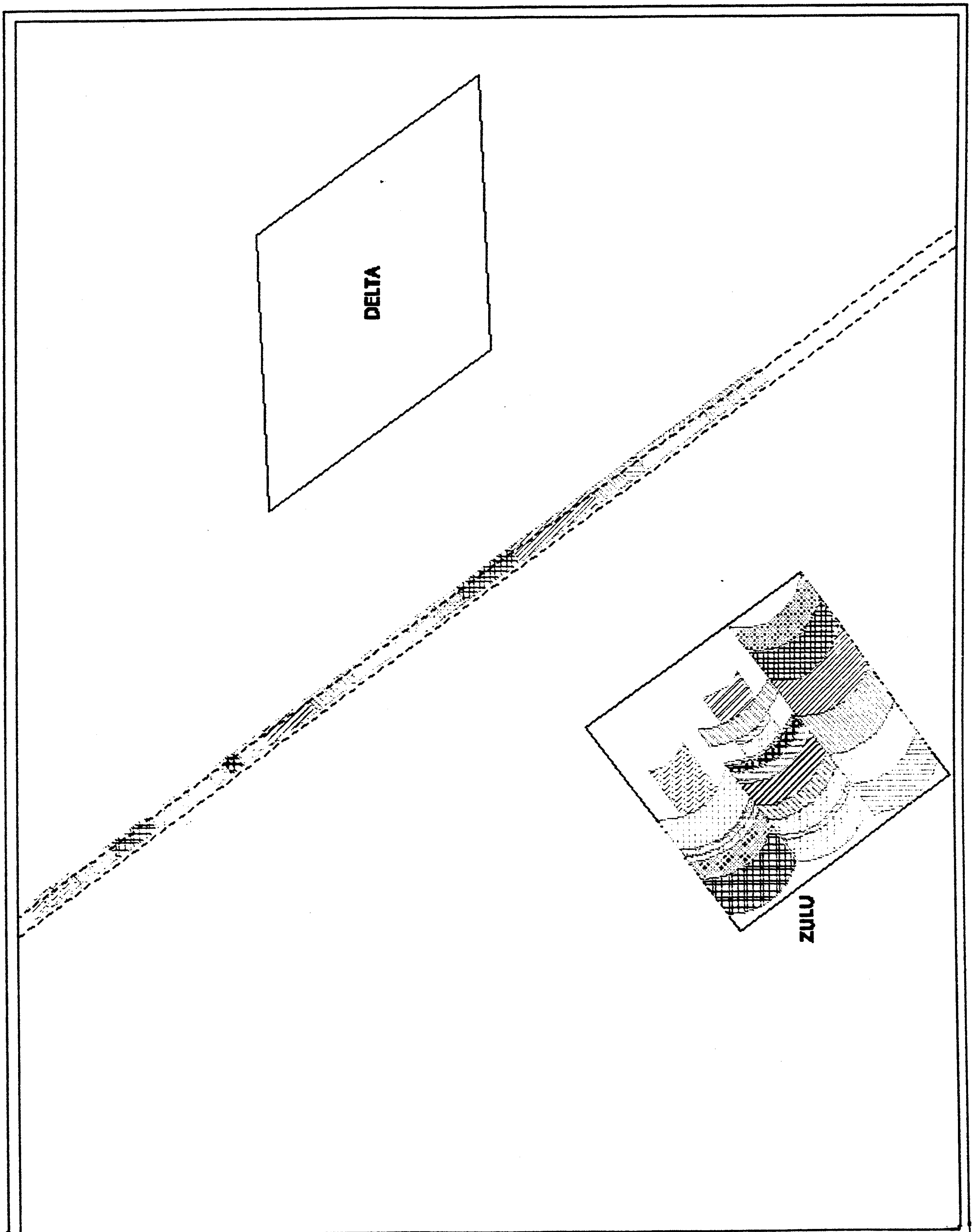
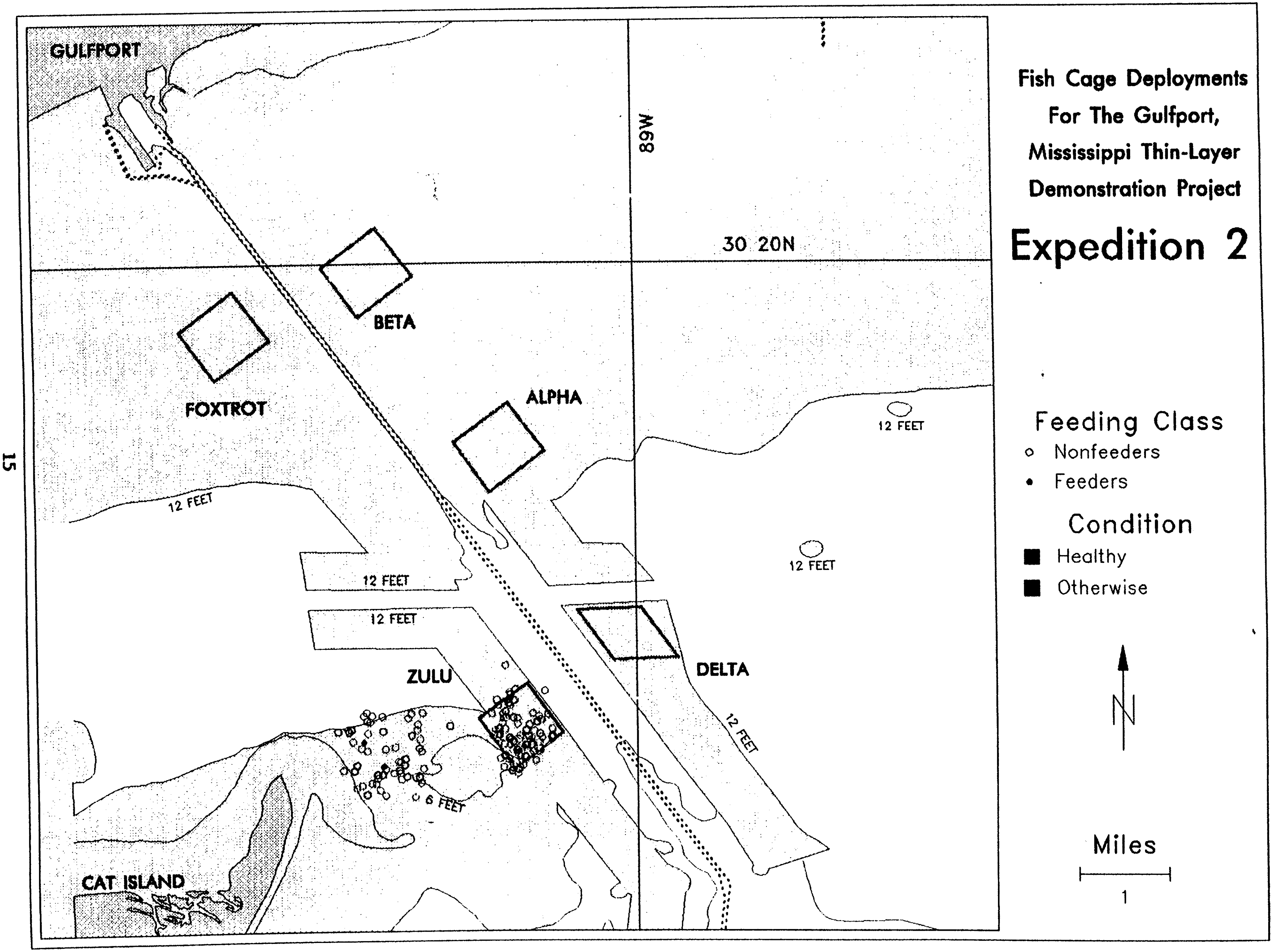
washer and
codder pins
sediment
surface
cage
frame
anchor
pins
= 20.0 cm
feeding cage
modification
(top view)
zipper
closure


Fish Cage Deployments
For The Gulfport,
Mississippi Thin-Layer
Demonstration Project
Expedition 1
GULFPORT
89W
30 20N
BETA
FOXTROT
ALPHA
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
DELTA
ZULU
6 FEET
CAT ISLAND
Feeding Class
Nonfeeders
Feeders
Condition
Healthy
Otherwise
N
Miles
1


DELTA
ZULU


Fish Cage Deployments
For The Gulfport,
Mississippi Thin-Layer
Demonstration Project
Expedition 2
Feeding Class
Nonfeeders
Feeders
Condition
Healthy
Otherwise
N
Miles
1
GULFPORT
89W
30 20N
BETA
FOXTROT
ALPHA
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
ZULU
DELTA
6 FEET
CAT ISLAND

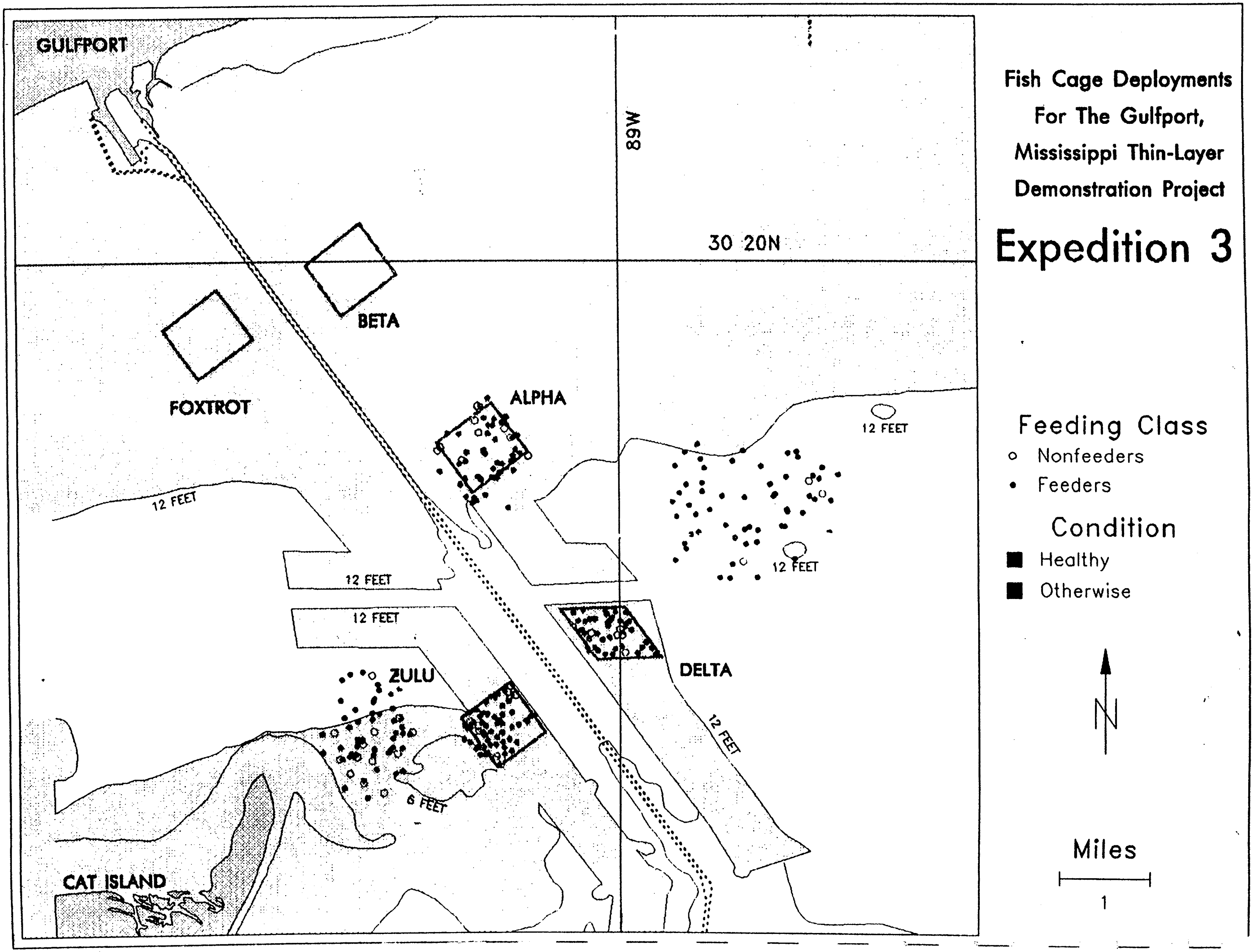

Fish Cage Deployments
For The Gulfport,
Mississippi Thin-Layer
Demonstration Project
Expedition 3
Feeding Class
Nonfeeders
Feeders
Condition
Healthy
Otherwise
N
Miles
1
GULFPORT
89W
30 20N
BETA
FOXTROT
ALPHA
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
12 FEET
DELTA
ZULU
6 FEET
CAT ISLAND

Table 1. Results of feeding trials of juvenile Spot in Mississippi Sound

| Time Period | Experimental Site | Experimental Fed | Experimental Not Fed | Control Fed | Control Not Fed | Chi-square | p-value |
|---|---|---|---|---|---|---|---|
| August 1992 | Alpha | 5 | 9 | 9 | 6 | 1.71 | 0.191 |
| July 1993 | Alpha | 26 | 4 | 27 | 2 | 0.67 | 0.413 |
| July 1993 | Delta | 37 | 1 | 29 | 1 | 0.03 | 0.865 |
| July 1993 | Zulu | 53 | 6 | 49 | 11 | 1.62 | 0.203 |
| October 1993 | Foxtrot | 19 | 5 | 6 | 1 | 0.15 | 0.700 |
| October 1993 | Beta | 18 | 5 | 6 | 8 | 4.79 | 0.029 |
| October 1993 | Delta | 11 | 12 | 5 | 9 | 0.52 | 0.471 |
| October 1993 | Zulu | 13 | 11 | 8 | 6 | 0.03 | 0.859 |
| October 1993 | Alpha | 13 | 8 | 16 | 5 | 1.00 | 0.317 |
| OVERALL TOTALS | | 195 | 61 | 155 | 49 | 0.002 | 0.962 |
| (HYPOTHETICAL DIFFERENCE) | | 185 | 71 | 165 | 39 | 4.46 | 0.031 |

The principal food items in the guts of experimental Spot were, with the exception of occasional nematodes, restricted to copepods, foraminifera, and diatoms. Each fish was assigned to a feeding class for each of the food types (none, 1-9, 10-99, 100+) and loglinear model analysis was used to test differences in the feeding profiles for each type. These tests provide a means of both looking for differences in feeding profiles between experimental and control fishes on a given site and expedition, and also examining the evidence for convergence in the two over time. The Alpha site was sampled on three of the four trips and therefore those data are perhaps the best for examining whether feeding profiles did in fact converge over time (Figure 9).

Loglinear model analyses were conducted to test null hypotheses concerning feeding profiles of fish on thin-layered versus the corresponding control sites . The results of these tests for each of the major food types are given in Table 2.

It is interesting to find that the one case in which (at least marginal) differences were detected for all three food types was for Alpha on the first expedition which took place immediately after the site was thin-layered. Differences were less 11 months later and had disappeared 14 months after the thin-layering. Differences were also found on Zulu and Delta in July, a few months after they were thin-layered, but not later when they were revisited in October. No differences were found for Foxtrot, but there were two on Beta, which of course had shown higher feeding success of fishes deployed on the thin-layered site than on the control.

**Figure 10. Feeding profiles for Alpha and control in August 1992. The different bars represent numbers of prey consumed on an ordinal scale. The height of the bars are the percentage of the fish in the sample in that ordinal feeding class.**

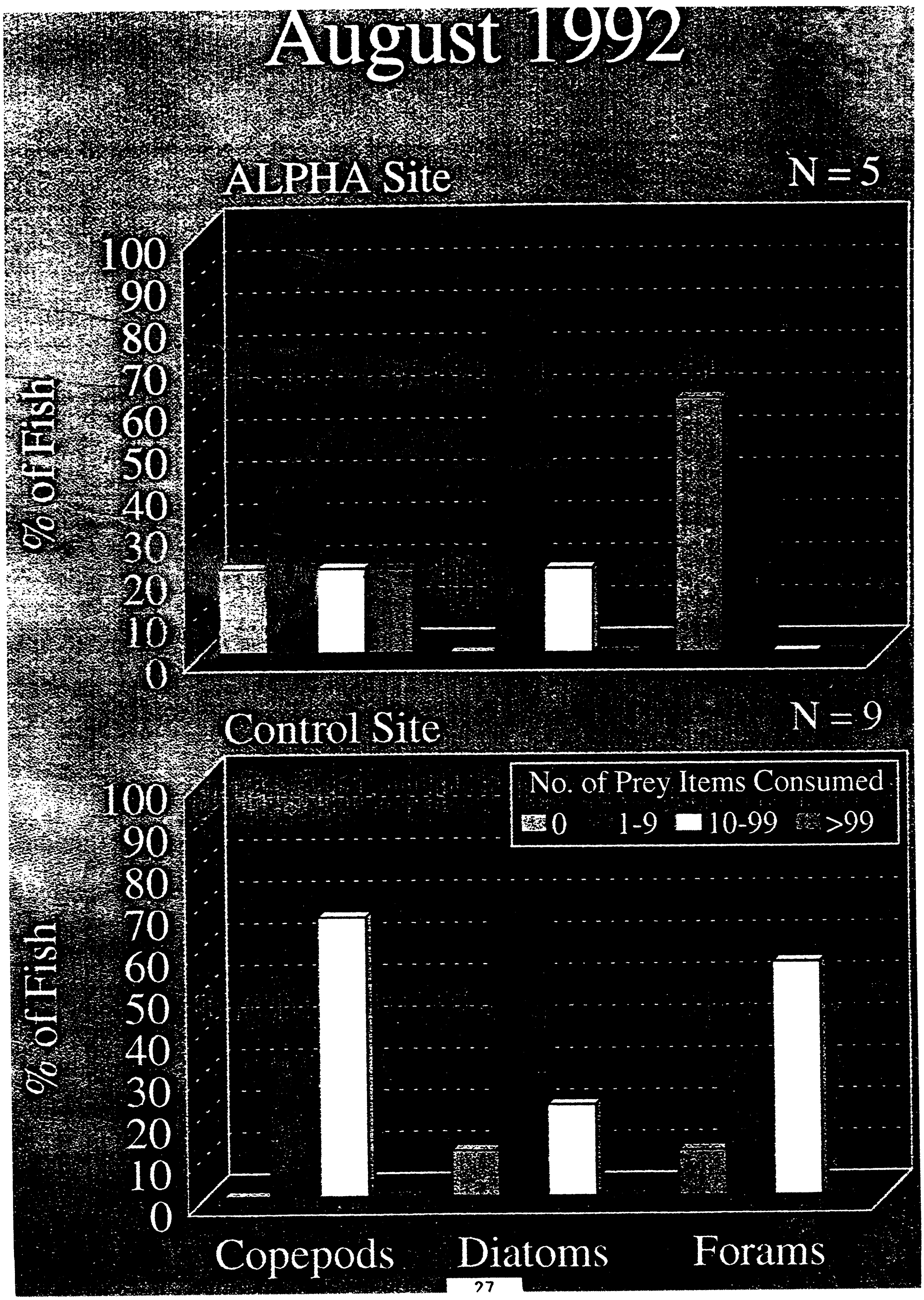

August 1992
ALPHA Site
N = 5
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Control Site
N = 9
No. of Prey Items Consumed
0
1-9
10-99
>99
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Copepods
Diatoms
Forams

**Figure 11. Feeding profiles for Alpha and control in July 1993.**

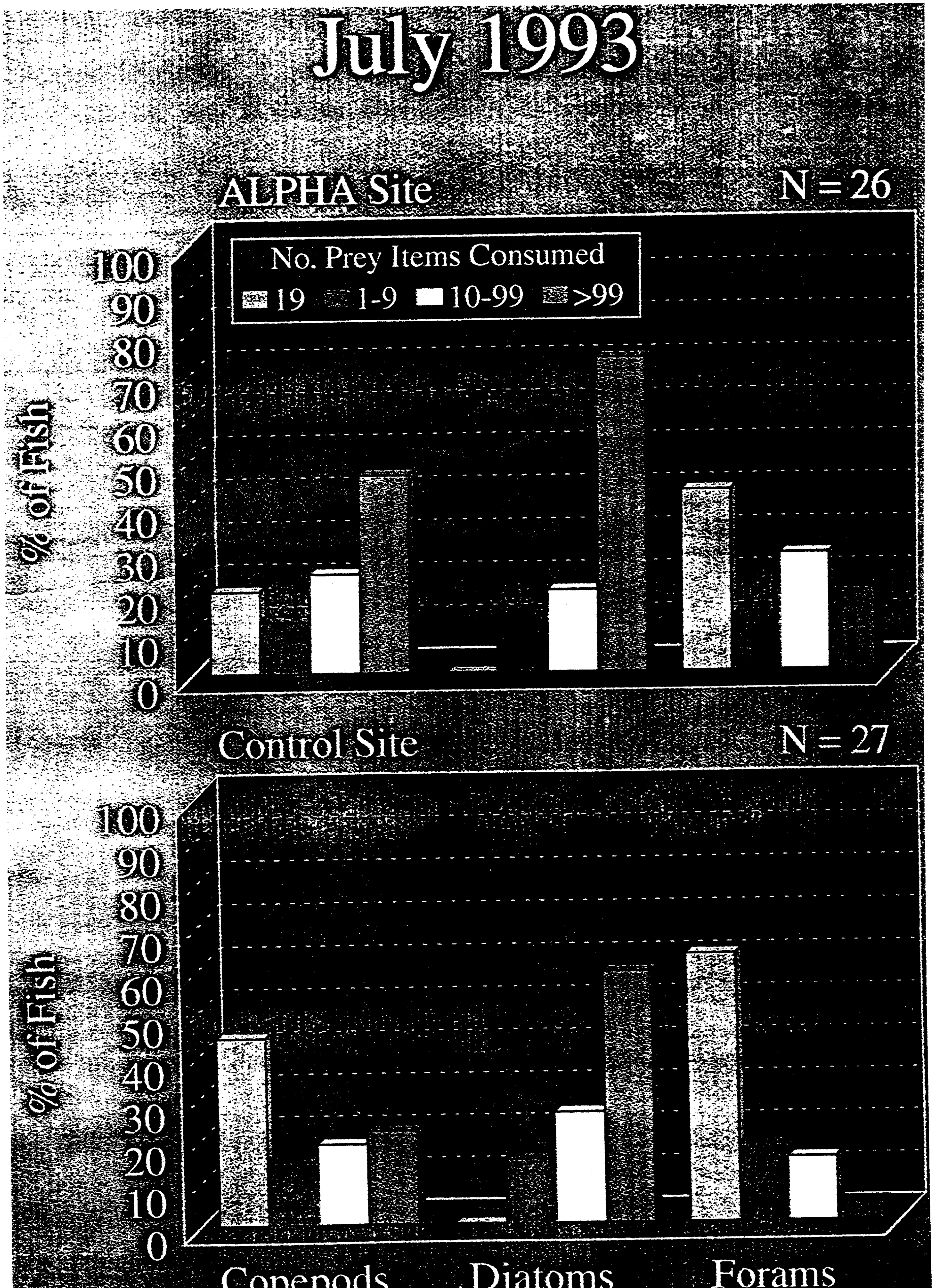

July 1993
ALPHA Site
N = 26
No. Prey Items Consumed
19
1-9
10-99
>99
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Control Site
N = 27
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Copepods
Diatoms
Forams

**Figure 12. Feeding profiles for Alpha and control in October 1993.**

# October 1993

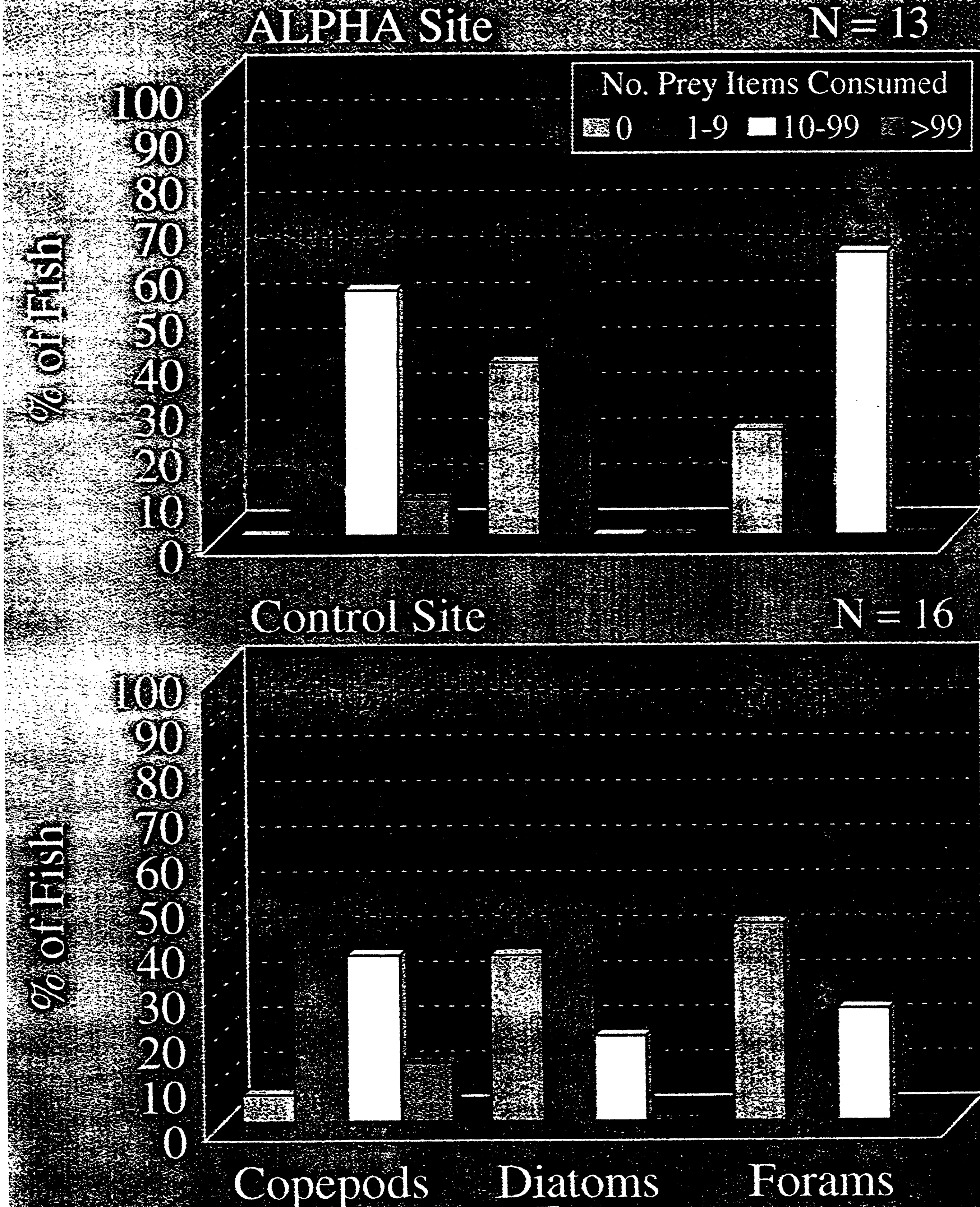
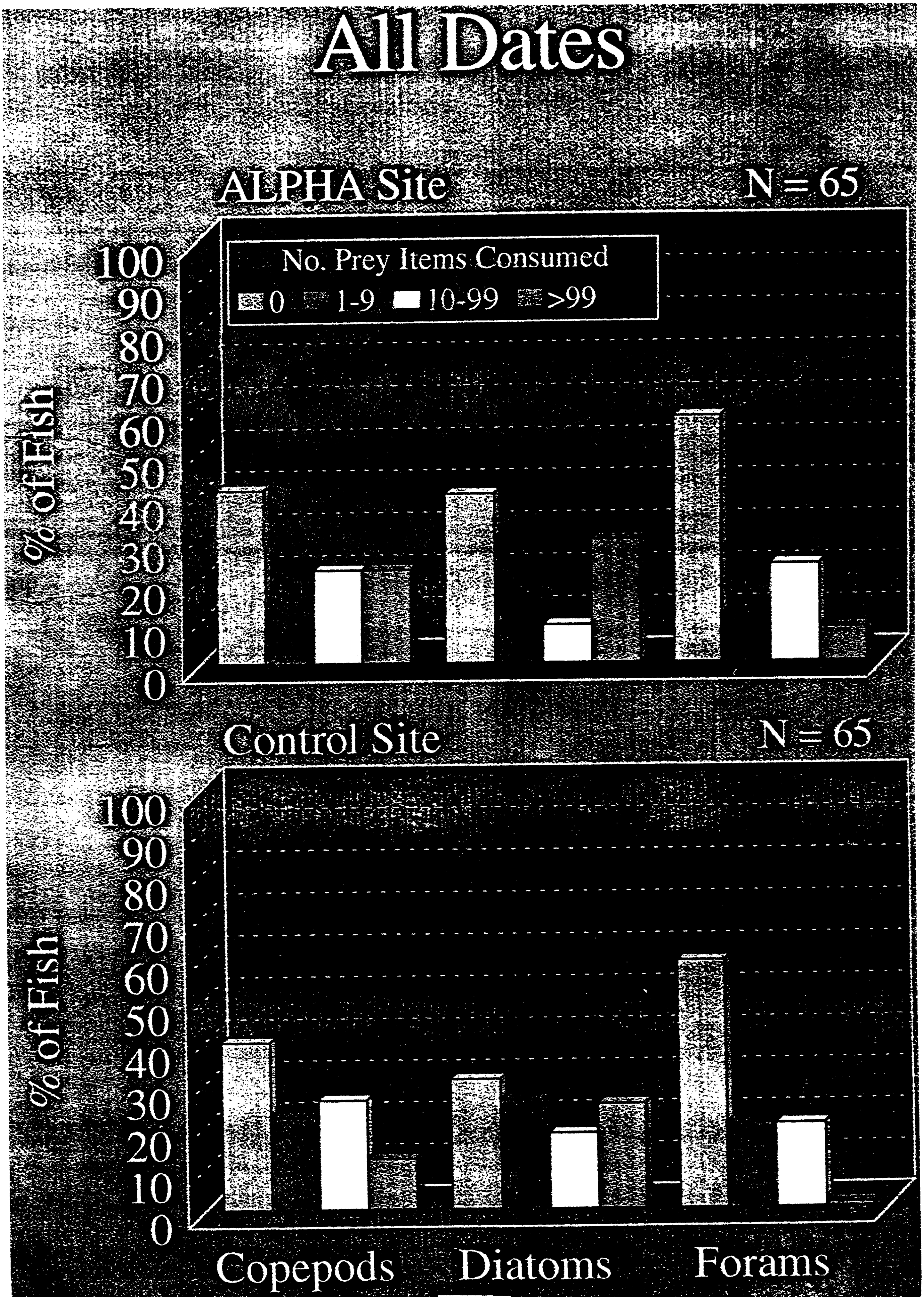


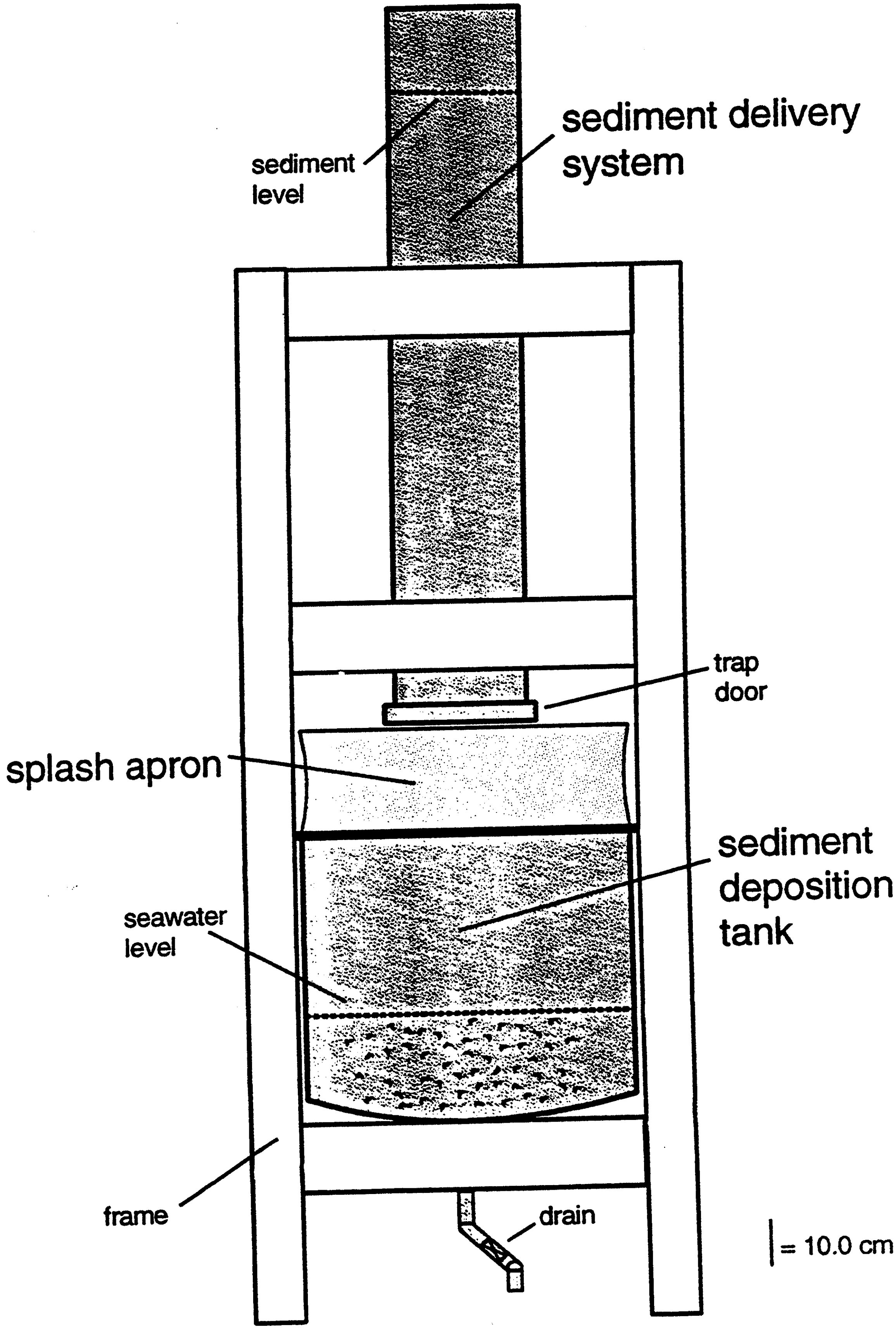
**Figure 13. Feeding profiles for Alpha and control over the entire study period.**



All Dates
ALPHA Site
N = 65
No. Prey Items Consumed
0
1-9
10-99
>99
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Control Site
N = 65
% of Fish
100
90
80
70
60
50
40
30
20
10
0
Copepods
Diatoms
Forams

The data from the study failed to reject the null hypothesis that fish placed in cages on control and experimental sites would have an equal probability of having fed during their period of submergence. On the other hand there was clear evidence that in the short term, at least, the feeding profiles would differ with heavier feeding on control sites for at least some food types. Finally, the study provided evidence that the food resources on thin-layered sites tend to converge with those on adjacent unmodified areas over 6 to 14 months, or else come to exceed them.

**Figure 19. A schematic diagram of the test column used in the second phase of the simulated thin-layer deposition experiments.**


sediment level
sediment delivery system
trap door
splash apron
sediment deposition tank
seawater level
frame
drain
= 10.0 cm

use. All dead fish found trapped below the surface of the sediment were promptly removed, counted, examined for trauma, and measured for standard length.

After 24 hours the survival of fish in the holding container was recorded. Then, an ample amount of freshly hatched *A. franciscana* nauplii was added to the container. The fish were allowed to feed in the container for one hour, after which they were recovered, anaesthetized in a dilute solution of Finquel, measured for standard length, preserved in a 5% solution of buffered formalin, and later their gut contents were examined. Individual fish were given a score of 1 if they fed successfully and a 0 if their guts were empty.

## 3.2 Results

The results of this research are presented separately for the two phases because of the differences in the treatment sets tested, the equipment used, and procedures followed. We first present the results of the first phase of the experimentation on a species by species basis.

Forty sets of 10 Spot were tested in the first phase of the investigation and their survival under different treatments are shown in Table 3.

Table 3. Survival of 400 Spot tested during the first phase of the simulated thin-layer deposition experiments.

| Sediment particle size | Depth (cm) | Number of fish tested | Percent survival |
|---|---|---|---|
| Very coarse sand | 10 | 10 | 90 |
| | 20 | 20 | 75 |
| | 40 | 20 | 60 |
| Coarse sand | 10 | 10 | 30 |
| | 20 | 10 | 100 |
| | 40 | 30 | 80 |
| Medium sand | 10 | 30 | 90 |
| | 20 | 30 | 87 |
| | 40 | 20 | 50 |
| Fine sand | 10 | 30 | 77 |
| | 20 | 10 | 100 |
| | 40 | 30 | 97 |
| Very fine sand | 10 | 10 | 100 |
| | 20 | 20 | 95 |
| | 40 | 20 | 100 |
| Clay (Carotex) | 10 | 10 | 50 |
| | 20 | 30 | 93 |
| | 40 | 10 | 100 |
| No sediment control | – | 40 | 45 |

The two factor nature of the experimental design was, of course, based upon the premise that the particle size of the sediments, or the depth of the simulated thin-layer, or both, would influence the survival of fishes exposed to the simulated thin-layer deposition. Examination of Table 3 however provides little evidence in support of that premise. Somewhat to our embarrassment, the next to lowest survival was observed for the "no sediment control" treatment in which Spot were simply placed in the test column without any exposure to falling sediments. In addition, in the other six treatment sets in which depth of a particular sediment was varied, there were three sediments (Coarse Sand, Fine Sand, Clay) in which survival was higher at the maximum depth (40 cm) than at the minimum depth (10 cm). Survival for the greatest depth was equal to survival at the minimum depth for Very Fine Sand. Since there were only six grain sizes used, this is not very convincing evidence of a "depth effect". On the other hand if one averages survival across depths of sand, then the averages suggest that survival increases as grain size decreases. The average survivals for the five sands were, from coarsest to finest 75%, 70%, 76%, 91% and 98%.

Twenty sets of 10 Croakers were also tested in the first phase of the experimentation. The results are shown in Table 4.

Table 4. Survival of 200 Croakers tested during the first phase of the sediment deposition experiments.

| Sediment particle size | Depth (cm) | Number of fish tested | Percent survival |
|---|---|---|---|
| Very coarse sand | 10 | 10 | 80 |
| | 20 | 10 | 100 |
| | 40 | 10 | 80 |
| Coarse sand | 10 | 10 | 90 |
| | 20 | 10 | 90 |
| | 40 | 10 | 70 |
| Medium sand | 10 | 30 | 93 |
| | 20 | 10 | 100 |
| | 40 | 30 | 87 |
| Fine sand | 10 | 10 | 100 |
| | 20 | 10 | 100 |
| | 40 | 10 | 100 |
| Very fine sand | 10 | 10 | 100 |
| | 20 | 10 | 100 |
| | 40 | 10 | 100 |
| Clay (Carotex) | 10 | 30 | 100 |
| | 20 | 10 | 100 |
| | 40 | 20 | 100 |
| No sediment control | – | 40 | 98 |

The results for the Croaker again showed little evidence for an effect of depth, and all mortality was encountered in very coarse sand, coarse sand, and medium sand. Finer sediments showed no mortality at all, and survival in the "no sediment controls" was 98%.

Laboratory spawned Spot were tested using only two depths, 10 and 40 cm and excluding very course sand and very fine sand . The results are shown in Table 5.

Table 5. Results for 300 post larval Spot tested using a restricted set of depth and grain size treatments.

| Sediment Particle Size | Depth (cm) | Number of fish tested | Percent survival |
|---|---|---|---|
| Coarse sand | 10 | 20 | 75 |
| | 40 | 20 | 35 |
| Medium sand | 10 | 40 | 92 |
| | 40 | 40 | 92 |
| Fine sand | 10 | 20 | 95 |
| | 40 | 20 | 100 |
| Clay | 10 | 40 | 95 |
| | 40 | 40 | 30 |
| No sediment control | – | 60 | 98 |

Survival of the post larvae was low for the deeper treatments of course sand and clay, but otherwise 75% or better.

The last species to be tested in the first phase of the experiments were Pinfish. The treatments were restricted to 10 and 40 cm depths of medium sand and clay, as well as a no sediment control. The results are shown in Table 6.

Table 6. Survival of Pinfish in simulated thin-layering tests.

| Sediment particle size | Depth (cm) | Number of fish tested | Percent Survival |
|---|---|---|---|
| Medium sand | 10 | 40 | 88 |
| | 40 | 40 | 98 |
| Clay | 10 | 40 | 95 |
| | 40 | 40 | 15 |
| No sediment control | – | 40 | 95 |

The survival of Pinfish in the deeper application of clay was the lowest observed in the entire series of experiments. Otherwise, survival was high.

Generally, most fish recovered alive from the test columns fed when offered a feeding challenge 24 hours later. The results are given in Table 7 on the next page.

Table 7. Results of feeding challenges to fishes 24 hours after their recovery from the test columns. A total of 754 fish were given the feeding challenge.

| Sediment grain size | Depth (cm) | Percent having fed |
|---|---|---|
| Very coarse sand | 10 | 80 |
| | 20 | 83 |
| | 40 | 77 |
| Coarse sand | 10 | 77 |
| | 20 | 80 |
| | 40 | 85 |
| Medium sand | 10 | 87 |
| | 20 | 90 |
| | 40 | 88 |
| Fine sand | 10 | 97 |
| | 20 | 100 |
| | 40 | 90 |
| Very fine sand | 10 | 100 |
| | 20 | 71 |
| | 40 | 61 |
| Clay | 10 | 93 |
| | 20 | 74 |
| | 40 | 62 |
| No sediment control | – | 95 |

The lowest percentages were for the deepest clay and very fine sand treatments and within each of those sediment grain sizes, the percentages steadily decrease with increasing depth. Croakers and juvenile Spot had shown high survival in the clay treatment, but Pinfish and post-larval Spot had not.

The second phase of these experiments were carried out in February and March 1995. We first ran some tests using beach sand and Spot, or combinations of Spot and Pinfish when we had insufficient numbers of one species for a trial. We followed those tests with some trials using coarse sand and mixed sets of Spot, Pinfish and Croakers. Then we ran a number of trials in which coarse sand was alternated with the no-sediment control treatment. We ended the series with some tests of the clay treatment. The results of the second phase of these experiments are summarized in Table 8.

More than 90 percent of the fish were recovered alive in every species-treatment combination. With a single exception, survival 24 hours later was 82 percent or higher. The exception was for some early tests with mixtures of Spot, Pinfish and Croakers when the 24 hour survival was 64 percent and less than half of the fish tested fed during the feeding challenge. The best survival and feeding results for a sediment treatment was seen in trials of beach sand with combinations of Spot and Pinfish. The fact that more than half of the Menhaden tested with coarse sand fed after 24 hours is somewhat astonishing, given the extremely fragile nature of Menhaden larvae.

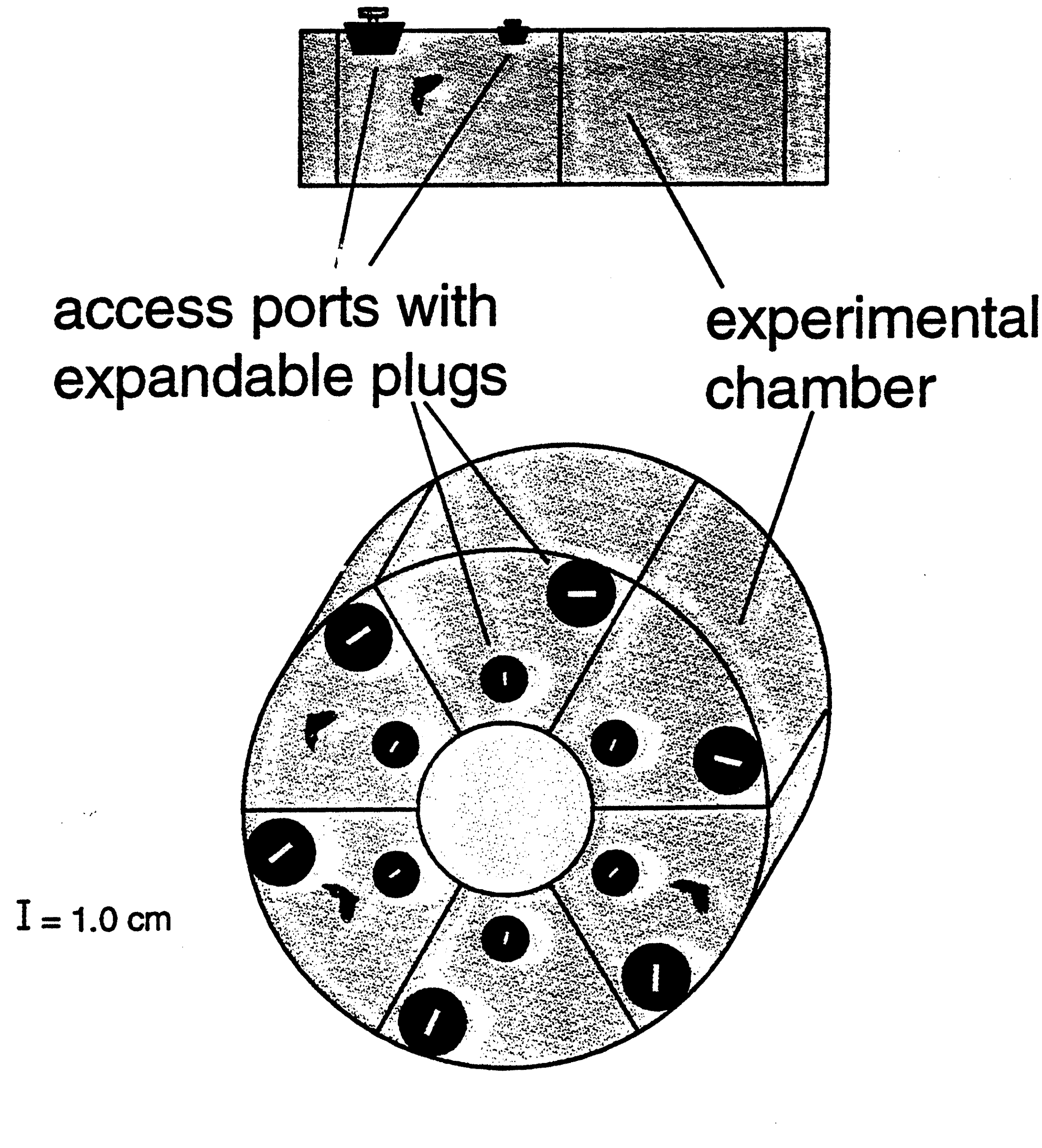
The appearance of the sand falling within a test column resembled the roiling appearance of the mushroom cloud following a nuclear explosion. On a number of occasions Spot were observed to instantly respond to the falling sediment by rapidly swimming upwards in the column. This implies that they were able to detect the shock wave generated as the sediments hit the surface of the water. This in turn suggests that if they were in close proximity to a thin-layer discharge, they would readily detect it and probably attempt to move away to reduce their exposure to the falling sediments.

The design of the test apparatus for the second phase of experimentation made at least limited provision for avoidance of falling sediments by lateral movement. However, because the fishes were not confined directly under the discharge column prior to sediment release, we have no measure of the fishes' tendency to move laterally following the release. In any case, there were no statistically significant differences in initial or 24 hour survival of a species between a sediment treatment and the corresponding control treatment.

One of the more remarkable results from the experiments was the very low numbers of fish that were buried by the falling sediments. This held even for fragile, relatively weak swimming Menhaden larvae. Larval Flounders often rest on the floor of an aquarium (or test column) and they would therefore seem especially vulnerable to burial, but that proved not to be the case. This suggests that they too responded to the initial shock wave of the falling sediment hitting the surface of the water by instantly swimming upward into the water column, thereby remaining above the sediment as it accumulated on the floor of the column or tank.

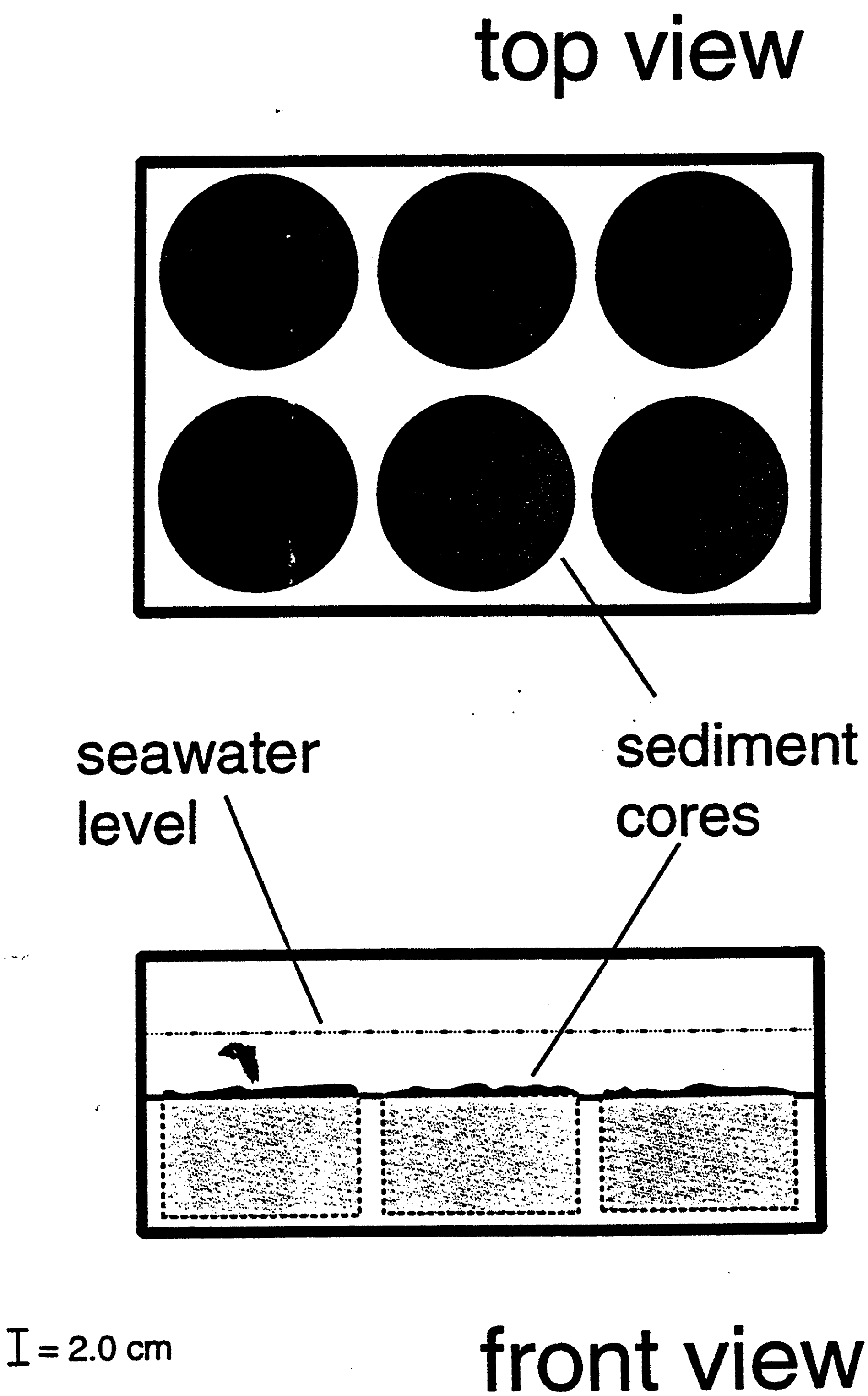
Our overall conclusion from the experiments is that the larval and post-larval species tested were remarkably robust to the falling sediments. Therefore it would seem unlikely that direct physical injury from thin-layer deposition would constitute a major source of mortality for larval and post larval fishes.

horizontal orientation




vertical orientation

**Figure 32. A schematic diagram of the apparatus used to test foraging of spot over different substrates during the second phase of the experimentation.**


top view
seawater
level
sediment
cores
I = 2.0 cm
front view

After each experiment, the MS was rinsed with freshwater and reused and the DNS was discarded. The UNS cores were returned to the exclusion cage, replenished with new sediment if necessary, and allowed to recolonize for at least 24 hours before reuse.

## 5.2 Results

During the first phase of the foraging behavior experiments twelve trials were run to compare the five grain sizes and the two colonization times. A total of 3032 bites were scored for the 12 juvenile Spot. The number of feeding events for each of the treatment combinations is shown in Table 12

Table 12. Results of 12 foraging experiments investigating foraging over 5 grain sizes of sand that had been exposed to colonization by meiofauna for less than one or more than ten days.

| Sediment Grain Size | Less than 1 day colonization | More than 10 days colonization |
|---|---|---|
| Very course sand | 82 | 611 |
| Coarse sand | 82 | 524 |
| Medium sand | 97 | 515 |
| Fine sand | 57 | 569 |
| Very fine sand | 62 | 433 |
| TOTALS | 380 | 2652 |

The Spot were remarkably consistent in their foraging. With 10 exceptions out of 120 cases, every fish foraged over every treatment sediment. There was a clear and consistent preference for the sediments that had had at more than 10 days to become colonized (Chi.sq=13.71, 4 df, $p<0.008$). There was however no evidence of a preference for one grain size over another, or presumably any differences in the prey items they provided.

In the second phase of the experimentation, we first compared the foraging of Spot over cups of medium sand and over cups of intertidal sediment that had been naturally colonized within a subtidal exclusion cage prior to their use. The results of 21 trials are provided in Table 13.

These results are convincing of the idea that a juvenile Spot doesn't waste a lot of effort foraging over unprofitable substrates. That 10 of the fish had 3 or fewer bites in the medium sand implies that they could readily detect which cups of sediment contained prey without having to actually bite samples of it. Two fish never sampled the natural substrate, but they only took 4 and 2 bites respectively, of the medium sand as well, so were clearly making little effort to forage.

In the next series of experiments, we added another sediment for the fish to choose from. This was naturally colonized sediment that had been "disturbed" by being mixed briefly in a blender just prior to the experiment. Thus, it contained prey items, but not in their normal orientation with respect to the surface. Table 14 displays the results of 33 trials with Spot.

Table 13. The number of feeding bites of sediment by individual juvenile Spot foraging over 3 cups of naturally-colonized, intertidal sediment and 3 cups of medium sand devoid of prey.

| Natural sediment | Natural sediment | Medium sand | Medium sand |
|---|---|---|---|
| 39 | 257 | 21 | 14 |
| 417 | 24 | 2 | 5 |
| 24 | 117 | 0 | 17 |
| 20 | 0 | 3 | 4 |
| 34 | 93 | 0 | 8 |
| 531 | 102 | 3 | 3 |
| 234 | 0 | 21 | 2 |
| 11 | 37 | 1 | 1 |
| 89 | 290 | 4 | 5 |
| 83 | 114 | 2 | 0 |
| 413 | | 24 | |
| Totals | 2929 | Totals | 140 |

Twenty seven of the 33 fish exhibited a pattern in which the number of bites was greatest in the undisturbed colonized sediment, followed by the blended sediment, followed by the medium sand. There were four fish that fed most frequently on the blended sediment. None had the most bites in the medium sand. Over the 33 trials, 82 percent of the bites were in the undisturbed, colonized sediment, 16 percent in the blended sediment and 2 percent in the medium sand.

Six trials were run with juvenile Croakers, using the same three sediment types. However, only 32 bites were observed in total. Nevertheless, 25 of the 32 were over the undisturbed, sediment, 5 over the blended and 2 over the medium sand, paralleling the predominant pattern of preference shown by the Spot. The Croakers general failure to feed much in these trials was also consistent with their failure to feed in the cage trials in Mississippi Sound.

## 5.3 Discussion and Conclusions

One consequence of thin-layer disposal is the burial of organisms living in and on the surface of the sea floor. The effect of this burial on fishes that prey upon these organisms will depend in part upon their ability to detect reduced abundance of prey in and on the thin-layered deposits, and thus continue moving to feed elsewhere.

A second potential consequence of thin layer disposal could arise from changes in the grain size composition of the surficial sediments, if the grain size composition of the dredged sediments differ markedly from those they bury. The grain size composition of sediments can influence which organisms colonize them and in what level of abundance, and therefore thin-layer disposal could change the overall quality of the sea floor affected as to its suitability for foraging fishes. The first series of foraging experiments deliberately compared sands of different grain size categories. The results indicated that they were all about equally attractive to the foraging Spot and presumably to colonizing prey as well. Instead, what was of major importance was the length of time the sand had been available for colonization.

Table 14. Number of bites of sediment by juvenile Spot in a series of 33 experimental trials.

| | Naturally colonized sediment | Blended colonized sediment | Medium sand |
|---|---|---|---|
| | 153 | 15 | 0 |
| | 301 | 37 | 0 |
| | 63 | 18 | 0 |
| | 210 | 29 | 0 |
| | 170 | 14 | 0 |
| | 75 | 10 | 0 |
| | 127 | 285 | 0 |
| | 168 | 60 | 0 |
| | 349 | 134 | 0 |
| | 44 | 4 | 0 |
| | 0 | 5 | 0 |
| | 438 | 7 | 2 |
| | 56 | 13 | 1 |
| | 15 | 0 | 0 |
| | 236 | 25 | 10 |
| | 14 | 1 | 0 |
| | 72 | 25 | 13 |
| | 0 | 3 | 2 |
| | 29 | 15 | 3 |
| | 826 | 71 | 4 |
| | 27 | 16 | 6 |
| | 315 | 40 | 7 |
| | 18 | 14 | 0 |
| | 48 | 3 | 1 |
| | 154 | 31 | 5 |
| | 36 | 3 | 3 |
| | 521 | 55 | 23 |
| | 438 | 36 | 7 |
| | 320 | 21 | 8 |
| | 96 | 34 | 8 |
| | 144 | 31 | 4 |
| | 19 | 7 | 1 |
| | 4 | 8 | 4 |
| | 157 | 23 | 19 |
| | 412 | 51 | 10 |
| Totals | (6055) | (1144) | (141) |

The second series of experiments convincingly demonstrated that juvenile Spot can readily distinguish the suitability of a sediment surface for foraging and further indicated that they apparently can do this without actually sampling (biting) the sediment as part of their assessment.

## 6.0 SUMMARY AND OVERALL CONCLUSIONS

The research reported in this document has attempted to address certain potential consequences of thin-layer dredged material deposition on the production of fishery resources. Its direction was partly dictated by the fact that comparison of standing crops of fishes on thin-layered and adjacent sites was found wanting as a metric for addressing potential effects of the method, if for no other reason than that fishes tend to be highly mobile as juvenile and adults and are readily advected as planktonic larvae. Fish are also frequently aggregated either in response to hydrographic phenomena which concentrate foods or simply because they form schools. The aggregated nature of their spatial distributions tends to produce high levels of variation among samples, leading to low statistical power in detecting differences in density from one study site to another.

The first research project compared the feeding success of individual juvenile Spot placed in cages on the floor of Mississippi Sound, either on, or adjacent to, sites that had been thin-layered. The comparison of fish that had fed, or not fed, revealed evidence of differences only on the Beta site, and that implied that more fish that had been placed over the Beta site had fed than those place over the adjacent area of Mississippi Sound. On the basis of the feeding success criterion then, the evidence favored rapid recolonization of the thin-layered sites by meiofauna taking advantage of the available uncolonized substrate that was made available as a part of the process of thin-layer disposal. In that sense, the ecological process was similar to weeds invading newly exposed soil.

Comparisons of the food types found in the guts of the caged fishes revealed some differences that were not apparent in the comparisons of whether they had fed or not. Alpha was studied from immediately after it was thin-layered in August 1992 until 14 months later in October 1993 and thus provided the best data for examining for evidence of temporal convergence in foraging opportunities between thin-layered and control sites. Comparison of food profiles for copepods, diatoms and foraminifera revealed differences immediately following the thin layer deposition. Subsequent sampling 11 months later in July 1993 however, indicated that there were higher proportions of heavy consumers of copepods and forams on Alpha than on the corresponding controls. By the following October the food type profiles were indistinguishable. The Zulu and Delta sites also revealed differences several months after thin-layer deposition, but these differences too were no longer detected during the October 1993 investigation. No differences in the food profiles between the thin-layered site and the control samples were detected for Beta and Foxtrot when sampled in October 1993, 12 to 13 months after they had been thin-layered.

The studies of feeding by Spot deployed in cages on the floor of Mississippi Sound thus revealed that the effects of thin-layering were manifested not in whether fish had fed, but rather, at least for several months, in terms of what they fed upon. The data also indicated that convergence in food resources for benthic feeding fishes like Spot probably is achieved within 8 - 14 months in a system like Mississippi Sound.

The investigation of direct physical effects of thin-layer deposition on larval and post larval fishes through laboratory-simulated, thin-layer deposition revealed that even the most fragile fish larvae are relatively robust to sediment falling through the water column. The relatively limited mortality observed may have been due, at least in part, to the process of recovering the fish at the termination of an experimental trial. Given that the experimental simulation restricted the fish in ways they would not be in an actual thin-layer deposition, and because we deliberately included relatively fragile larval stages of fishes in the tests, the results represent a "worst case" set of events. We therefore find it unlikely that thin-layer deposition will cause an important amount of fish mortality through direct physical effects of the falling sediments.

Increased turbidity is another consequence of thin-layer deposition, although its spatial extent and temporal duration may be quite limited, depending upon the sediments deposited, prevailing currents, and other factors. Our highly replicated studies compared the feeding response of 5 species of larval and juvenile fishes to differences in turbidity and prey concentration that extended over four and three orders of magnitude respectively. Each species exhibited a different pattern, with Spot showing little reduction in the probability of having fed if prey concentrations were high, regardless of the turbidity. Paralicthid Flounders on the other hand only had a high probability of feeding if the water was relatively clear and the prey concentration was high. Subsequent experimentation with wild-caught plankton assemblages, generally revealed that the fishes tested exhibited responses that tended to parallel their earlier responses when brine shrimp were the prey, and thus increased our confidence that the earlier results were not tied to the fact that brine shrimp, rather than their normal prey, were used.

If a foraging animal can not readily detect ambient densities of its food, then when confronted with an artificially created habitat (i.e. a thin-layered site, perhaps largely devoid of food) it may continue to expend energy foraging over unproductive environments and thereby suffer the consequences in terms of diminished growth and production. On the other hand, if it can readily detect unprofitable environments, it can continue to move on in search of other, more food-rich environments, and the overall effects of the artificially food-poor environments will be minimized. Our several studies of the foraging behavior of juvenile Spot were remarkably consistent in demonstrating the capability of that species to detect differences in the relative profitability of different substrates for foraging. We conclude that juvenile Spot are very capable of putting their foraging effort in to searching substrates that yield food and not wasting foraging effort over those of low prey concentration. Therefore, we would expect that the effects of temporarily diminished food resources on a thin-layered site, on production of benthic feeding fishes like Spot, would be less important than if they were unable to so effectively assess the food resources of their immediate environment.