Model Tests of the Sea Trek™ Barrel Cage

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Abstract

Sea Pride Industries of Gulf Breeze, Florida is developing a
four-spar, 42-foot, cylindrical, floating barrel cage which will
serve as a solid, non-freezing fishing platform. It is planned
for use in the Gulf of Mexico, and tests are planned for late
summer 1977. The barrel cage will be used as an experimental
structure for developing new fishing techniques. The barrel
cage will be equipped with lights and other devices to
At low tide the entire cage will be submerged in water

The barrel cage is the key element of the Sea Trek system
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Preliminary wave and current tests conducted at the National
Wave Tank Facility at the Massachusetts Institute of
Technology showed that the barrel cage is capable of
surviving waves and currents encountered in the
Gulf of Mexico. The barrel cage is expected to have
a life expectancy of at least 10 years, and it is
planned to conduct a comprehensive test program
on the barrel cage in the Gulf of Mexico. The test
program will include monitoring of wave and current
conditions, as well as the performance of the barrel

cage. The test program will provide valuable
information on the design and construction of
floating barrels, and it is expected to contribute
to the development of new fishing techniques.

The barrel cage is designed to accommodate a variety
of fishing activities, including the cultivation of
shellfish and other marine organisms. The barrel
cage is equipped with lights and other devices to

Experimental evidence has shown that the barrel
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The Sea Trek Concept

Sea Pride Industries is the first aquaculture enterprise to receive full governmental approval for an operation in the United States' exclusive economic zone (EEZ). Sea Pride, 1995, The Sea Trek Ocean Farming System is a technology under development by Sea Pride for installation in their permitted area.

System Design

The Sea Trek system is comprised of a gravity-based support platform surrounded by six cylindrical barrel cages arranged in a radial fashion. A conceptual representation of the design is shown in Figure 1. Each cage will measure 20 feet in diameter by 220 feet overall length and will be constructed of marine-grade steel tubing and fiberglass plating. The weight of the steel cage structure will be offset by buoyancy provided by two internal ballast tanks attached to each end of the cage. Waterways built into the tanks will allow the tanks to be filled by ballasting individual chambers appropriately. This rotation will ensure holding of the net enough exposure to the air and sunlight while allowing convenient pressure washing and inspection.

The center axis of the cage is a four-inch diameter pipe that is attached to the ends of the barrel tanks and two intermediate points to transverse annular rings by lengths of four-inch diameter tubing. There are eight longitudinal members, also of four-inch diameter, running parallel to the axial tube and intersecting the rings at the corners of an octagon. Three additional transverse rings will provide further stiffness to the structure. The structure is completed by adding four diameter diagonal members to connect neighboring outer longitudinals between each ballast tank.

The cage is supported by an arrangement of nets in order to contain the fish and exclude predators. An outer net prevents the contained fish from predation is supported by three eighteen-inch fiberglass rods.
waves and currents. Understanding the hydrodynamic behavior of the barge cage in wave and current conditions will facilitate survivability engineering for the structure and its service life.

**Scale Model Tests**

Scale model tests have been conducted at two facilities at the Massachusetts Institute of Technology to predict hydrodynamic forces on the Sea Track barge cage and attachment housetops at a central location.

These tests were designed to measure the response of the cage as a rigid structure fixed at mooring points in either end. The results are expected to indicate the upper bounds for encounter forces and rolling moments in waves and currents. Any arrangement of compliant mooring lines would reduce the forces imposed on the cage and its supporting structure.

Two basic types of tests were performed. The cage was subjected to a series of waves at various frequencies and amplitudes in the MIT Civil Engineering Three-Dimensional Wave Basin. The response of the cage model was due to current velocities at the submergence and freeboard areas was measured in the MIT Ocean Engineering Test Tank. These facilities are described in more detail below along with the full experiment descriptions.

**Description of the Scale Model**

The model for these tests was designed to embody the major details of the full-scale cage in scaled-down form. The members were chosen to match the scaling with reasonable deviations as shown in Table 1. Stock availability and practical limitations on welding required the model structure to be fabricated from aluminum. Exact scaling of all the members would have made proper welding impossible. Some smaller tubular members could only be represented by solid aluminum rods. The plates used for the cage and ballast tanks could not be thinner than one-eighth inch in order to avoid buckling and deformation of the welded members. The assumption of overall rigidity gives accuracy in the scale of the outer dimensions priority over wall thicknesses. Structural definition within the model structure can be ignored.

<table>
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<th>Component</th>
<th>Full Scale</th>
<th>Model</th>
<th>Ratio</th>
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</tr>
<tr>
<td>Upper Longitudinals</td>
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The fiberglass rods located on the cage are simulated by lengths of glass tubing through one-sixteenth-inch holes drilled at the edge of the seven rings and bed. Figure 2 shows a side view of the model and Figures 3 and 4 are details of the transverse components.

Space restrictions in the test facility made it necessary to shorten the model from a scaled length of 102.7 to 65.7 to maintain the 1:128 scale of the model's diameter. This decreases the length-to-diameter ratio of the model from 4.05 to 3.54, and may be noted when interpreting the data. An effort can be made by comparing the data obtained from test model runs to determine distributed forces and the two-rolling motions independently. Careful attention to the model's weight will allow the invocation of Peedee scaling to extract the scaled forces (Toedt, 1967). Since the model is scaled by 1:128 in each dimension, the weight must be scaled by 1:20 along with all body forces. The aluminum model weighed approximately 36 pounds, and the full-scale structure has been predicted to weigh approximately 450,000 pounds.

The model does not exactly mimic the structural intricacies of the full-scale design. Instead, enough detail is preserved to reflect the hydrodynamic effects of
the most prominent members without unnecessarily complicating the construction of the replica. The hollow members and ballast chambers were made of light gauge metal and water tight to supply the setup. The ballast chamber buoyancy required an arrangement of olive weights to be fixed within the ballast tanks to achieve neutral buoyancy.

An important objective of the test was to compare the loads resulting from the netting surrounding the structure to those of the bare cage itself. This was achieved by cutting individual sleeves of 2000 nylon 12-mesh monofilament netting. These sleeves were over the length of the cage between the two end rings. Multiple layers of netting were used to simulate the effect of larger规模 of netting. To quantify the effect, estimates of the blockage ratio of each set of nets were made from close-up, high-resolution video images. Using image processing, the ratio of netted area to total area was calculated on a pixel-by-pixel basis. The resulting blockage ratios for layers of one, two, and three nets are shown in Table 2.

<table>
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<td>2</td>
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<td>3</td>
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</table>

Instrumentation

The experimental objective was to measure three components of the rigid body motion of the structure, namely the heave and sway forces and the roll moment. This was accomplished through the integration of a six-component scaling load cell (Model 450.14001.01, Advanced Mechanical Technology, Newton, Mass.), a 10,000-lb load cell, and a PC-based AD converter (C1640-SH12, ADI). Additional instrumentation included a digital storage oscilloscope software package (Siglent Storage Scope, HEM Data Corporation, Inc.) and data acquisition computer.
Southfield, Mich., which served as a data monitor, logger, and analysis tool.

Data was sampled during each run at 500 Hz covering a ten-second interval after the response waves attained a steady state. To ensure reliable results, instrument calibration was performed between runs after all equipment had cooled. Each sample was stored in a cataloged file for future review and analysis. Examples of each testing mode were recorded photographically and on videotape for visual presentation.

Wave Interaction Tests

The first set of tests exposed the barrel cage model to monochromatic plane waves traveling in the direction perpendicular to the cage’s longitudinal axis. These tests took place in the MIT Civil Engineering Three-Dimensional Wave Basin, which features computer-controlled hydraulic wave paddles and energy-absorbing sloping “beaches.” The basin is divided into three separate bays to allow multiple users to conduct experiments. It was necessary to compromise on the water depth due to the presence of another study in progress. The tests were run in 18 cm of water, which scales to approximately 88 feet, less than the full-scale cage diameter. The Sea-Trek concept anticipated installation in 59 to 60 feet of water. The model and load cell were attached to a set of actuators that presented minimal frontal profiles to the waves. The structures were restrained with weights to maintain overall rigidity.

Each individual run required input of wave frequency and amplitude into the computer. The wave paddles were actuated to swash to produce a uniform wave. The frequency and wave number of the waves are related by the dispersion relation for linear wave motion in infinite depth given in Equation 1 (Fonseca, 1993). Wavelength is inversely proportional to wave number by a factor of 2π. Radial frequency and linear frequency in terms are directly proportional by the same factor.
\[ w^2 = g \kappa \tanh \kappa \]

- \( w \) = radian frequency \[ \text{radians per second} \]
- \( g \) = acceleration of gravity \[ \text{m/s}^2 \]
- \( \kappa \) = wave number \[ \text{rad/m} \]
- \( \kappa \) = water depth \[ \text{m} \]

**Equation 1. Finite Depth Dispersion Relation**

The horizontal forces measured at a single attachment point on the model were recorded over a ten-second interval for each individual run. These forces were processed individually to obtain a root-mean-square (rms) average. Table 3 presents these averaged measurements and Table 4 presents the extrapolated estimates for the full scale. The peak loads can be obtained by multiplying the figures by the square root of two. This assumes that the wave forms are sinusoidal, which is reasonable based on the exclusion wave form parameters and graphical inspection of the data. Examination of these data reveals that the structure's response increases with wavelength and then plateaus, suggesting that a peak response is bracketed in the wavelength interval of the tests.

The behavior of the model was captured through measurement of three body forces including the horizontal forces that are presented above. Figures 2 and 5 show examples of data sampled during two particular runs whose parameters are nearly identical except for a change in submergence. The slight change in wavelength was necessary because of problems associated with reflections as the wave base. The apparent waviness in Figure 5 is due to external interference which was shielded against in subsequent tests. The wave force is represented by \( P \) and is positive in the direction of the wave source. The buoyancy response is indicated by \( B \) and is assumed to be in phase with the passing wave as an indication of the change in the model's draft. This buoyant force is positive upwards. \( M \) is a measurement of the rolling moment of a transverse force applied to the cage by the passing wave. This moment was measured positive in the counter-clockwise direction from the perspective where waves are seen approaching from the left. These graphs are intended to compare the wave forms of the rolling moment time series which are comparable in magnitude but vary in shape. The increase in submergence affects these measurements by entraining additional members of the structure in the passing wave peak. Figure 7 illustrates this effect and shows the right-hand side orientation of the forces measured. The model is shown from one end and is a transparent structure showing the internal shape of the ballast chambers, the transverse rings, and the spokes that connect them to the central tube. The vector represents the forward velocity of a passing wave peak. The data that make up these time series have been preserved in digital form in anticipation of future studies concerning the seakeeping characteristics of the structure.
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Figure 5: Sample data from a numerical simulation of a beam of casting, showing wave 40° in length and 2° in amplitude, and error tolerance of 20 percent.

Figure 6: Sample data from a numerical simulation of a beam of casting, showing wave 50° in length and 3° in amplitude, and error tolerance of 10 percent.
Current Interaction Tests

The second mode of testing simulates the interaction of the cape with a steady current flow. The model, shown in Figure 2, is a full-scale, 1:50 scale model of the cape. The model is made of fiberglass and is mounted on a base that allows for easy movement. The model is placed in a flume, which is a long, narrow channel used to simulate the flow of water. The flume is surrounded by a water tank, which provides a constant water level for the model to interact with. The water tank also serves as a reservoir for the flume, ensuring a constant water flow. The model is observed from above, allowing for a clear view of its interaction with the current. The current is generated by a pump located downstream of the model, and its speed is controlled to simulate different current velocities. The interaction between the model and the current is observed and recorded, providing valuable insights into the behavior of the cape under different current conditions. The results of these tests are used to refine the design of the cape and its interaction with the surrounding environment.
Table 5: National Farm Product for Full Scale

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Note: The values are in percentage units.
Future Projects

The focus described in this paper represents an initial phase of research that will be incorporated into the development of the Sea Torx concept before full-scale prototypes are constructed and deployed. As interest grows from the world in determining the potential of this instability for energy production, and improving the material in the blade environment, future testing will benefit from implementation of proposed testing methodologies and improvement of their performance in measurement. Materials testing using the attachment points and blades will represent a variety of loads, ranging from static to dynamic, while the turbine will change from real-time and testing in small scale.

The presence of the actual environment and the performance of its interaction with the system, as well as the task force, will have a significant effect on the overall operation of the Sea Torx system under conditions. Environments will vary, and with the presence of an unpredictable wave climate, the system will be subjected to various types of waves on or near the surface of the sea. In order to accommodate these conditions, the Sea Torx system must be flexible, capable of adapting to changing environmental conditions, and capable of maintaining its performance under a wide range of environmental conditions.

References

Transgenic Fish in Open Ocean Aquaculture

Susan Samperio
University of Maryland, Biotechnology Institute
Center for Public Health Biotechnology
College Park, Maryland

I. Introduction

As of the early 1990s, 22 research groups in 14 countries were working on genetically engineered\ntransgenic fish (Halloran & Rappeport 1992b) and by 1994, 23 fish species had been altered\n(Halloran, Rappeport, & McAninch, 1996). Most of\nthe characteristics selected through transgenesis are\ntended to ultimately increase yield for aquaculture.\nThus, enhanced growth rate should decrease\nharvesting of larger fish, which in turn should\nreduce the need for wild stocks and allow\nfor fish to be raised in locations considered\nunsuitable for the natural species. Dependent\nmanagement and dynamic interactions will\nalso affect the results in different settings.\nOverall, the experimental results of transgenic fish have been mixed in\nthe open ocean environment, however, and the\nlong-term benefits are not expected to be clear in\nthe near future. This paper provides an overview of the current research with transgenic fish, examining the potential\nbiotechnological policies associated with using them in open\nsea aquaculture, describing the current regulatory\nsystem that would affect their introduction, and the\nconsiderations and potential risks associated with the\nmanagement of transgenic fish in the\nopen ocean environment.

II. Transgenic Fish for the Marine Environment

Most transgenic fish are produced in the laboratory by direct injection of modified DNA constructs\n(Feit et al., 1986). Examples of these fish also include the beverage transgenic trout as the focus of the next\nsection.
The table on the following page illustrates some recent successes with transgenic fish, and these may be appropriate for transgenic agriculture (Table 1).

To date, there have been only a few domesticated species of transgenic fish. These include several species that have been selected and propagated because they are being selected for their growth and reproduction rates. The table illustrates the potential advantages of transgenic fish in aquaculture and urban agriculture (Table 1).
long-term effects of fish in the late 1980s, when it was thought that
marine fish were being introduced into the Baltic Sea. However, re-
sults have suggested that open ocean aquaculture may not be feasible
under current conditions, but further research is needed to deter-
mine the feasibility of this approach.

2. Fishes Associated with Releasing Transgenic Fish

Several studies have shown that transgenic fish can interbreed with
native species and introduce novel traits into the wild population.
The consequences of this are not well understood, but potential im-
ports could include changes in the gene pool of the wild population,
which could affect the survival and reproduction of other species.

From this, it is apparent that the introduction of transgenic fish can have
serious ecological consequences, and careful consideration should be
given to any potential releases. It is important to ensure that any
transgenic fish introduced into the wild are monitored closely to

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Risk Assessment and Legal Oversight

When all of these potential impacts are evaluated, the effects of these events may be mitigated, thus reducing the potential for negative outcomes. Risk assessment should consider the probability of occurrence, the potential for risk to the ecosystem, and the adverse effects on the environment. The risk assessment should be conducted by an independent body to ensure that the assessment is unbiased and objective. The results of the risk assessment should be used to develop strategies to mitigate the risks and to monitor the effectiveness of these strategies.

The legal framework for risk assessment and management should be established to ensure that these events are handled in a manner that is consistent with the law. The legal framework should establish the procedures and protocols for risk assessment, management, and communication. The legal framework should also establish the procedures for reporting and investigating incidents that may result from these events.
It has been suggested that lyme disease may spread more readily in areas with cooler temperatures and higher humidity. However, no significant correlation has been found between lyme disease prevalence and climate factors. The disease is transmitted by Ixodes ticks, which are most active in cooler temperatures and humid environments. The ticks, which feed on mammals, can then transmit the disease to humans. In addition, the disease can be transmitted through contact with infected animals, such as deer or other mammals. The disease is often characterized by a bull's eye rash and can cause a range of severe symptoms if left untreated. The disease can be treated with antibiotics, but prevention is key. Public health officials recommend avoiding tick-infested areas, using insect repellents, and performing regular checks for ticks after spending time outdoors. Early detection and treatment can prevent complications.
[No text content provided]
Introduction

While the history of offshore fishing in the New England has been short, it has also been driven by new commercial developments. Perhaps the most significant of these developments is the construction of a new, high-tech, industrial fishing fleet. The New England fishery has long been known for its high costs and low profitability, and the introduction of new technology to the commercial fishing industry has resulted in much lower operating costs. As a result, the New England fishery has been analyzed as a prime example of how new technology can transform an industry and increase profitability. In this paper, we will explore the impact of new technology on the New England fishery and the implications for the future of the fishery.
Identifying Essential Habitats

At first glance, it is somewhat daunting to take on the task of identifying the essential habitat for an animal. A number of federal programs exist to help identify and map the critical habitat for non-marine species, but they all require detailed data and analysis. Therefore, the task is not a simple one, and it requires a great deal of effort to complete.

Near the coast, essential habitat may include estuaries and other coastal features, as well as the areas adjacent to the coast. These areas are important because they provide habitat for a wide range of species, including fish, birds, and other marine animals. In general, the essential habitat for a species is defined as the area that is necessary for the survival and recovery of that species. This includes areas where the species can breed, feed, and escape from predators.

A number of factors need to be considered when identifying the essential habitat for a species. These factors include the physical characteristics of the area, such as the type of substrate, water depth, and temperature, as well as the availability of food and shelter. In addition, the essential habitat may also include areas that are protected from human activities, such as pollution and development.

In conclusion, identifying the essential habitat for a species is a complex and challenging task. It requires a great deal of effort and resources, but it is essential for the conservation of endangered species. By identifying the essential habitat for a species, we can better understand the needs of the species and work to protect these areas from human activities that may threaten their survival.
Northern coastal habitats have been identified for

**Figure 1 - Cape Cod Bay Component of Northern Right Whale Critical Habitat**

...the North Atlantic white. It is unclear at this
time whether MPA's will serve to identify and designate,
...on the Habitat.

Another area where essential habitats are getting

**Figure 2 - Great South Channel Component of Right

...globally. (DFO 1999), that represents an "early" phase of the
...solutions to the problems of habitat change, which should
clearly be considered in the development of the
...determine the number of habitat units for a given
...habitat, not the number of MPA's. (DFO 1999)
influence on oil spills will be significantly affected by the development of several important policy initiatives by the Councils and NMFS. How this will be accomplished in the still unexplored area of the continental shelf will be determined through discussions and negotiations. The Councils will be involved in this process in the same way that the Councils have been involved in the development of the current environmental regulations.

The final decision regarding how to handle the environmental impact of oil spills is made by the Councils and NMFS. The National Marine Sanctuary Program (NMSP) has been evolving since 1978 to address and minimize the environmental impacts of oil spills. Since the passage of the National Marine Sanctuary Act in 1978, the NMSP has worked to establish and implement laws and regulations that protect the marine environment. The Act established the National Marine Sanctuary Program, which oversees the nation's marine sanctuaries.

In addition, the program has had little contact with key federal offshore natural resource agencies, partly because of the complexity of the regulatory process. NMSP regulations are being written by federal agencies, and NMSP resources are being used by federal agencies. While these management plans are developed for the management of the nation's marine sanctuaries, it has only been in the last few years that the sanctuaries have been explicitly acknowledged in the regulations governing the protection of marine life in the area.
In addition to the potential benefits of the federal facility, there would be considerable public visibility of the project, and the project would operate on a large scale. The facility would be in the public domain and would not be subject to environmental scrutiny.

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Table 1: NMS Site Regulations Affecting Marine Use

<table>
<thead>
<tr>
<th>Regulation Name</th>
<th>Type</th>
<th>Jurisdiction</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Access</td>
<td>Permit</td>
<td>State</td>
<td>Coastal</td>
<td>Regulates access to coastal areas</td>
</tr>
<tr>
<td>Seafood Regulations</td>
<td>Law</td>
<td>Federal</td>
<td>West Coast</td>
<td>establishes regulations for seafood industries</td>
</tr>
<tr>
<td>Aquaculture Regulations</td>
<td>Ordinance</td>
<td>Local</td>
<td>Islands</td>
<td>Regulates aquaculture practices</td>
</tr>
</tbody>
</table>

...
The Sable Island Fishery Management Plan

In 1991, the NOAA had conducted an extensive public review of the proposed designation. Congress designated the Sable Island Fishery Management Plan in 1992 in order to prevent overfishing and to ensure the sustainability of the fishery. The plan includes measures to protect the habitat, including the creation of no-take zones and seasonal closures. The plan also establishes monitoring programs to assess the impact of fishing on the fishery.

Figure 5: Sable Island Fishery Management Plan

"Sable Island is the proverbial 'hidden gem.' A well-kept secret, this place is one of the last true wilderness areas in the world. Its natural beauty and diversity make it a unique and special place. The Sable Island Fishery Management Plan is in place to ensure that this treasure is protected for future generations to enjoy."
During the review of the proposed designation, no comments were made on the "Somerset" concept. Of the comments made, the most relevant one was the concern that the proposed designation might result in the exclusion of certain areas from the sanctuary. The commenter, a representative of the U.S. Army Corps of Engineers, noted that the proposed designation could result in the exclusion of certain areas that are currently designated as sensitive areas. The commenter recommended that the proposed designation be modified to include these areas. The commenter also noted that the proposed designation could result in the exclusion of certain areas that are currently designated as critical areas. The commenter recommended that the proposed designation be modified to include these areas.

The chosen area of the candidate sites that will be submitted for consideration must be determined by the Secretary. The Secretary will make a determination on the basis of the best available scientific data and information. The Secretary will consider the impacts of the proposed designation on the natural and cultural resources of the area. The Secretary will also consider the impacts of the proposed designation on the activities of the candidate sites. The Secretary will provide for the protection of the natural and cultural resources of the area. The Secretary will also provide for the protection of the activities of the candidate sites.
To address this situation, the committee has recommended several specific steps that can be taken to help address this problem. In the example of the hypothetical scenario discussed earlier, the following recommendations have been made:

- **Public Awareness Campaigns**: Conducting public awareness campaigns to inform the public about the importance of the issue and the steps that can be taken to address it.
- **Community Engagement**: Encouraging community engagement through public forums, workshops, and other community-based activities.
- **Expert Panels**: Establishing expert panels to discuss the issue and provide recommendations for action.
- **Policy Review and Development**: Reviewing existing policies and developing new policies to address the issue.

These recommendations are intended to help address the problem and ensure that the public is informed and engaged in the process of addressing the issue.

**Conclusion and Some Observations**

The committee has identified several key areas where significant efforts can be made to address the problem. These areas include:

- **Public Awareness**: The public needs to be more aware of the issue and the steps that can be taken to address it.
- **Policy Review**: Existing policies need to be reviewed and updated to reflect the new realities.
- **Community Engagement**: Engaging the community in the process is crucial to ensure that the solutions are effective.

The committee believes that by focusing on these areas, significant progress can be made in addressing the issue.

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The Blue Frontier
Jeff Fish,
President
The Aquaculture Coalition
Boston, Massachusetts

I am Jeff Fish, President of The Aquaculture Coalition (TAC), an umbrella organization representing_breeding, engineering, genetics, processes, distributors, state and federal regulators, suppliers, academicians, consumers, marine education, technology companies, and others with an interest in the development of the aquaculture industry in New England. By many, members of the group still referred to as the "first wave" of the aquaculture industry which of which includes the biological diversity of our waters, makes us think internationally, and eliminates our local, regional and regional comparisons.

The members of the group are united on a common belief that we must move the development of the aquaculture industry in Massachusetts and New England through education, communication, and networking.

I am pleased to be here today at this conference where we have been treated to compelling insights into all the technology available to us all for the 'Blue Frontier'.

I am not an expert, nor a guru, nor a genius. The statement of fact is a few facts with which a great deal of vision. I am going to introduce myself as an maverick in future.

Until the next year, when we go back to aquaculture, my experience has been at least equal and on West where. I dealt with the problem of what