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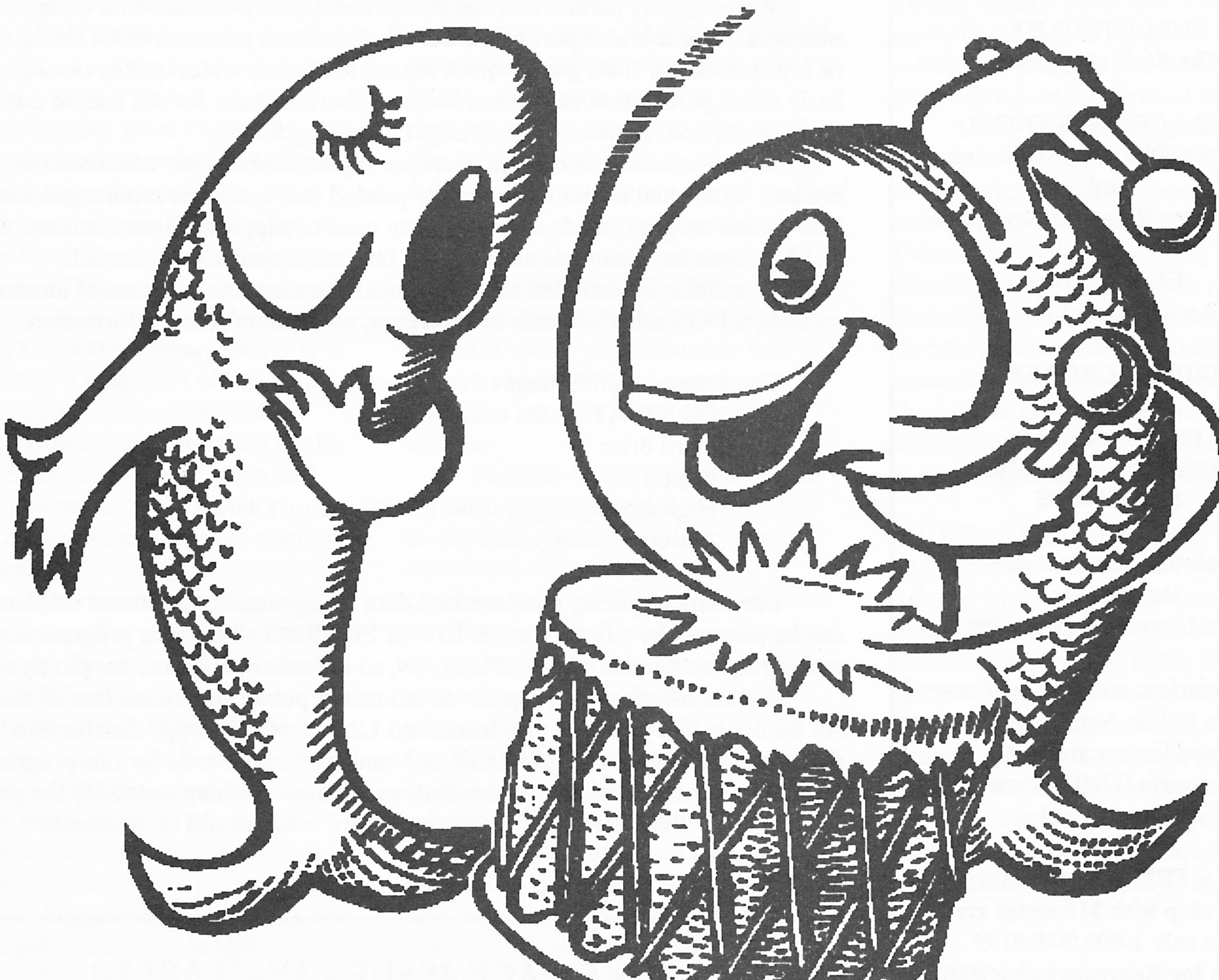

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DRUM & CROAKER
c/o Fishnet
102 Hiram Street
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Aqua-Pro Database

by Jay Hemdal, Curator of Fishes, Toledo Zoo

The Toledo Zoo Aquarium has recently completed a prototype database program we use to help manage information about our systems, fish and invertebrates. Fully menu driven, this program contains five modules: specimen inventory, water quality records, treatment records, necropsy reports, and animal weight records. It is a "flat field" database, thus is very easy to use. It cannot however, relate information between the different modules automatically.

The specimen inventory system compiles current inventory status, prints "tank cards", as well as offering in depth information concerning the specimens, such as related necropsy reports, dangers to humans, feeding requirements, special medical information, etc. There is also a means to store a fish's ARKS number for those who also use that computer program.

Water quality parameters can be retrieved in any combination of dates or tank numbers. One useful report prints out all of the tank parameters for the last three or four test dates. This gives a quick means to identify water quality trends. All basic water parameters can be tracked, and there is space for the user to enter any of their own special parameters they might be testing for.

The treatment records and necropsy reports operate as "electronic note-books". Individual copies can be easily printed out, and basic reports generated. The animal weight records are most often used to supply staff veterinarians with weight trends for mammals and reptiles, but could also be used for fish.
A set of utilities are included such as, a means to clear the program of unwanted records, a DOS sub-shell, user help screens, and system status information.

The system requirements to run this program are:

- PC XT, AT or 386 computer
- Hard drive
- Printer
- High density floppy drive (740K, 1.2 or 1.44MB)
- A mouse is suggested

For users requiring non-standard data manipulation, the stored information can be accessed by either DBASE III+ or FOXPRO. The basic program does come with a runtime version of FOXPROLAN, so the other programs are purely optional.

We are offering this program to interested public aquariums free of charge. All we ask is that you send us a formatted 1.2 or 1.44MB floppy disk,(or two 740K disks) and a stamped and addressed disk mailer. Source code for this program may be made available in certain circumstances for those wishing to modify the program on their own. Suggestions for improving future versions will be welcome.

Loggerhead Sea Turtle Head-Start Evaluation Project: A Classic Example of the Conservation Role of Zoological Parks and Aquariums

by W. Mark Swingle, Aquarist, Virginia Marine Science Museum, 717 General Booth Blvd., Virginia Beach, VA 23451; Doug Warmolts, Curator, Johnson Aquatic Complex, Columbus Zoological Gardens, 9990 Riverside Drive. Powell, OH 43065; and John Keinath, Research Associate, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062

INTRODUCTION

All sea turtles are listed as either endangered or threatened species under the U.S. Endangered Species Act. This status has been assigned because of the general belief that sea turtle populations are in decline worldwide. Loggerhead sea turtles *Caretta caretta* are the most abundant sea turtles along the east coast of the United States. Nesting occurs on beaches from Florida to Virginia on the U.S. mainland (Musick, 1988). For loggerheads, as for other sea turtle species, natural mortality of eggs and hatchlings is high. Estimates of the survival rates of loggerhead eggs to maturity range from only 1 in 400 to less than 1 in 3000 (Frazer, 1986). It is believed that a large part of this mortality occurs during the post-hatching period when young sea turtles are vulnerable to a host of avian and marine predators.

Captive raising, or head-starting, of sea turtles to a size large enough to avoid most predators has historically been encouraged as a conservation tool. For example, the state of Florida had until recently been heard-starting turtles for 30 years. Although considerable money, time, and effort have been put forth in these programs, there is no evidence that a single head-started animal has survived to enter a breeding population (Woody, 1990). Possible reason for this perceived lack of success from head-starting include loss of navigational abilities, lack of anti-predator responses, loss of homing instincts, and improperly developed swimming and feeding skills which are necessary for survival and maturation in the wild. Add the fact that sea turtle maturation may require in excess of 20 years and it is clear there are great difficulties involved in evaluating the relative success of head-starting.

Compounding the difficult questions surrounding management and conservation practices such as head-starting are the tremendous gaps in our understanding of sea turtle life histories, particularly their oceanic movements and dispersal patterns. Until recently, the studies of wild sea turtles' movements and behaviors were confined to short term visual or radio tracking and traditional tagging studies. The former provides valuable information for short durations within a limited geographical range, yet is prohibitively expensive in terms of personnel and vessel/aircraft time. The latter is relatively inexpensive, yet information returned is sparse and ultimately fails to address the majority of remaining questions regarding sea turtle life histories.

Satellite telemetry utilizes earth based transmitters which relay signals to satellites where the information is stored and relayed back to earth receiving stations. Recent advances in satellite tracking of wild animals has led to application of this technology to the study of sea turtles. Results from a pilot study in 1980 demonstrated the feasibility of such an approach by tracking a loggerhead sea turtle for 8 months in the Gulf of Mexico (Timko & Kolz, 1982). Improved transmitter technology can return valuable information including water temperature, number of dives, and dive durations in addition to the all important transmitter location (Keinath & Musick, 1990a).

As a result, the satellite tracking of loggerhead sea turtles has received increased attention in recent years (Byles & Dodd, 1989; Keinath, Byles & Musick, 1989; Stoneburner, 1982). While much more data needs to be collected, the first detailed pictures of the oceanic movements of loggerhead sea turtles are coming to light.

HEAD-START EVALUATION PROJECT

In 1989, the Columbus Zoo and the Virginia Institute of Marine Science (VIMS) jointly participated in a research project to study the post-release movements and behavior of a captively raised loggerhead sea turtle.

Using satellite telemetry, researchers were able, for the first time, to study detailed movements of a head-started loggerhead sea turtle in the wild (Warmolts & Keinath, 1990; Keinath & Musick, 1990b). As a result of this preliminary investigation, a union of rather diverse agencies and institutions was created to facilitate the further study of the captive growth and post-release movements and behavior of head-started loggerhead sea turtles.

PROJECT PARTICIPANTS

In October of 1989, the Virginia Marine Science Museum (VMSM) and Columbus Zoo joined with VIMS and the Back Bay National Wildlife Refuge (BBNWR) (U.S. Fish and Wildlife Service) in a cooperative research project. Under the project proposal, each of the participating groups would fulfill specific goals relating to their areas of expertise, their capabilities, and their authority (Keinath & Musick, 1989).

PROJECT OBJECTIVES

On November 15, 1989, the USF&WS awarded a special use permit to VIMS for the initiation of the "Loggerhead Sea Turtle Head Start Evaluation" project. This permit authorized the removal of hatchling loggerhead sea turtles from BBNWR and transfer to VIMS, VMSM, and the Columbus Zoo. This began a unique partnership among participating institutions and agencies to achieve the four major objectives of the study.

1. The first objective is to document husbandry practices used to raise loggerhead sea turtles and compare the results to past and present head-start programs. This study provides a unique opportunity to evaluate the husbandry process as it involves loggerhead hatchlings being raised simultaneously at three different institutions. Aquarium systems, water quality parameters, and other carefully planned and monitored aspects of the sea turtle life support systems will be compared and evaluated. This paper represents the beginning of a commitment to share the result of this valuable study.

2. The second objective involves the careful monitoring and recording of information on growth, behavior, and diet regimes of the young sea turtles. Despite tens of years and thousands of turtles head-started, very little published data exists to document the specifics of the various programs. In this study, careful recording of a variety of husbandry parameters will provide the most detailed picture to date of the captive growth of loggerhead sea turtles. Growth is monitored by weekly measurements of carapace/plastron lengths/widths and weights. Diet is recorded by food type and weight of food eaten on a daily basis. Uniformity of diet among institutions is maintained to facilitate comparison of growth and behavioral data as it relates to parameters such as tank size and water temperature. Finally, behavioral records will provide further information on the development of swimming, diving, and feeding skills in young loggerhead sea turtles.

3. The third objective of this study is to tag and release healthy 2-3 year old head-started loggerhead turtles into the wild. Selected individuals will be fitted with satellite transmitters to be purchased with funds provided by the participating institutions. The post-release movements and diving behavior of these sea turtles will then be monitored. The results of the satellite tracking study will provide a detailed picture of post-release behavior for head-started sea turtles. Most importantly, the information obtained may begin to provide solid evidence for further evaluation of head-starting as a management and conservation strategy.

4. The final objective of the project is to institute public education programs on the biology, ecology, research and conservation of sea turtles. This objective is being achieved through innovative public exhibits and interactive programs. Other aspects of the public education efforts include lectures, outreach programs and public information campaigns to spread the message of sea turtle conservation. The public education commitment of the four participating agencies and institutions is recognized as a critical element in the success of this project and in the general conservation of all sea turtle species.

PRELIMINARY RESULTS

VIMS collected the first group of hatchlings from three nests on BBNWR in October of 1989. In December, the hatchlings were distributed to VMSM and Columbus Zoo where intensive monitoring of the head-start process would take place. The hatchling sea turtles were housed in recirculated seawater life-support systems specially designed to maintain appropriate physical and qualitative parameters. Project guidelines called for maintaining water temperatures at 28 C (+/- 1 C) and salinities between 30-35 ppt (Keinath & Musick, 1989). Lighting systems with an automated day/night cycle and utilizing a combination of full spectrum and black light fluorescent lamps were placed on all rearing systems. Individual hatchlings were separated into tanks of varying sizes depending on the institution and the particulars of their water systems.

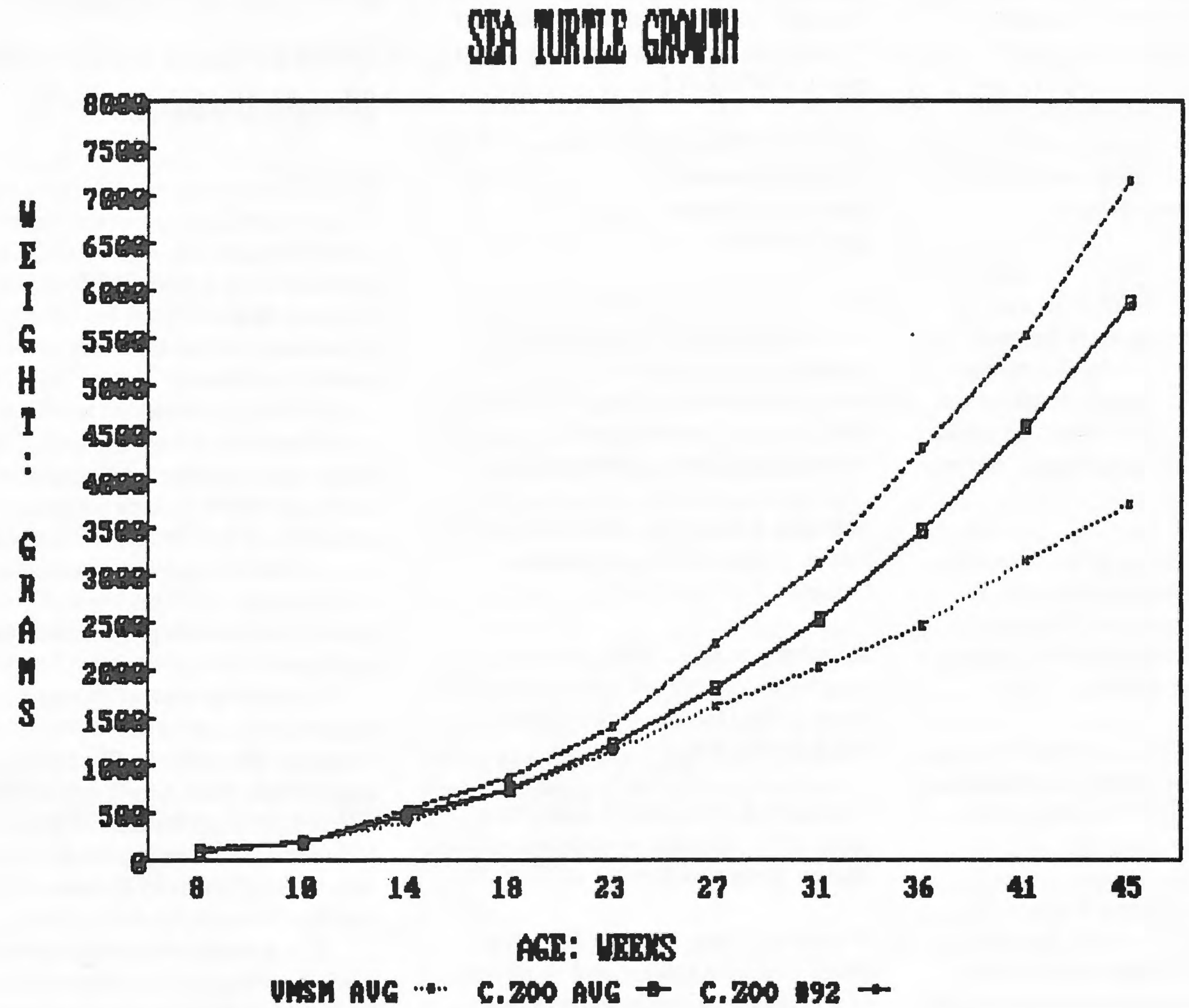
Initial tank sizes ranged from 10 and 20 gallons at VMSM to 50 and 150 gallons at Columbus Zoo. Water quality was maintained by standard mechanical and chemical filtration techniques and monitored regularly with chemical testing. Food for the hatchling loggerheads consisted of a marine animal gelatin diet developed at VIMS (Choromanski, et al., 1987). This diet was prepared by each of the participating institutions using raw materials originating from a single source and lot, thereby assuring maximum qualitative uniformity of food. Individual sea turtles at VMSM and Columbus Zoo were fed daily throughout the study period.

Preliminary results of the project have been quite remarkable. Growth rates recorded during the first 10 months, both in weight and carapace length, have far exceeded any found in the literature. In one case, a loggerhead sea turtle at Columbus Zoo has reached a weight of 7000 gm and a length of 35 cm in only 45 weeks. This rate of growth projects to 40 cm and 8000 gm in one year. These figures are more than double the maximum growth rates currently reported (Dodd, 1988). Since quantity of food eaten, water temperature and salinity are being recorded daily, these parameters, along with tank sizes, will provide valuable insight into the factors effecting these remarkable growth rates.

DISCUSSION

Traditionally, the primary conservation role of zoological parks and aquariums has been one of public education. As centers for information transfer, they have provided the main outlets for the results of basic biological research in a form made understandable to the general public. In fact, the expertise and information derived from research provides the authority and basic knowledge used to prepare and maintain quality exhibitions (Potts, 1989).

Increasingly, institutions of this type are becoming involved in the sponsorship and support of scientific research activities. This naturally follows from a professional commitment to conservation of world wildlife resources. At a time when funding for basic research is becoming more



VMSM AVG = average weights of 4 turtles.
C.ZOO AVG = average weights of 5 turtles.
C.ZOO #92 = weights of turtle #92.

NOTE: All sea turtles represented in this graph are from the same clutch.

difficult to secure, the marriage of a successful zoological park or aquarium with a research related organization can be mutually beneficial (Scavotto, E.D. 1986).

The joining of rather diverse agencies and institutions in this sea turtle research project has demonstrated the possibilities for successful efforts of this type. From both the financial and operational standpoints, the project has thus far been a resounding success. Significant research on the growth and development of loggerhead sea turtles has begun. Perhaps most importantly, the vital messages of sea turtle conservation have reached a wider audience than ever before. It is clear to all participants in this project that head-starting, alone, cannot save sea turtles.

Unless we can protect them from human-induced mortalities and preserve their nesting sites, then sea turtles that have survived for over 100 million years are doomed to disappear (Woody, 1990). The final goal of a project such as this, after all, is to preserve the future of sea turtles throughout the world. As Pritchard (1980) said; "Nearly all sea turtle biologists, sooner or later, become sea turtle conservationists. . ." In turn, nearly all zoological parks and aquariums, sooner or later, will become involved in conservation issues. This project represents a classic example of this conservation role and has broad applications for future research.

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Regional Aquatics Workshop (R.A.W.) Established

In 19891 representatives from a number of aquarium facilities in the Great Lakes Region and nearby states began meeting twice a year to discuss topics rrelating to the captive husbandry of fishes, marine invertebrates and other aquatic organisms.

R.A.W. is unusal in that there are no officers, dues, etc., Participating institutions take turns hosting the meetings which provide a relaxed atmosphere where aquarium personnel and professionals from related fields can exchange information and present updates on current projects at their facilities.

Institutions represented at the recent meeting at the St. Louis Zoo included: The John G. Shedd Aquarium, Toledo Zoo, Sea World of Ohio, Pittisburgh Zoo, Columbus Zoo, Milwaukee County Zoo, Belle Island Aquarium, Cleveland Metropark Zoo and For Wayne Children's Zoo.

The next meeting is scheduled for April 26, 1991, in Milwaukee. Contact Rich Sajdak 414/771-3040 for more information. Involvement by aquatic biologists from outisde of the Great Lakes Region is welcomed and encouraged.

Captive Rearing of the Zebra Mussel, *Dressenia polymorpha*

by Jay Hemdal, Curator of Fishes, Toledo Zoo Aquarium

Recently, a small mollusk known as the zebra mussel was accidentally introduced into the waters of United States. Many opinions have been presented concerning the adverse environmental impacts these organisms may have on the environment, and a number of scenarios have been offered, ranging from clogged city water intakes and lower plankton levels, to destruction of game fishspawning grounds.

The native range of the zebra mussel is the Caspian region of Eastern Europe. The specific name may be in reference to the unique shell colors many individuals possess. Apparently, when this ship drained its ballast tanks to take on cargo, it released some larval zebra mussels into Lake St. Clair. As of 1989, these creatures had spread throughout Lake Erie, reaching Lake Ontario as well as portions of Lake Huron. By the summer of 1990 there were reports of stray zebra mussels in southern Lake Michigan.

The zebra mussel grows to a length of slightly over 2", and may live 3 to 5 years. Local populations reproduce in synchrony during a one or two day period in the summer. The resulting larva are between 40 and 50 microns in length. This veliger stage lasts 8 to 21 days. At the end of this time, the veliger forgoes its planktonic existence, and settles to the bottom. If it lands on a hard surface, it turns into a juvenile mussel. Larva which by mischance land on soft sediments perish. Very often, the juvenile mussels settle on surfaces already overgrown with older individuals. This process soon forms a thick mat, with the new mussels growing over the shells of those beneath them. Because populations in one locale may spawn at different times of the year than those in another area, colonies of zebra mussels are often comprised of individuals of different sizes, potentially making the colony more resistant to size specific predators and environmental stresses such as freezing.

A single adult zebra mussel can filter up to one liter of water per day of all suitable sized algae - those with a size of 10 to 30 microns. In addition, they remove other particles from the water in sizes they cannot utilize. This inedible material is expelled as pseudofeces which accumulate at the base of the colony.

The Toledo Zoo Aquarium has a 900 gallon display tank as well as a smaller reserve aquaria in which we are attempting to rear zebra mussels. Due to their planktonic life stage, it is doubtful we will be able to reproduce them, but we are investigating methods to maintain the adults in captivity. One benefit of this activity would be to allow researchers easy access to colonies of mussels in their own labs to use in studies on how to better control them in the wild. Another important reason for working with this species is to offer our public a glimpse of a species, (perhaps for the first time) that they have been hearing so much about in the news.

Our mussels were collected in Lake Erie at various sites. Some were found growing on clam shells washed up on the beach, others were found growing on "rip-rap" lining ship channels. The majority were collected off-shore near a series of barrier islands in a bay of the lake. Once in the proper habitat, it was no problem for the collector to locate the mussels as virtually every rock was covered with them. Rather than severing the byssus threads of individuals, (and potentially injuring them) the mussels were collected in situ with their associated substrate.

Aquatic biologists with the Michigan department of natural resources have presented an interesting hypothesis: because much of the animal's energy is expended during reproduction, (as evidenced by comparing the before and after bio-mass of the individuals) they feel that animals collected outside the normal breeding period will have a better chance at survival in captivity than animals weak from the effort of spawning might.

Proper feeding seems to be the main obstacle to successfully rearing this species. Zebra mussels require large amounts of phytoplankton of a specific size. We are growing two species of algae (Chlorella and Nanocystis) in the hopes that we can use these mixed with a artificial food made of yeast and blended fish to keep the mussels alive for extended periods of time.

Because of the slight probability that veligers might enter our water systems, all tanks housing these animals are isolated and water drained from the tanks during routine exchanges is chlorinated before entering the sewage system. Tank tools are washed thoroughly after exposure to these systems.

Typical water parameters for our tanks are: Ph: 8.0 - 8.5, Temperature: 68 to 74 degrees F., Dissolved solids: 180 to 450 us, Light: 60 to 150 foot-candles, as well as normal ranges for ammonia, nitrite and nitrate.

Currently, our mussels are fed on a daily basis. The small tank receives 200 to 800 ml of cultured algae in varying concentrations. The large 900 gallon display is fed liquid invertebrate food, and algae culture as available. Table 1 lists the ingredients we use for the liquid invertebrate food. The components are blended at high speed, and the mixture is allowed to settle for a few minutes to separate any larger particles. The liquid decanted from the top of the mixture is frozen in ice cube trays for later use. It is then fed at a rate of approximately 10 ml per 100 gallon of tank capacity per day.

As high concentrations of nutrients are present in the algae culture water fed to these tanks, blue-green algae soon begin grow in vast numbers.

Table 1: Liquid Invertebrate Food Ingredients

2 liters of water
1 human vitamin-mineral tablet
2 grams of calcium powder
40 grams of flaked fish food
10 grams of activated yeast
algae collected from exhibit tanks (as available)
2 whole smelt

If this algae coats the shells of the mussels, it can be removed by hand. Periodically, the mussel colonies are examined, mortality rate estimated, and detritus removed from between the animals.

Zebra mussels kept under suboptimal conditions soon show symptoms common to many other species of bivalves that fail to thrive in captivity. The first symptom is subtle; if removed from their substrate, the mussels fail to properly develop new bysuss threads, and have difficulty re-attaching. If the environmental problems are not corrected, some mussels in the group will no longer fully extend their siphons. This is followed by a more profound malaise, with most individuals in the colony being effected to some degree. Eventually, some animals fail to open at all, and soon perish. The total time for an entire colony to succumb ranges from 3 to 5 months depending on the degree of environmental stress. Because one of the early symptoms of a problem affects the filter feeding ability of the mussel, subsequent correction of the difficulty by the aquarist may not save the animal as it is no longer feeding properly and cannot regain its strength.

As we have working with this species only a short while, (beginning in September 1989) it is difficult to say if we are on the right track to the solution of maintaining this species in captivity through its normal life span. Early attempts by us to maintain these animals solely on a basic liquid invertebrate food of blended fish flakes and smelt did not prove successful. Our record under that feeding regime was only 6 months. Since incorporating the cultured algae diet in the summer of 1990 and modifying the recipe for the liquid invertebrate food, we have noticed a substantially lower mortality rate. Time will only tell if we will be able to exceed the year mark for these animals in captivity.

Highlights of the International Zebra Mussel Research Conference (December 5-7, 1990)

by Pete Mohan, Asst. Curator/Aquarium, Sea World of Ohio

I was able to make the trip to Columbus for the second (and only full day) of the International Zebra Mussel Conference.

Presentations given on the first day covered basic biology, including metabolism, larval abundance and distribution. Day three centered on socioeconomic and monitoring techniques. Ecology, ecosystem impacts and control alternatives were discussed during the sessions I attended.

I have compiled a brief summary of some of the new information on *Dreissena polymorpha* that may be of interest to public aquariums, particularly those in the Great Lakes region. Abstracts of the presented papers are available for a nominal charge through the Ohio Sea Grant Program, The Ohio State University, 1314 Kinnear Rd., Columbus, OH 43212 (614/292-8949).

I. In European lakes, zebra mussel populations may either remain stable or can fluctuate. Stable populations are found in long, shallow lakes with low flushing rates. While the large size of the Great Lakes makes it difficult to compare them to the European model, it was suggested that areas where high flushing rates are found, such as Lake St. Clair and the western basis of Lake Erie, could exhibit locally unstable population densities. (Ramcharan, et al.)

II. Native bivalves (unionids) are colonized by *D. polymorpha*, resulting in shell gape deformations and eventually death. In areas where zebra mussel populations were high, live unionids were rare. (Hunter & Bailey)

III. 1990 Diatom populations in western Lake Erie were only 10% as high as 1984 levels. Filtering by *D. polymorpha* is a suspected cause. Increased water clarity has accompanied this phenomenon and has in turn encouraged the growth of macrophytes in the area. (Beeton)

IV. Benthic algae are more likely to escape pelletization in pseudofeces of zebra mussels. This, along with an increase in light penetration, could lead to a shift from a planktonic to benthic algae community. (Lowe, et al.)

V. Walleys are depositing more eggs in areas heavily infested with zebra mussels than in relatively clear areas. Adherent eggs stick to the mussels and hatching rates for eggs deposited among mussels were not different from controls. (The impact of mussels on fish larvae remains to be examined.) It is unknown how egg densities prior to the invasion compare to current ones. Amphipod populations have soared due to the mussel invasions. Smelt and perch feed on the amphipods and may be benefiting from the introduction of *D. polymorpha*. Spottail shiners will eat zebra mussels up to 7 mm long. (Dermott, et al.)

VI. Potassium is toxic to zebra mussels and could be used to control the species (Fisher). [During the Q&A period a member of the audience noted that old data exists for the toxicity of potassium to native bivalves. This implies that potassium compounds are not suitable for treatment of mussels where native bivalves are also present.]

VII. Work is in progress to develop a thin film coating (similar to the silicone veneers used to suppress biofouling in artificial hearts) that can be used to protect man-made surfaces from mussel colonization. (Baier)

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