DOCUMENT RESUME

ED 371 938 SE 054 357

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TITLE A Comparison of Coastal and Inland Residents' Knowledge of Marine Organisms and Their Feeding Relationships.
PUB DATE [94]
NOTE 48p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Concept Formation; *E!-mentary School Students; Geographic Regions; *Grade 4; Intermediate Grades; *Knowledge Level; *Marine Biology; Science Education; Scientific Concepts; Sex Differences
IDENTIFIERS Texas

ABSTRACT

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A COMPARISON OF COASTAL AND INLAND RESIDENTS' KNOWLEDGE OF MARINE ORGANISMS AND THEIR FEEDING RELATIONSHIPS

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The purpose of this investigation was to compare the knowledge regarding marine organisms and their feeding relationships of fourth grade residents of one coastal and one inland community in south Texas and to generate grounded theory concerning the participants' construction of such knowledge. Four male and four female students were randomly selected from the fourth grade populations at one coastal and one inland site (n= 16). Both free-recall and stimulated clinical interviewing strategies were employed to examine each participant's knowledge of the selected topics. Participant responses were compared across the variables of gender and region of residence. Overall, coastal residents were aware of more marine organisms than were inland residents, especially those organisms native to the waters near their home community. Gender was not shown to be a significant variable. Students from both groups were found to rely upon a limited number of critical physical attributes to identify marine organisms. A majority of the most commonly named organisms were those that the participants identified as being dangerous to humans. All of the participants were found to rely primarily upon a size-dependent, predator dominated "big fish eat little fish" framework when constructing understanding of marine trophic relationships.

A Comparison of Coastal and Inland Residents' Knowledge of Marine Organisms and Their Feeding Relationships

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Introduction

Much of the science education research that has been reported in recent years has explored the content of students' personal "spontaneous" knowledge (Pines & West, 1986) concerning numerous science topics (See: Osborne & Freyburg, 1985; Wandersee, Mintzes, & Arnaudin, 1989). By exposing student ideas about various phenomena and processes, this body of "conceptual framework" or "misconceptions" research has enabled scholars to not only explore conceptual change processes (e.g.,Gilbert, Osborne, & Fensham, 1982; Posner, Strike, Hewson, & Gertzog, 1982), but also to propose research-based "constructivist" teaching strategies (e.g., Asoko, Driver, & Scott, 1991; Brown & Clement, 1989; Novak,1991; Zeitoun,1984). The studies that have been reported span the science disciplines, including investigations involving physical (e.g., Andersson & Karrquist, 1983; Erickson, 1979; Novick & Nussbaum,1981; Stead & Osborne,1981), earth (e.g., Happs, 1982; Klein, 1982; Nussbaum & Novak, 1976; Sneider & Pulos,1983), and life science concepts (e.g., Arnaudin & Mintzes, 1985; Bell, 1981; Biddulph, 1983; Brumby, 1984; Tamir, Gal-Choppin, & Nussinovitz, 1981; Trowbridge & Mintzes, 1985). Importantly, although the list of biology topics that have been explored is extensive, there remains at least one important gap in our knowledge regarding student "generation" of knowledge (Osborne & Wittrock, 1983) regarding biological phenomena. The field of marine/aquatic education has not received much attention from researchers (Fortner & Mayer, 1989). As a result, not much is known about children's construction of knowledge regarding the marine environment. A recent content analysis of the educational research literature for the years 1963 to 1986 (Wandersee, Mintzes, & Arnaudin, 1989), for example, employed both computer and hand searches to identify 103 studies involving conceptual learning in biolog ife science. Papers were identified from Africa, Asia, Australia, the British Isles, Europe, and North America. Of these papers, 17 reported investigations regarding student conceptualization of life and death, 20 involved plants and animals, 16 centered on the human body, 23 focused on biological continuity, and 27 explored "other" biological phenomena. Interestingly, no studies were identified that dealt specifically with students' understanding of marine related topics. A subsequent literature review conducted by this researcher has revealed only a handful of studies (e.g. Fortner, 1978; Fortner & Mayer, 1983; Brody & Koch, 1986; 1990) that deal directly with students' understanding of marine related information. These findings are remarkable in light of the fact that most of Earth's surface is covered by saltwater. This state-of-affairs poses several interesting questions. It is not known, for example, what types of intuitive or "commonsense" (Hills, 1989) ideas regarding the marine environment and its inhabitants students are likely to possess when they come to the classroom. Also, what are the sources of any marine related knowledge that children may possess when they enter school? Since the United States is a nation that relies heavily upon its marine resources, and in light of the fact that it has been projected that 80% of the United States' citizens will live within 50 miles of the coast (including the Great Lakes) by the year 2000 (Spence, 1989), a critical need exists for research exploring individuals' construction of knowledge regarding the marine environment. Because the current goal of several influential organizations of scientists and science educators is "scientific literacy" for all Americans (AAAS, 1989; NSTA, 1993), a basic understanding of marine ecology concepts would appear to be an important component of such competency. In fact, since most of Earth's surface is covered by oceans, any science education program claiming to promote scientific literacy would seemingly have to include a substantial exposure to marine topics. Because so little research has been done involving children's learning of marine related concepts, little is known about the prior knowledge that students are likely to possess concerning such topics when they come to the classroom. In fact, almost nothing is known at the present time regarding how students use their personal knowledge frameworks in understanding marine related phenomena. It is not clear, for example, whether children actually develop a discrete "marine framework" that they employ in constructing understanding of the marine environment, or whether they simply employ any prior knowledge that is available to them, including knowledge of terrestrial habitats. Little is also known about any strategies that students may employ in recognizing and understanding marine organisms. For these reasons, the current study was seen as providing an important baseline in the construction of understanding regarding children's learning in marine science.

PROBLEM

A combination of free recall and stimulated clinical interviewing strategies were employed to examine the question:

What similarities and differences exist in the content and sources of knowledge regarding marine organisms and trophic interactions of fourth grade coastal residents and their inland counterparts?

PURPOSE

This paper describes the knowledge frameworks of a random sample of fourth grade students from one coastal and one inland community in south Texas concerning marine organisms and trophic interactions. Each participant's stated beliefs have been described and compared in terms of both content and sources of knowledge. The participants' statements were also compared across the variables of place of residence and gender in order to generate "grounded theory" (Glaser & Strauss, 1967; Spector, 1984) concerning the possible effects of these variables on both the content and apparent sources of students' knowledge regarding marine organisms and trophic interactions.

RESEARCH QUESTIONS

The following research questions were of primary interest:

1. Which marine plants and animals are the participants aware of and what are the apparent sources of this knowledge?

2. To what extent can the participants link marine organisms acccrding to trophic relationships and what are the sources of this knowledge?

3. What similarities and differences (quantitative and qualitative) exist in the conceptual frameworks and knowledge sources of the coastal and inland residents regarding the selected marine ecology topics?

4. What similarities and differences (quantitative and qualitative) exist in the content and sources of knowledge regarding marine organisms and trophic interactions of female participants and their male counterparts?

5. What, if any, shared "alternative conceptions" (Abimbola, 1988; Hewson, 1981) regarding marine organisms and feeding relationships are held by the members of the various sub-groups of interest?

HYPOTHESIS

The declarative hypothesis, "Both qualitative and quantitative differences will exist in the knowledge regarding marine organisms and trophic relationships of students from coastal and inland communities," was proposed.

The selection of a problem by the investigator indicates a belief that the average coastal resident should be more aware of marine organisms than the average inland resident. Through experiences such as fishing trips, beachcombing, and various water sports, coastal residents are provided with opportunities to acquire knowledge of locally occurring plant and animal species. They may also have learned of marine fauna through vicarious experiences such as listening to "fish stories", reading printed material concerning marine themes, or watching locally produced television programs dealing with marine topics. This is not to say that the average inland resident was predicted to be a "tabula rasa" concerning marine topics. On the contrary, it was predicted that inland residents would exhibit fairly well-developed conceptual frameworks concerning organisms which had been the subjects of media attention such as sharks, seals and whales. It was also predicted that inland residents would possess much less information concerning many organisms native to Texas waters (e.g., locally occurring fish species such as the "redfish" , and invertebrates such as shrimp, and crabs).

The situation was predicted to be much different regarding marine autotrophs. Very few people go to the beach or out in a boat to view or collect marine plants. Also, it is not likely that children often hear either personal or media accounts involving such organisms. In the absence of these sources of knowledge it would be difficult for individuals to construct significant conceptual frameworks concerning marine plants. In fact, in one early investigation involving children's ability to identify and classify various animals and terrestrial plant species (Ryman, 1974) it was found that while most of the participants could easily identify drawings of common animals by name, they experienced considerable difficulty identifying similar drawings of various plant species. Not surprisingly a survey of 226 fourth, eighth, and eleventh grade students from across the state of Maine (Brody & Koch, 1986) revealed a very low level of conceptual development regarding marine autotrophs. In another study involving 13-15 year old students from one Nigerian school (Adeniyi,1985), the participants were again found to possess an extremely limited amount of knowledge regarding aquatic vegetation and this fact was believed to have restricted their ability to construct aquatic food chain diagrams. Based on such data it was predicted that both coastal and inland residents would exhibit equally low knowledge levels regarding marine autotrophs including phytoplankton.

Method

Sample

Participants were randomly selected from the populations of fourth grade students residing in two south Texas communities. For the purpose of the investigation, the communities were referred to fictitiously as "Tidetown" and "Thornville". The two communities were selected as research sites based upon several criteria. During the initial selection process, the investigator identified several coastal and inland communities that were of approximately the same size, and that provided residents with roughly the same "informal" educational opportunities from sources such as motion pictures, public libraries, and television. The schools in each community were also compared regarding both the size of the population served and adopted curriculum and texts. Finally, the populations of students at each prospective site were compared in terms of both ethnic and socio-economic make-up. Using these criteria, one coastal (Tidetown) and one inland (Thornville) site were chosen. A short description of each community follows.

Life in Tidetown

Tidetown, Texas is a community of approximately 6,000 individuals located on the Gulf coast. According to administrators and teachers within the Tidetown schools the community is composed largely of working class families who fall within the lower to middle class range socioeconomically. Major sources of employment for the area include several chemical plants, an aluminum smelting facility, a recently commissioned United States naval base, and several construction facilities that produce and repair marine drilling equipment. A number of families within the community also acquire at least a portion of their income through commercial fishing activities including crabbing, oystering, and shrimping. Fishing, boating, and other water related activities are popular recreational pursuits for many Tidetown residents.

The Tidetown schools are fully accredited by the state of Texas falling within the 3A classification of schools. Tidetown Elementary School is located within five kilometers of the seashore. Approximately 300 students in grades four and five attend Tidetown Elementary. Classes are self-contained with the students remaining with one teacher for most of the instructional day. In 1991 the Tidetown ISD adopted the laser disc program, "Windows on Science" (ten Brink, 1992) as its sole science program for grades K-6.

Tidetown residents receive VHF and UHF television signals from a number of transmitters including both English and Spanish language stations. Several cable and satellite television providers also serve the community. While there is no motion picture theater in Tidetown, there are three video rental stores and several neighboring communities (including one major urban area) that have theaters that provide Tidetown residents with access to motion pictures. These neighboring communities also provide Tidetown residents with other potential sources of marine-related knowledge. One such neighbor, "Shrimpton," purports itself to be the "shrimp capital of the world." Each year for over 50 years Shrimpton has held a "Shrimpfest" celebration. The events held during this festival range from the predictable "Shrimp Queen" pageant to shrimp eating competitions and fishing contests. In another nearby community, "Oyster Fair" is the annual carnival and mollusks simply replace crustaceans as the object of celebration.

In summary, Tidetown is a small coastal community in south Texas that has close associations and ties with the sea. Through activities associated with occupations, recreation, and socialization, information about the marine environment is filtered to Tidetown residents.

Life in Thornville

Thornville is located on the arid plains of south-central Texas approximately 180 kilometers north of Tidetown and the Gulf coast. In many ways Tidetown and Thornville are quite similar. Thornville residents also generally fall within the lower to middle socioeconomic class according to school officials, and Thornville school facilities are very comparable to those of Tidetown. Fourth grade classes at Thornville Elementary are self-contained and have a student-to-teacher ratio that is approximately the same as that in Tidetown. Fourth grade teachers in Thornville, however, use a state adopted textbook as their primary source for science material rather than the laser disc program. Major sources of employment include farming and ranching, petroleum production and refining, and construction. Thornville contains one movie theater as well as several video rental facilities, and is within 50 kilometers of a major metropolitan area. Both UHF and VHF, as well as cable and satellite television programming are available to Thornville residents. Each spring Thornville residents celebrate "Farm and Ranch Days," much as the coastal residents enjoy "Shrimpfest." Several nearby communities also hold spring carnivals that highlight some aspect of the area's agricultural heritage. The primary source of water-related recreation for Thornville residents consists of fishing and boating on a large fresh water reservoir that is located approximately 40 kilometers to the south of the town.

While Thornville does resemble Tidetown superficially, it is obvious that many fundamental differences exist between the two communities. Unlike Tidetown residents, the people of Thornville have not learned to live in close association with the sea. Their geographic location has dictated that they learn those things necessary for life on the mesquite and cactus covered plain.

Sample Selection

Using class lists and a table of random numbers, eight participants (four male and four female)were randomly selected from the fourth grade populations at each site (n=16). To insure that individuals who had recently relocated to either site were not included in the study, only those students who had lived in their respective communities since grade one were included in the initial sampling pools. This was especially desirable in the case of Tidetown due to the transitory nature of many families from that community who relied on either temporary construction work or the United States Navy for their livelihood.

Data Collection

Initially, a combination of free-recall and stimulated clinical interviews were employed to explore each participant's knowledge of the selected topics. These interview sessions lasted for approximately 45-60 minutes. The format employed in these initial individual interviews is described in the following sections.

Free-recall Phase

During this interviewing stage, the participants were asked to respond to a verbal request to identify a marine organism. The investigator began each interview as follows:

> "Hello (participant's name) , my name is Mr. McDonald, and I would like to spend some time with you today talking about life in the oceans. I am very interested in finding out how many living things you can identify that make their homes in the sea. This is not intended to be a test, and no grade will be given. If you do not know the English name for something, but know its Spanish name, please tell me the Spanish name. By interviewing you and your classmates I hope to find out what most of the fourth graders in (Tidetown or Thornville) believe about the organisms that live in saltwater. I will be tape recording this interview because I can't write as fast as we can talk. I will use the tape later to remember what we said during the interview. Do you have any questions? OK, (participant's name), please tell me the name of something that lives in the ocean?"

After the participant had responded with the name of an organism, the following basic interview format was followed:

A. *Participant identification of a marine organism* - Questioning was initiated using the prompt, "(child's name), please tell me the name of something that lives in the ocean."

B. *Verification of meanings of names/terms employed by participant* - Once an organism had been identified, the investigator explored the child's knowledge of that organism by using the prompt, "Tell me about a (name of organism identified in step A.)."

C. *Participant identification of possible sources of knowledge* - For this step, the investigator would ask, "Where did you learn about (name of organism)?"

D. *Participant identification of food source* - Once the participant had identified their perceived sources of knowledge about an organism the investigator would ask, "What is food for a (name of organism)?"

E. Return to step B. and repeat the questioning cycle with the organism identified as food in step D. If no food organism was identified the researcher would repeat step A.

Following this procedure the investigator probed each participant's understanding of marine life forms and their food sources. The free recall stage was terminated when a participant could not identify any more organisms.

Phase II - Stimulated Recall Phase

During this part of the interview the participants were asked to identify pictures of 25 marine organisms that are commonly found in the waters near Tidetown (Appendix I).

The drawings included locally important finfish and marine invertebrates. To insure that feeding relationships were not inferred based upon the size of the drawings, all of the prompts were of similar size. The researcher presented the drawings individually, each time asking the interviewee to name the organism pictured. If organisms were recognized at this time that had not been named during the free recall stage, the investigator followed the basic interview format in establishing student knowledge regarding the animal and its feeding habits, as well as the sources of this knowledge.

Knowledge of Plants

If a participant failed to mention plants in the course of the interview, the investigator would ask, "Do any plants live in the ocean?" If a participant responded in the affirmative to this question the researcher used the previously described interview format to explore their knowledge of marine plants and their feeding relationships. If the participant indicated that plants did not live in the sea, this phase of the interview was terminated.

Food Chain Diagrams

During the interviews the investigator sat beside each participant at a table. When a participant identified a plant or animal, the organism's name was written on a sheet of paper. As trophic relationships were reported, the investigator would write the name of the food organism(s) beneath the consumer and connect the two organisms with an arrow indicating the direction of the trophic interaction. For example, a statement by the subject that sharks feed upon crabs was recorded as follows:

$$\begin{array}{c} \text{shark} \\ \uparrow \\ \text{crab} \end{array}$$

In this way diagrams of all of the feeding relationships that were identified by each participant were constructed. This procedure w employed for several reasons. The diagrams were drawn primarily to provide the children with a method of organizing and remembering their statements. It was the investigator's belief that if the participants had constructed any useful prior knowledge concerning the construction of food chains, they would be able to use this schema as a "scaffold" upon which to construct responses during the interview. Unfortunately, none of the participants appeared to be able to make use of the diagrams in the way that the researcher had hoped. In fact, none of the participants paid much attention to the diagrams during their interviews. This was true of the residents of both communities, even though all of the Thornville residents reported that they had studied food chains at school in the past while their Tidetown counterparts all said they had never studied food chains before. (By May of 1993, all of the participants from both communities reported having studied about food chains at school.)

Each participant's testimony yielded a number of individual food chains. During data analysis all of the single "chains" that were constructed during an individual's interview were combined to form a "master" diagram (Appendix II) of that participant's ability to construct knowledge of marine feeding relationships. These master diagrams (simple food webs) were not viewed as visual models of each participant's "concrete" knowledge of marine trophic relationships, but rather as graphic representations of each individual's "zone of proximal development" (Vygotsky, 1934/1962), regarding marine organisms and their feeding behaviors.

Follow-up Interviews

In addition to the initial interviewing sessions, a series of follow-up interviews were conducted at each site between the beginning of March and the end of May of 1993. These short (5 - 10 minute) interviews were much less formal than the initial sessions, and generally focused upon statements that the individual had made during the initial session that required further elaboration.

DATA ANALYSIS

All interview sessions were audio recorded and transcribed by the investigator. The names of all of the organisms that were identified, as well as the apparent sources of each participant's knowledge of each organism, were subsequently recorded on data collection and analysis forms A and B (See Appendix III). Form A served as an initial "raw" data collection form. On this form the names of all of the organisms that were named by an individual were recorded and the reported sources of knowledge regarding each organism were identified. From these charts, a master list containing the names of every organism that was identified by the total sample was compiled. The number of participants from each sub-group who identified each species was then recorded in the appropriate cells (See Appendix IV). Form B was subsequently used to explore the participant's knowledge of the organisms identified at greater depth . By using the "find" feature on a word processor the researcher could easily isolate the comments of any participant regarding a particular organism. Expanded data concerning each individual's knowledge of every organism of interest was then recorded on individual copies of Form B. In this way, all of the interview transcripts were analyzed and compared. The participants' statements concerning marine organisms and their feeding relationships were compared in terms of conceptual content, sources of knowledge, knowledge of trophic relationships, and reported "alternative" conceptions.

Conceptual Content

The statements of each participant were analyzed qualitatively by comparing their conceptual content. The focus of this portion of the analysis was to determine not only which organisms the participants were aware of, but also to explore the extent of this awareness. After a participant had identified a marine organism the investigator directed him/her to "tell me about" the organism named.

Sources of Knowledge

After a participant had identified and briefly discussed an organism, the investigator probed the sources of the participant's understanding by asking, "Where did you learn about *(organism)*?" After the participant had responded, the researcher asked specifically if the organism in question had been encountered in the following ways:

1. A real-life encounter
2. In books or magazines
3. In television of motion picture productions
4. During classroom instruction

Feeding Relationships

After the researcher had explored a participant's basic knowledge of an organism, and the sources of such knowledge, the participant was asked, "What's food for a *(organism)*?" In this way each child's beliefs concerning feeding relationships in the sea were explored.

Reported Alternative Conceptions

Throughout the interviews, the investigator sought to identify any common "alternative conceptions" (Driver & Easley, 1978) that were held by each participant. The texts, Shore Ecology of the Gulf of Mexico, (Britton & Morton, 1989), Marine Biology: An Ecological Approach (Nybakken, 1988), The Underwater Guide to Marine Life (Ray & Ciampi, 1956), and Invertebrate Zoology (Barnes, 1987) were used to verify the scientific accuracy of the participants' statements.

Using the analysis forms, the food chain diagrams, and the interview transcripts, the investigator examined the data in an effort to develop "grounded theory" (Glaser & Strauss, 1967) concerning the role of various information sources and learning processes in the construction of knowledge regarding marine organisms and trophic interactions by fourth grade residents of coastal and inland communities.

Limitations

While factors such as the small sample size employed and qualitative nature of much of the data collected in this study obviously limit the generalizability of any findings reported, it is hoped that the data concerning the content, sources, and patterns of participant responses will prove to be valuable to educators, curriculum developers and future researchers. Certainly, patterns noted within or across the data set may suggest new directions for future research. Care should be taken in interpreting the findings reported here, however. One area of concern involves the number of individuals from each group that identified creatures such as whales, seals, octopi and dolphins. No flash card prompts were provided for these species because the prompts were designed primarily for stimulating memories of marine species native to Texas that had not been the subject of much media attention. Because no flash card prompts were provided for organisms such as whales, seals, etc., the number of individuals that may have identified a picture of these animals is not known. Had flash cards depicting these species been provided it is likely that more participants would have identified them than did based solely upon free recall.

Another area of concern involves the interviewing protocol employed. The experimental design used in the current investigation was employed specifically to probe individual students' personal prior knowledge of marine organisms and feeding relationships. While this design did provide greater detail concerning individually held beliefs than did the surveys and questionnaires employed in earlier research, care should be taken in interpreting the results since children in school settings often do not work in isolation. Children working in cooperative groups, for example, might be expected to construct different ideas concerning individual organisms and their feeding relationships than would single individuals. Because children in cooperative learning situations have the experiences, viewpoints, and beliefs held by a number of individuals to incorporate into their group construction of meaning, it would not be surprising if such constructions were conceptually different from the constructions produced by single individuals. Also, since the interviewing context is very different than the typical classroom situation it is likely that this factor could influence an individual's construction of meaning as well. While such variables might significantly influence a child's beliefs concerning individual species of organisms, they should have much less impact upon the broad frameworks or models that underlie that individual's beliefs. Personal ideas concerning the feeding behaviors of one particular species, for example, could be greatly influenced by the ideas of other group members, while the fundamental theoretical model underlying the child's understanding of feeding relationships in general could remain unaffected. While such variables certainly deserve consideration, it was the researcher's belief that the basic experimental design employed in this study was adequate for the purpose of determining the participants' personal awareness of, and beliefs concerning marine organisms and their feeding relationships.

RESULTS AND DISCUSSION

Awareness of Marine Organisms

A total of 55 marine organisms were identified by the participants (Appendix IV). Of these 55 organisms only 20 were identified by at least four of the 16 children (25%) who were interviewed, however (Table 1.). Overall, the coastal residents identified more marine organisms than the inland residents. The average coastal resident was able to identify around 15 organisms, the average inland resident could name but 13 (See Table 2.). While the inland residents actually identified more organisms than the coastal residents during the free-recall stage of the interview, the coastal residents recognized far more organisms during the stimulated-recall stage. Because the flash cards used as prompts during the stimulated portion of the interviews featured only the pictures of organisms that were commonly found in the waters near Tidetown, this difference in awareness was attributed to the coastal residents' day-to-day encounters with information concerning the organisms commonly found in the local environment.

Table 1. - Twenty most commonly identified marine organisms, and the number of participants from the sub-groups of interest naming each (cell n=4).

Organism	Male Coastal	Female Coastal	Male Inland	Female Inland	Percent of Sample
catfish	3	2	4	4	81%
"crabs"	4	4	4	4	100%
dolphin	2	2	3	2	56%
eel	1	2	0	1	25%
hermit crab	2	1	1	0	25%
jellyfish	4	3	2	2	69%
lobster	2	0	0	3	31%
octopus	4	2	1	3	62%
"plants"	1	1	2	2	37%
redfish	2	2	0	0	25%
sand dollar	1	4	3	2	62%
seahorse	3	3	3	4	87%
"seaweed"	2	3	2	1	50%
sharks	4	4	4	4	100%
shrimp	4	3	0	2	56%
squid	2	2	3	1	50%
starfish	1	1	1	4	44%
stingray	3	3	3	2	69%
tuna	3	1	0	0	25%
whale	3	1	3	3	62%

Although the average coastal male identified more marine organisms than did the members of any of the other sub-groups, gender was not a significant factor in the overall awareness of marine flora and fauna. The average female participant identified 13.75 organisms, while the average male participant named 14.5 (See Table 2.). The participants' responses were also much more evenly distributed across the gender variable, with the boys reporting only slightly more organisms than the girls during the free-recall interview stage, but with both groups performing equally well during the stimulated phase.

Table 2. - Average number of marine organisms that were identified during each interview stage by the members of the various sub-groups.

sub-groups of interest	free recall phase	stimulated recall phase	total organisms
coastal males	8.25	8.25	16.5
inland males	7.25	5.25	12.5
all males	7.75	6.75	14.5
coastal females	5.25	8.75	14.0
inland females	8.75	4.75	13.5
all females	7.0	6.75	13.75
all coastal residents	6.75	8.5	15.25
all inland residents	8.0	5.0	13.0
all participants	7.4	6.75	14.1

Strategies Used to Identify Marine Organisms

All of the interviewees were found to use a limited number of critical physical attributes as "obligatory variables" (Schallert, 1982) in constructing schemata for various marine organisms. The attributes of "pinchers", tentacles, fins, and spines were of particular importance in the children's recognition of various marine species. A number of the participants from both communities also exhibited an awareness that many marine animals can injure humans with their pincers, tentacles, fins, or spines. In fact, eight of the 14 most commonly named organisms were animals that the participants said could bite, pinch, sting, or "poke" a person. This observation led the authors to conclude that the participants from both communities had constructed a good deal of their knowledge regarding marine organisms within a personally relevant context. Marine animals and plants were "understood" in terms of what they could "do" to a participant. Creatures such as jellyfish and crabs, for example, were well known because they might "pinch," "poke," or "sting," while dolphins were remembered as friendly creatures. The following quotes, for example, were typical of those made by the residents of both communities concerning dolphins.

> It's a little animal that's very gray. I mean, it's not that gray. It's gray and white and it's very sweet. A nice animal. (Female Thornville resident)
>
> He's big and got a little hole so water can go out, and he's long and he's gray, and they save people if they're drowning. (Male Tidetown resident)
>
> They're nice and can do tricks for you. (Male Thornville resident)

These findings led us to conclude that the residents of both communities had primarily constructed awareness and understanding of those marine organisms that might affect a person should he or she chance to enter the marine environment. Within this personally relevant framework, the participants' fears regarding marine organisms were discovered to play an important role. Overall, most of the participants were found to exhibit an apprehensive and fearful attitude toward marine organisms in general. It was subsequently determined that the majority of these fearful feelings had been constructed as a result of the "stories and prejudices of adult society" (Bowd, 1983, p. 314) that had been transmitted to the participants through either the "fish stories" that they had be told by others, or television and motion picture productions dealing with "dangerous" marine organisms. These fearful attitudes or "prejudices" were found to have strongly influenced the intuitive classification schemes that the participants had constructed regarding marine species. Repeatedly the attributes of pincers, tentacles, "arms," or sharp fins were identified as being critical in recognizing species such as crabs, jellyfish, and octopi. One participant even identified "scorpions" as marine organisms based upon one attribute asserting that,

> Well, they have "pinchers" just like crabs and lobsters, but they have this tail that they sting you.

Importantly, almost all of the attributes that the young participants reported as being useful in identifying various marine species were attributes that are also used by "real" scientists when identifying organisms. This link between children's intuitive classification schemes and the formal classification systems employed by the taxonomist beautifully illustrates the likely origin of modern biological classification. In early times our ancestors initially constructed knowledge of those organisms that were either useful or potentially harmful to them, i.e. they constructed personally relevant knowledge. Certainly it is reasonable to propose that the biological classification systems we use today began with our ancestors' primitive, "egocentric" taxonomies long ago. From this perspective, modern ological classification systems may be viewed as emerging from our species' instinct for survival.

The use of personally relevant metaphors was also found to be an important strategy employed by the participants in their construction of awareness concerning several marine species. By constructing metaphorical connections with existing personal knowledge frameworks, the participants were able to remember marine organisms by linking them with objects and organisms from their daily lives. Students from both sites made statements linking various marine species with seemingly unrelated living and non living things. In one instance, a young Mexican-American female resident of Tidetown identified the "flounder" as an ocean dwelling creature. When asked to elaborate upon her knowledge of this flat fish, the young girl smiled broadly and announced that,

"Flounders are as skinny as tortillas."

In another case, a male participant from Thornville identified the stingray as a marine organism, explaining that stingrays were, "like horny toads (Phrynosoma sp.)." When asked to explain this unexpected comparison, the boy stated that,

> He (stingray) protects his self from the ground, just like a horny toad when it goes in the ground and you can't see it.

The boy went on to explain that he had kept a "horny toad" as a pet, and had observed this behavior, and had subsequently noticed the same behavior exhibited by a stingray he viewed in a television presentation.

Sources of Knowledge

As in previous studies that examined children's knowledge of marine and aquatic topics in general (e.g., Fortner & Mayer, 1983; Fortner & Teates, 1980), more individuals reported television and motion pictures as sources of information about marine organisms than reported any other source. While non-science programs such as "Flipper", "Bay Watch", "Jaws" and "The Little Mermaid" were identified by several of the participants from each community, broadcasts such as the documentaries produced by The National Geographic Society and programming on "The Discovery Channel", "The Learning Channel" and, in the case of Thornville residents, the local PBS "educational" channel, were also mentioned frequently. While many of the children identified these media sources, few specific examples of this variety of programming were provided. Television advertising was also found to be an important source of marine related knowledge. Several students in both the investigation reported herein, and an earlier pilot study, reported that they had learned about various marine organisms as a result of viewing a televised commercial advertising the "Trials of Life" video series from *Time/Life* books. This commercial, which featured short and violent scenes depicting marine animals such as sharks, killer whales, and sea lions attacking other creatures, received considerable air play during the time that the initial interviews were conducted. Importantly, even though each of the film clips used in the commercial were very short (~ 3-5 seconds) in duration, all of the students who reported this advertisement as a source of information provided vivid descriptions of scenes depicting species such as sharks and sea lions attacking smaller organisms.

Another source of information about marine organisms that was found to be of importance to many of the participants was printed material. While a number of individuals remembered experiencing such encounters with various marine organisms, very few specific publications were identified. Of the children who reported learning something about marine life from books, only one individual was able to give numerous examples of the organisms she had viewed in a printed source. This individual had constructed considerable awareness of marine animals by reading wildlife encyclopedia. Other printed sources that reportedly had provided some of the participants with information about marine organisms were *Highlights* magazine, *National Geographic* magazine, and *Ranger Rick's Nature Magazine*.

A number of individuals from both communities also reported that they had learned about marine organisms as a result of personal encounters with various species while visiting the shore. Even though a number of the residents of both communities reported such encounters, one fundamental difference was noted in the responses of the participants from each community. While the inland residents who reported such encounters with marine life all stated that they had occurred during family vacations to the coast, the coastal residents reported more encounters with marine species as a result of their day-to-day activities. A second important difference that was noted was related to gender. Although the male participants from both communities frequently reported having learned about marine species as a result of their own experiences while fishing, the females more often reported having only watched other individuals (usually older males) fish. Direct contact with marine species was found to be a particularly important source of information for those children who had experienced many such encounters. The participants who had experienced hands-on encounters with marine species were able to describe those organisms in much more detail than the participants who had not had such experiences. The comments that were made by one coastal resident regarding shrimp, an organism that he remembered using for bait while fishing, illustrated beautifully the kinds of knowledge construction that such encounters could foster. When asked to "tell me about" a shrimp, the nine-year-old male provided the following description:

> The brain is like...O.K., the brain isn't that big. They're like this big (gestures "pea sized"), and when you fish you can look through that little plastic covering that they have. It's like plastic. You can see right through it, and you can see the brain. It's gray. Then there's like blood vessels and they jerk up like that (gestures). And their eyes are about that far away from them (gestures). Their eyes are round.

This child had constructed a considerable "shrimp schema" based upon his experiences while fishing. By comparison, those children who had not had many encounters with shrimp were able to provide few details about the organism.

The inland residents reported learning more about marine life via classroom-based instruction than did the coastal residents. Most of the instruction that was remembered by the residents of both communities had centered on large marine animals such as whales, dolphins, and sharks. Several of the Thornville residents, for example reported that they had learned about whales and dolphins from their second grade teacher, "Mrs. H." When this teacher was contacted she verified her former students' claims, revealing that the students had even participated in an "Adopt a Whale" class project. Several students from Tidetown also recalled learning about whales and dolphins in school. Other organisms that individuals remembered learning about at school were the octopus and sand dollar (Mellita quinquiesperforata). One female Thornville resident recalled building an "octopus hat" from a plastic bowl and paper streamers while in kindergarten, while a number of students from both communities remembered learning about the "birds" that can be found inside a sand dollar as a result of classroom instruction. Other than these species, most of the participants denied learning about marine organisms as a result of classroom instruction. In fact, when asked if they had learned or "studied" about organisms such as shrimp, crabs and jellyfish at school, the residents of both communities frequently responded with laughter or an incredulous "no," apparently finding the suggestion of studying about such organisms in their elementary classrooms to be absurd. The researchers found this observation to be disturbing for several reasons. While it was determined through both the participants' interview comments and informal interviews with school personnel at both sites that each school had experienced some success in teaching their students about large marine animals such as whales and sharks, the opposite was true regarding smaller organisms. Without an awareness of at least a few important small marine invertebrates it would be very difficult for any of the participants to construct an adequate understanding of marine feeding relationships. Combined with the general lack of knowledge that was noted regarding marine vegetation and its important functions in the oceans, this lack of awareness of small invertebrates effectively prevented the participants from understanding energy flow through the marine environment. The lack of classroom instruction regarding the marine environment and its inhabitants was also found to have negative implications for individual students from both communities. Several of the young residents from each site were discovered to possess a good deal of "commonsense" (Hills, 1989) knowledge regarding marine topics that they had constructed as a result of their personal experiences. Seemingly, these individuals might be viewed as "above average" should they get the opportunity to use their personal prior knowledge of marine organisms in a classroom setting. The nine-year-old coastal resident whose description of the "plastic" covering of a shrimp was mentioned earlier, for example, had obviously already constructed considerable knowledge regarding this important crustacean. Vygotsky (1934/1962) might say that this child was "positioned" to construct still greater understanding of this organism. Given proper instruction the boy could have replaced his intuitive understanding of the "plastic" covering of a shrimps' head with a more accurate understanding of the concept "carapace". Since this child was both the son of a commercial fisherman and a frequent beach visitor, such personally relevant knowledge could have opened many windows of understanding for him. Sadly, in subsequent discussions with school personnel it was discovered that this individual was labeled as being a "hyperactive" child with a short attention span who had experienced considerable school failure. In fact, several of the other participants who were found to possess the most knowledge regarding marine organisms were also subsequently identified by their teachers as less than average students. The fact that these individuals could possess so much understanding regarding personally relevant science topics, yet be labeled as less than average science students due to the procrustean nature of behaviorist inspired curriculum models, provided a powerful example of the inadequacy of current pedagogical models that view students as passive consumers of "final form science" (Duschl,1990), rather than active constructors of personally meaningful knowledge.

While actual teacher directed instruction regarding marine organisms was apparently rare in the case of both communities, the school was shown to be an important source of knowledge about some marine species, nonetheless. Through participation in school-based informal activities suc a viewing marine-related films and videos and going on school sponsored field trips to marine aquariums, zoos, and aquatic theme parks, the residents of both communities were found to have constructed awareness of certain marine organisms, particularly large species of fish and marine mammals. During interviewing it was discovered that, while the coastal residents had all participated in a school sponsored field trip to the Texas State Aquarium in Corpus Christi, Texas, all of the inland residents had visited the Sea World of Texas theme park in San Antonio on a school trip. Both of these school trips had taken place near the end of the preceding school year. Overall, the children who had visited the aquarium were able to remember many more specific organisms than were those who visited Sea World. In fact, several of the children who had visited Sea World failed to mention the experience during their interview until the researcher reminded them of the school trip. This included one girl who had not identified dolphins as marine animals during her initial interview, but was subsequently found to have actually fed dolphins while at Sea World! Importantly, the individuals who had visited the aquarium remembered a number of specific marine organisms that they had seen at the facility, while those who had visited the theme park apparently remembered the event more as a trip to an amusement park.

A final source of information concerning marine organisms that was found to be of great importance to the residents of both communities were the "fish stories" told by others. By listening to the stories told by other individuals, participants from both regions had acquired certain "facts" about various aquatic species. This was particularly true regarding those organisms that were perceived as being dangerous to humans. A number of the participants from both geographic regions related the frightening stories they had heard concerning organisms such as catfish, stingrays, and jellyfish. One female Tidetown resident, for example, made the following comments concerning the "stingray" (Dasyatis americana):

Participant: It mostly stays on the ground and it has a long tail and at the end it has these things...and if you step on it, it will flip it up and sting you (gestures with arm to mimic motion of stingray tail).

Investigator: I see by your motions that you know something about stingrays. Where did you learn about them?

P: From my friend. She stepped on one of them. She has a huge scar right there (indicates lower leg). They cut you.

I: Have you ever seen a stingray?

P: Not that I know of.

A female Thornville resident also reported learning about stingrays from another individual. During the stimulated-recall interview phase this child identified a flash card prompt depicting polychaete worms (See Appendix I) as "stingrays." When questioned further about this statement, the girl reported that, although she had never actually seen a stingray (She was subsequently unable to identify the flashcard prompt depicting a stingray.), her teacher had been "stung" by one of the creatures and had told the class about the experience. The girl remembered several details from the teacher's account vividly and thought that the polychaete worms with their threatening head appendages could possibly be the type of creature that had harmed her teacher. When the teacher was later questioned concerning this girl's statements, she verified the story. Indeed, the teacher's description of being "stung" was virtually identical to the girl's account. The fact that the child had only heard the story on one occasion several months earlier, yet remembered several details of the account vividly, convinced the investigators that such "fish stories" were powerful sources of knowledge concerning the marine world. Ultimately, several students reported similar knowledge construction based upon the stories that other individuals had told them concerning organisms including crabs, catfish, jellyfish and flounder.

Knowledge of Feeding Relationships

All of the participants were discovered to employ a size dependent "big fish eat little fish" model in understanding a majority of marine feeding relationships. As a result, very few of the participants were able to provide much information regarding marine trophic relationships. One consequence of this size dependent food chain model was that most of the children had constructed an understanding of marine trophic relationships that relied strictly upon predation as a feeding strategy. Four of the 16 participants even reported that aquatic plants were predators that entangled and consumed small fish in order to survive. Two additional participants reported "water" as food for marine vegetation, and one other identified "salt" as aquatic plant food. While several individuals did seem to be aware that plants did not acquire energy by "feeding" in the traditional sense, none of them exhibited any knowledge of photosynthesis.

Because none of the participants mentioned scavenging as a feeding strategy, the investigator developed an interview question for exploring their beliefs about this important feeding behavior. During follow-up interviews, each participant was asked to respond to the prompt:

> If a fish or some other animal dies in the ocean, what happens to the dead animal?

All of the participants were found to possess little or no awareness of the importance of scavenging and decomposing in marine ecosystems. While all of the children reported that a dead fish would float to the top, few could provide an explanation of what might subsequently become of the dead organism. Several did report that a dead fish might "disintegrate," "dissolve," or be buried in the sand, but the role of other organisms in the process was poorly understood.

As with the participants' construction of the intuitive classification system discussed earlier, the reliance upon a size dependent food chain model and the general lack of knowledge regarding scavenging may be at least partially explained in terms of "egocentric" thinking. Human beings are among the largest 5% of species on Earth (Earl, 1991). Since most of the foods that children consume are physically smaller than the children themselves, and since our meals are almost always prepared in relatively small-sized portions in any case, it might be expected that children would construct a size dependent intuitive model of feeding relationships. Also, since none of the participants from either community appeared to have been forced to "scavenge" for food, that feeding behavior was not well understood.

Alternative Conceptions Regarding Marine Organisms

Most of the shared "alternative" frameworks that were observed in the testimonies of the participants in this investigation were related in some fashion to either the intuitive classification systems the children had constructed for identifying marine organisms, or the size dependent food chain model. A number of alternative beliefs were noted in the participants' statements regarding marine vegetation. Several children, for example, reported that "water" was food for aquatic plants, while four others believed the ocean's plant life to be carnivorous. Most of the participants also exhibited what might be considered unreasonable fear of many marine species. The vast majority of the participants, for example, labeled sharks as "man eating" creatures that routinely seek out humans for food. While this may be true of certain species on rare occasions, the general belief that sharks actively prey on humans can certainly be viewed as being contrary to accepted scientific thinking. Furthermore, the commonly reported belief that the sea is a predator intensive ecosystem lacking both decomposers and scavengers may also be labeled as an "alternative" to the actual case.

Both the "big fish eat little fish" model of feeding relationships and the intuitive classification systems exhibited by the participants in this investigation are "spontaneous" knowledge structures (Pines & West, 1986) that should be of interest to researchers in that they illustrate the broad, overarching nature of some intuitive biological knowledge frameworks. The existence of intuitive biological knowledge frameworks has been debated with some fervor in recent years. The published debate between Anton Lawson and Joel Mintzes was perhaps the most spirited of these discussions (See: Lawson, 1988; Mintzes, 1989). Although Mintzes found evidence supporting the existence of such intuitive cognitive structures, Lawson reported an investigation that appeared to refute any construction of "spontaneous and naive" biological theories by young children. The findings from the investigation reported herein clearly illustrate that children do construct intuitive frameworks regarding biological phenomena.

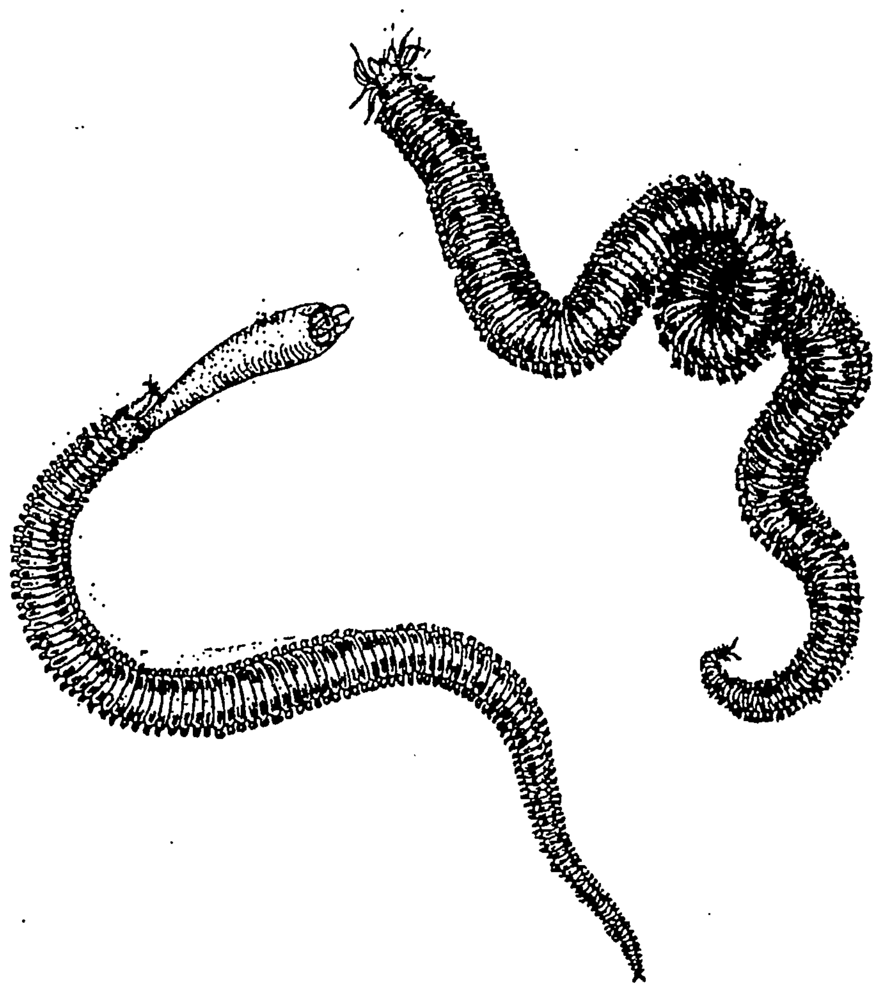
Implications

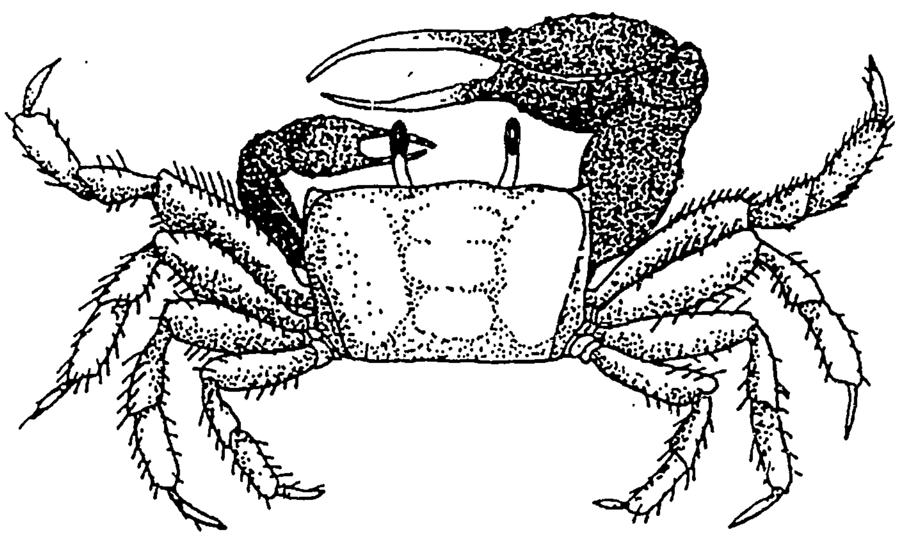
The discovery that all of the participants in this investigation relied almost exclusively upon an intuitive, size dependent and predator intensive model to describe the feeding behaviors of the marine organisms they identified provides an interesting avenue for future study. Do students of various ages construct intuitive models to describe the trophic interactions of terrestrial organisms? If so, what similarities and differences exit between those models and the "big fish eat little fish" model described in this investigation? In light of the fact that the theme "energy" is widely used in the science education reform efforts being undertaken in several states (e.g., California Department of Education, 1990) information concerning students' abilities to construct explanatory models describing energy flow is sorely needed. To date, few studies have been undertaken that explored students knowledge of food chains/webs (e.g. Griffiths & Grant, 1985).

For the teacher, the finding that students from both communities possessed a substantial amount of knowledge about large marine organisms, but generally lacked knowledge of small marine creatures is important. If specific knowledge of small marine organisms can empower students to understand marine feeding relationships more fully, then teachers should consider spending more class time introducing these organisms. This is particularly true for those teachers whose students reside along our nation's coasts. With only slight modifications to existing curricula, teachers could provide much more relevant instruction. Anatomical studies, for example, could be performed using locally important marine species such as squid, crabs and shrimp as well as terrestrial animals. Also, small marine animals including both the larval stages of invertebrates and small animals such as copepods and amphipods make wonderful subjects for neophyte microscopists and could be easily substituted for the more commonly used single celled organisms such as the paramecium. While such modifications are minor, they could produce large dividends.

APPENDIX I

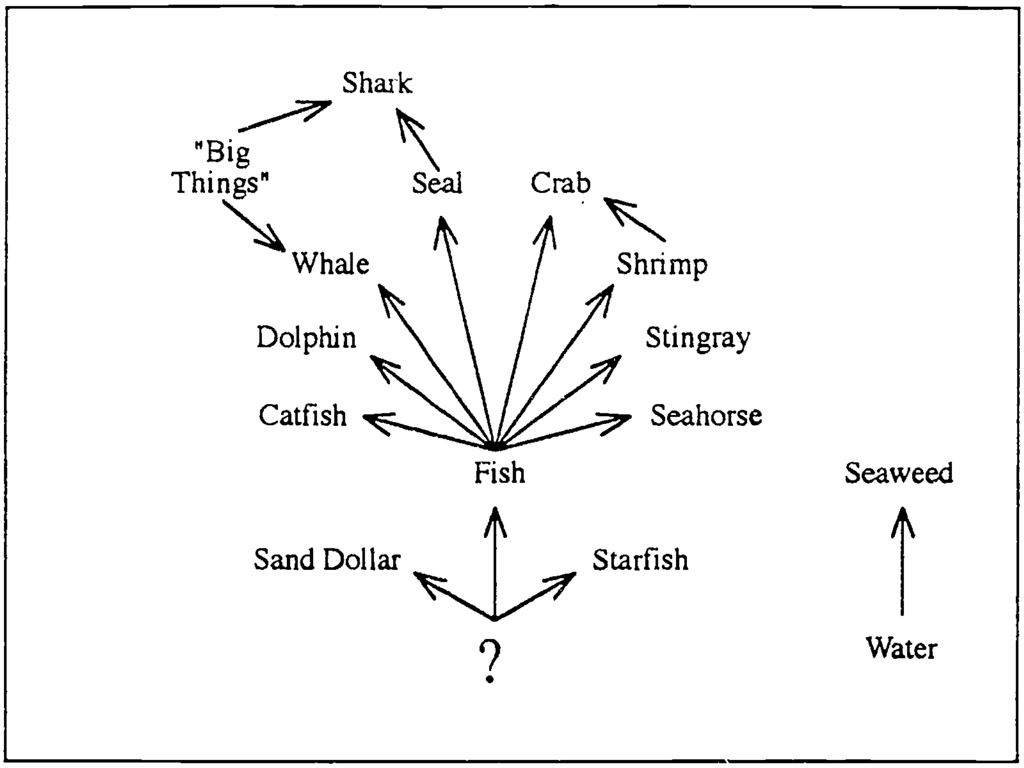
Sample Flash Card Prompts





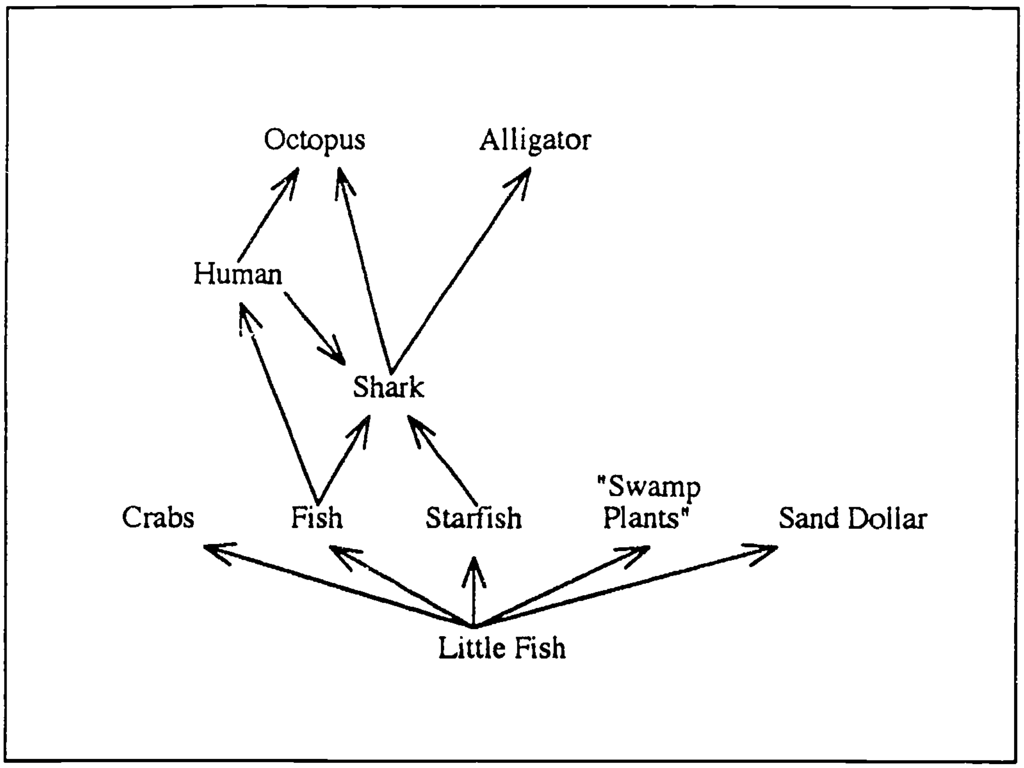
APPENDIX II

Sample Food Chain Diagrams



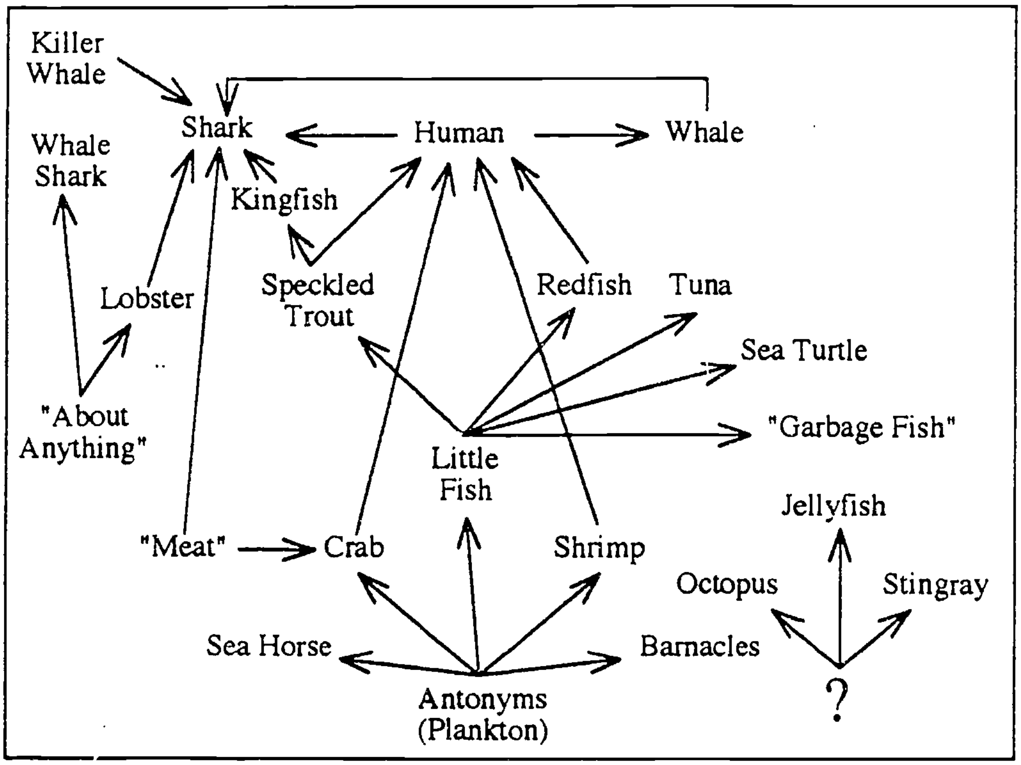
Female/Thornville

? = "I don't know"



Male/Thornville

? = "I don't know"



Male/Tidetown

? = "I don't know"

APPENDIX III

Data Analysis Forms

Form A. - Organisms identified and reported sources of knowledge regarding each.

Participant ____________________ Age_________

Residence: (coastal/inland) Gender: M / F

Organism	Movies & Television	Books & Magazines	Direct Experience	School Experience	Another Individual	Unknown or "Other"

Key:

TSA = Texas State Aquarium
CTV = commercial television
EP = educational program
FE=fishing expedition
FI = formal instruction
FT = field trip
SW = SeaWorld
SL = school library
PL = public library
IL = incidental learning
Tx = textboo
BV= beach visit
PB = personal book
M = movie
ST = "show & tell"

Form B. - Used for indepth analysis of each participant's knowledge of each organism.

Organism_______________________________

Participant	Direct Contact	Print Sources	Video Sources	Classroom Instruction	Another Individual	Food Source

APPENDIX IV

Master List of Marine Organisms Identified

Table 1. Total marine organisms identified, and frequency of recognition by each sub-group of participants (cell n = 4).

Organism	Male Coastal	Female Coastal	Male Inland	Female Inland	Total	% of sample
algae	0	0	1	1	2	12%
alligator	2	0	1	0	3	19%
anemone	0	1	0	0	1	6%
angel fish	1	0	0	0	1	6%
barnacles	1	0	0	0	1	6%
bass	1	0	1	1	3	19%
blowfish	1	0	0	0	1	6%
"bugs"	0	1	0	0	1	6%
cabbagehead jellyfish	0	1	0	0	1	6%
catfish	3	2	4	4	13	81%
clam	0	0	0	1	1	6%
clownfish	0	1	0	0	1	6%
coral	0	1	1	0	2	12%
crab	4	4	4	4	16	100%
crayfish	1	1	1	1	4	25%
dolphin	2	2	3	2	9	56%
eel	1	2	0	1	4	25%
flounder	3	2	1	0	6	37%

Organism	Male Coastal	Female Coastal	Male Inland	Female Inland	Total	% of sample
flying fish	0	0	0	1	1	6%
goldfish	1	0	0	1	2	12%
grouper	1	0	0	0	1	6%
hermit crab	2	1	1	0	4	25%
jellyfish	4	3	2	2	11	69%
kelp	0	1	1	0	2	12%
killer whale	3	2	0	2	7	44%
kingfish	1	0	0	0	1	6%
lobster	2	0	0	3	5	31%
octopus	4	2	1	3	10	62%
oyster	0	0	0	1	1	6%
penguin	1	0	1	0	2	12%
perch	1	0	1	0	2	12%
plankton	1	1	1	0	3	19%
redfish	2	2	0	0	4	25%
sailfish	0	0	0	1	1	6%
salmon	0	0	1	0	1	6%
sand dollar	1	4	3	2	10	62%
sardine	0	0	0	1	1	6%
seagrass	1	1	0	0	2	12%

Organism	Male Coastal	Female Coastal	Male Inland	Female Inland	Total	% of sample
sea horse	3	3	3	4	13	81%
seal	0	1	1	1	3	19%
sea turtle	2	0	0	0	2	12%
seaweed	2	3	2	2	9	56%
shark	4	4	4	4	16	100%
shrimp	4	3	0	2	9	56%
speckled trout	1	0	0	0	1	6%
spider crab	0	1	0	0	1	6%
squid	2	2	3	1	8	50%
starfish	1	1	1	4	7	44%
stingray	3	3	3	2	11	69%
sunfish	1	0	0	0	1	6%
"trout"	0	1	0	0	1	6%
tuna	3	1	0	0	4	25%
whale	3	1	3	3	10	62%
whale shark	1	0	0	0	1	6%

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