MIT SEA GRANT
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Quarterly Report

Bill Nuttle examines peat sample from Belle Isle Marsh

Fate of an Urban Salt Marsh

When the first colonists arrived in 1603 to settle Boston, a natural seaport, there existed only 1,185 acres of dry land to build their city on. The rest was salt marsh, mud, and sand flats: "useless" land where profitable industries and homes could be. In 1641 the colonists initiated a long process of filling the marshes, beginning with the creation of a town cove and eventually interring hundreds of wet acres to build an entire residential community still known as the Back Bay. Today there is but one salt marsh left in Boston.

Belle Isle, the sole marsh to survive the pressures of urban development in Boston, still fights for its existence. A decade ago it was eyed as a possible expansion site for the city's airport. Community residents and state agencies joined forces in a preservation effort that resulted in transferring the land to the regional park system. Even park designation, however, has not made the marsh invulnerable. Recently a major controversy surrounded state plans to pump stormwater runoff from nearby low-lying areas into Belle Isle. Fearful that the runoff would import hazardous materials into the marsh, local residents again succeeded in squelching the plan.

Like other urban marshes Belle Isle will continue to be threatened by the dense development around it. Some of the threats are direct and immediate, such as filling, others such as pollution of nearby coastal waters which is transported to the marsh, involve longer-term destruction.

The Friends of Belle Isle, a citizens group organized to protect the 300-acre open wetland, were relieved when MIT doctoral candidate Bill Nuttle began a Sea Grant project to study the hydrology of Belle Isle. To them, Nuttle's instruments sticking out of the marsh and the team of students and researchers collecting data mean, finally, scientific information on which to base management decisions.

Hydrology is recognized as one of the most important factors in marsh productivity. Through its effects on pore water flow, salinity, toxin removal, pollutant penetration, air entry, and exchange of substances with adjoining open water, hydrology heavily influences marsh functioning. Altering the hydrology of the salt marsh is potentially more damaging than pollution, and, short of filling, could be the biggest threat to marsh life.

It is a well-known mystery that salt marshes are far more productive than even the most well-tended and subsidized agricultural field. Given the marshes' lack of below-ground oxygen and high salinity, "there really shouldn't be anything growing there at all," Nuttle says. It is circulating water that provides a natural subsidy comparable to chemical fertilizer. The constant cycling of water brings nutrients in, carries wastes out, and in the process of desaturation draws life-sustaining air into the soil.

But until more is known about how hydrology affects marsh functioning, questions about the effects of human interference will remain unanswered. In Belle Isle, for example, a poorly drained subway car maintenance area is heavily used by shorebirds, but is it detrimental to the rest of the marsh, and should managers try to restore natural flow conditions? Can a dredge-spoil dump in the marsh be restored to its prior hydrologic function and revegetated, or is further filling to create upland habitat the only alternative left? What is the capacity of Belle Isle to receive additional stormwater and pollutants from possible recreation development nearby?

These questions Nuttle hopes to help answer by developing a model of the marsh's hydrology. One of his major tasks is to develop a soil water budget. High productivity depends on the relationship between salt marsh vegetation and the amount of water in the rooting zone of the soil. A soil water budget includes determining the marsh's response to groundwater forcing, tidal inundation, gravity drainage, evapotranspiration, and stormwater discharges. These hydrologic activities create pressure in the peat, which influences the water content of the peat. Using special-

In this issue

ized instruments developed in prior Sea Grant research, Nuttle relates specific changes in water pressure to changes in soil water content.

Changes in soil water content also depend on the hydraulic conductivity and ability of the peat itself to store water. Working with core samples of peat in the laboratory, graduate student Diane Chen imposes pressure on the peat and then decreases pressure to see how much water drains out. In this desaturation process air is drawn into the peat, providing much-needed oxygen to the plants and animals there. In addition to drainage into the marsh creeks, which transports life-sustaining products to the creeks, water also leaves the soil through evaporation, another item to be quantified in the soil water budget.

Developing models of water flow and relating hydrologic activities to the chemical and physical environment which supports the biological communities of the marsh will aid marsh management, Nuttle hopes. Then intelligent decisions can be made based on how obstructing tidal exchange or manipulating the local storm drainage and groundwater regimes will affect Belle Isle marsh in particular, and other marshes to which Nuttle's model is applied. ■

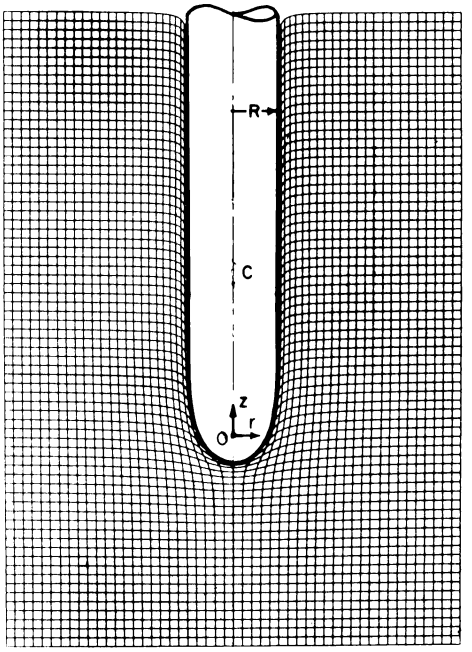
New Instrument Helps Measure Deepwater Pile Capacity

As bridges began to span greater distances, engineers had to change the conventional ways of supporting weight. Instead of handling loads with compression members heavy with riveted steel, new suspension bridges like the Golden Gate used cables. Tension leg platforms represent a similar fundamental design transition as offshore structures move steadily into deeper water. The traditional huge steel offshore platforms which press heavily on the ocean bottom become impractical at greater depths and are being replaced by floating structures held in place by taut cables anchored to piles.

Using piles in tension instead of compression creates new challenges, such as predicting how piles will react to continuous heavy and prolonged cyclic loading. New procedures based on understanding soil and pile interaction will be needed to ensure the stability of a structure, without compromising on safety or spending unnecessary millions for overdesign.

There are major uncertainties in predicting pile behavior under normal conditions, let alone in untried situations such as deeper water or different types of soil. Installing massive piles for deep foundations, or even slender scientific test probes, disturbs the soil in complicated ways. Many factors make it difficult to predict these effects, including large deformations and strains in the soil, complex behavior of soils, and the presence of water in the soil pores.

The initial step in designing deep foundations is to predict pile capacity, or how much weight a single pile can bear. For long piles driven in clays, a significant portion of pile capacity is related to the friction between the pile shaft and the surrounding soil, making this friction extremely important in pile design.



Deformation of square grid in saturated clays during penetration of simple pile

Over the past decade a major geotechnical study at MIT has probed the interaction between the friction piles used to support offshore structures and their underlying soils. Combining theory with measurements taken in the soil, this "MIT approach" offers an effective method for analyzing and predicting the behavior of friction piles.

There is currently a dearth of accurate and reliable measurements of the stresses acting on pile shafts, even though these measurements are necessary to carefully evaluate theoretical predictions. However, Professors Mohsen M. Baligh and Amr S. Azzouz of the MIT Dept. of Civil Engineering have developed a practical tool to get on-site measurements. The Piezo-Lateral Stress (PLS) cell provides simultaneous measurements of the average shear and normal stresses as well as the pore pressures acting on cylindrical pile shafts. "Predictions of pore pressures involve significant uncertainties. Measurement with the PLS represents a valuable addition to the reliability of our overall precedure," says Baligh. "The device measures what we want with sufficient accuracy for us to believe and incorporate into predictions." Experiments on actual piles at a test site in Louisiana have proven the value of the PLS cell for measuring soil-pile interactions.

The PLS makes it possible to evaluate the horizontal effective stress (the factor considered to dominate pile behavior), and the shear stress between the pile and the soil. Not only can it provide essential fundamental data on piles' behavior in clays, but it is an exploration tool for directly and instantaneously estimating the shaft resistance of cylindrical piles at a given site. Another fundamental advantage of the PLS cell is its reduced interference with the quantities being measured, such as the amount of water moving in the soil.

Right now Baligh and colleagues are planning a project with MIT Sea Grant to use the PLS behind an open-ended pile. Offshore piles are cylindrical steel open-ended piles up to two meters in diameter. As the open end pushes in the soil rather like a giant cookie cutter, it forces part of the soil inside the tube and squeezes the rest outside. Previous PLS measurements were all taken on a closed-ended tip that did not allow the soil to enter the core.

Baligh considers it important to study both closed-ended and open-ended modes. "We expect to see a big difference compared to earlier PLS data on closed-ended tips, especially in the time required for pore pressures to dissipate. Open-ended penetration influences a small zone around the pile, whereas closed-ended

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penetration deforms the soil in a large zone. The consolidation of excess pore pressure and the gain in strength of open-ended penetration is much faster."

Baligh's analysis of the test results from Louisiana indicated that the true capacity of the test piles was more than the estimated capacity, because excess pore pressure had not fully dissipated and the effective stresses had not yet reached their final value. In other words, Baligh found that the piles could support more weight than originally had been thought. Used for such practical design purposes, the PLS gives essential information about the behavior of the piles to be tested at a given site. As a research tool it indicates essential features of pile shaft behavior. Engineers who build offshore structures will find this collected information vital in figuring how to safely support a structure under a particular set of anticipated conditions. ■

Fish May Be Best 'Medicine' for the Heart

After 25 years of examining the diet, habits, and metabolism of Greenland Eskimos researchers think they may have discovered the secret that makes these people relatively free from coronary heart disease, an epidemic among Westerners. Defying accepted nutritional principles, consuming fat, cholesterol, and proteins galore, Eskimos nevertheless suffer ten times less heart disease than Americans. Likewise, with a similar diet, some Japanese have substantially lower incidence of heart disease.

The secret appears to be fish. Both Eskimos and Japanese fishermen eat many times more fish than do Americans. Fish oils abound in a class of fat components called omega-3 fatty acids which, evidence shows, reduce the levels of blood fats associated with heart disease. Omega-3 fatty acids are also thought to help prevent stroke-causing blood clots. After years of research, many scientists are suggesting that perhaps the best thing you can eat to prevent heart attacks is fish. This could be important news to the 25 percent of Americans who have dangerously high levels of blood fats and cholesterol.

Further research is needed to clarify the relationship of seafood consumption and heart disease. At MIT Sea Grant a project is underway to collect fish from local waters and determine the fat composition, especially the omega-3 fatty acid and cholesterol content. In September and October bluefish, spiny dogfish, and smooth dogfish caught in Cape Cod and Buzzards bays off the Massachusetts coast were cleaned, fast frozen with liquid nitrogen, and assayed in the National Marine Fisheries Service lab in Gloucester, Mass. The results are shown in Table I.

Although test results are preliminary and will vary seasonally and by location, the data so far indicate relatively low levels (46.1-57.1mg per 100g edible portion) of cholesterol in the three fish types compared to 57-67mg per 100g cholesterol in chicken breast, 72mg in lean beef, over 230mg in butter, and well over 1,000mg cholesterol per 100g egg yolks.

Though the correlation between seafood consumption and blood fat levels is not yet fully understood, most scientists agree that fish is an excellent health food. Fish liver fats are full of vitamins A and D, which our eyes, skin, teeth, and bones need. Fish flesh, rich in vitamin B, may help check skin and nervous system disorders. Beneficial minerals such as phosphorous, potassium, iron, iodine, and selenium come from fish. Shellfish are among nature's richest sources of zinc, which strengthens our immune system. Oysters, shrimp, clams, sardines, and salmon are high in bone-building calcium.

Sample	Cholesterol (mg/100g)	Omega 3 (g/100g)
Bluefish (Pomatomus saltatrix)	57.1 53.2 55.4	0.45
Smooth Dogfish (Mustelus canis)	46.1 47.5 51.5	0.25
Spiny Dogfish (Squalus acanthias)	not yet available	2.60

Table I. Cholesterol and Omega-3 content of three fishes

Although shellfish and some finfish have a high fat content it appears that it is not the quantity but the type of fat that is important in determining the liklihood of heart disease and atherosclerosis (hardening of the arteries). "Fat" is a term designating a large number of different compounds with different properties. Omega-3 fatty acids, for instance, seem to increase components that are thought to be beneficial in the blood and lower amounts of fats that are believed to be harmful.

Omega-3 fatty acids existed in varying amounts in the three fish tested by the MIT researchers. A 3.5-oz portion of spiny dogfish yielded 2.6g of omega 3 compared to .45g omega 3 in the same portion of bluefish.

Although humans need some saturated fats in their diet, an excess of saturated fats is believed to be among the worst offenders in the heart disease epidemic. Only 11 to 27 percent of the total fat in fish is saturated, compared with 36 percent in pork and 48 percent in beef. A 4-oz hamburger will give you at least 50 times more saturated fat than the same amount of poached cod or shrimp. Yet the average American eats only 14 to 15 pounds of fish per year and a whopping 145 pounds of red meat.

Fish is also low in calories. A 3½-oz portion of cooked white fish contains one-third of an adult's recommended daily allowance of protein, but has fewer than 100 calories. Although fatty fish such as salmon and mackerel have more calories, their omega-3 content makes them just as beneficial as lean fish such as cod and haddock.

In addition to measuring the benefits of local food fish, the Sea Grant researchers also will probe the edible portions of the seafood for heavy metals, some of which are known to be stored in fat.

Meanwhile, since the human body cannot synthesize omega-3 fatty acids, Americans could profit from the example of the Eskimo by eating more fish. Many nutritionists recommend eating seafood two or three times a week.

Close followers of the latest promising developments in omega-3 fatty acid research, such health organizations as the National Institutes of Health, the American Medical Association and the American Heart Association are encouraging more work in the field. ■

Research Update

New Trawl Opens Major West Coast, Alaskan Fishery

A revolutionary trawl has overcome limitations of its predecessors and opened a West Coast and Alaskan pollock fishery previously inaccessible to commercial fleets. The new trawl, by Nor'Eastern Trawl Systems of Bainbridge Island, Washington, was developed from scale model tests conducted by MIT Sea Grant at the U.S. Navy experimental tank in Bethesda, Maryland.

Midwater rope trawls previously used by West Coast fleets could not operate effectively in water shallower than 30 fathoms, where significant stocks of pollock lie. Because of their bulk and rigging, the old nets would crash into the bottom and be torn.

At the David Taylor Naval Ship R&D Center (NSRDC) where MIT Sea Grant conducts scale model tests of trawls, experiments were done on the new trawl design in the 22-foot-wide circulating water channel. Through observation, measurement, and adjustment using sophisticated testing apparatus specially installed for net testing, the concept was proven and the Unbridled Trawl was born. With no lower wings to hit the bottom and a rope top and sides which attach directly to midwater doors rather than with long bridles, the net can be towed safely in shallower water.

Thirty-five of the new nets were sold in a period of eighteen months. The productive waters now open to fishermen as a result of the Unbridled Trawl have enabled fleets to maintain good catch rates throughout the season.

Nor'Eastern is applying the unbridled concept to other fisheries as well, where its use as a semi-pelagic or a hard-bottom trawl has shown potential. Availability of the NSRDC test tank made possible the confident introduction of this innovative net, which might never have happened through the traditional evolutionary process of net development.

For Fishermen:
Trawl Net Training Courses

Following MIT Sea Grant's successful series of trawl net training courses at the David Taylor Naval Ship Research and Development Center (NSRDC) in 1985, five more courses will be offered in winter/spring 1986.

In the courses fishermen are able to compare trawl designs and changes in rigging, spread, and speed on trawl models in NSRDC's circulating water channel, allowing popular arrangments to be seen and adjusted for maximum performance.

The two-day sessions will be held at the NSRDC in Bethesda, Maryland, according to the following schedule:

Date	*Course Topic*
February 19-20	New England Bottom Trawls (under 250 hp)
March 19-20	New England Bottom Trawls (over 250 hp)
April 7-8	Bottom Trawls, all regions
April 9-10	Advanced Course
May 14-15	Bottom Trawls, all regions

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Abstracts

☐ High-Efficiency Brayton-Cycle Engines for Marine Propulsion

David Gordon Wilson
Theodosios P. Korakianitis
MITSG 85-10 109pp $5

In the research that led to this report, three alternative gas-turbine cycles were examined for their potential to provide greatly improved marine propulsion, with particular reference to fishing boats. Of the three—the direct-plus-inverted cycle, the intercooled regenerated cycle, and the regenerated cycle—the latter was most attractive for its potential as an engine that would be more efficient at full and part power, lower in initial cost, have lower mass and volume, and require less maintenance. In addition to a review of alternative forms of gas-turbine engines, this report identifies a baseline fishing vessel, presents a preliminary baseline engine design, looks at the effects on ship design, compares the costs and performance of both low pressure ratio (LPR) and diesel engines, and recommends future research needs.

☐ The Design and Performance Analysis of a Digital Acoustic Underwater Telemetry System

J.A. Catipovic, A.B. Baggeroer
K. von der Heydt, D.E. Koelsch
MITSG 85-12 54pp $5

Because the deepwater environment is a dangerous one for humans, remote sensors and robots are required for working there. This report, based on five years of research, discusses the design and performance characteristics of a system for transmitting data between deepsea instruments and surface work stations. The system, Digital Acoustic Telemetry System (DATS), incorporates the current state-of-the-art technology and is capable of reliable data transmission at rates useful for a wide range of tasks.

DATS is designed to operate in very reverberant channels, a requirement for deepsea transmission. It adaptively monitors the time and frequency dispersion of the channel and uses the measurements to correct the demodulator and decoder. This yields a more complicated, but significantly more robust system which can operate in more places and with less care than other dispersion dependent systems. The design of DATS is based on a realistic model of the high-frequency channel generally accepted in the ocean acoustic literature. The report presents measurements of the channel used at frequencies centered at 50 kHz and at ranges of up to 1km in shallow water.

☐ A Mathematical Model for Compliant Risers

N.M. Patrikalakis
C. Chryssostomidis
MITSG 85-17 79pp $10

Compliant risers are assemblages of pipes which are used to carry oil from the ocean floor or a subsurface buoy to a surface platform. To date they have been used successfully in protected waters for tanker buoy loading stations. Now the offshore industry believes that as alternatives to conventional production risers they could simplify offshore production systems. This report provides a general non-linear mathematical model describing the global behavior of a compliant riser idealized as a slender non-rotationally uniform rod with bending, extensional and torsional degrees of freedom in three dimensions. It also includes the internal fluid's pressure and speed effects on the system.

☐ Nonlinear Statics of Nonrotationally Uniform Rods with Torsion

N.M. Patrikalakis
C. Chryssostomidis
MITSG 85-18 79pp $10

This report describes research which extends the model presented in MITSG 85-17. The authors in this work have allowed for the computation of static responses and present an embedding technique to solve the general two-dimensional and three-dimensional static problems of a buoyant compliant riser. Configurations are presented in the presence and the absence of external currents.

☐ **Wide Bandwidth Positioning Systems for Space and Underwater Vehicles**

H. Kazerooni
T.B. Sheridan
MITSG 85-34 15pp $4

Remotely operative underwater vehicles sometimes must attach themselves to an underwater structure to employ manipulators and other tools for inspection, cleaning and repairing tasks. The interaction of classical control and the constraining attachment systems can result in high forces and possible destruction to equipment. To attack this problem a general technique known as impedance control has been developed. In this report, the concept has been extended to include constraints as a special kind of external load. Thus it is shown that the controller can be built to work safely with systems having constraints or attachment mechanisms which severely limit motion.

☐ **Mooring Dynamics for Offshore Applications**

Michael S. Triantafyllou, Antoine Bliek,
Jim Burgess, Hyunkyoung Shin
Part 1: Theory, MITSG 86-1
Part 2: Applications, MITSG 86-2
$12 each; $20 for the set

The use of mooring systems in offshore waters of 2,000 feet or more causes a design problem in that the natural frequency of the cables lie within the wave spectrum and are thus vulnerable to dynamic amplification. At the same time, longer lines are required, thereby increasing self weight and reducing the available margin for dynamic effects. The study described in these reports revealed the effect of some non-linearities for vibrating cables. It was proven that the principal non-linearity for vibrating cables in water is fluid drag except in those oscillations which are vortex-induced. A new method was developed by the research to couple the dynamics of several mooring lines, based on the principle of dynamic impedance. Volume 1 describes the theoretical conclusions of the work while Volume 2 presents the numerical applications to offshore problems in three categories: linear dynamics, nonlinear dynamics and snap motion and equivalent linearization techniques.

☐ **MIT Summer Session 1986 Preliminary Announcement**

10 pp No charge

A preliminary brochure lists MIT special summer programs for professionals. The courses, which run from one to two weeks, cover diverse areas from conflict resolution to biotechnology process engineering. Five of the 80 offerings in 1986 are being sponsored by Sea Grant. These include robot design, control and manufacturing; robot minipulators, computer vision, and artificial intelligence; corrosion, welding fabrication in marine and offshore structures; and high efficiency gas turbine design. Detailed descriptions of each course may be ordered from the full menu presented in the preliminary brochure.

Enclosed: $ _____

Please check off those publications you would like to order, and return this entire page – or a copy of it – to the Sea Grant Program, Massachusetts Institute of Technology, Building E38-302, Cambridge, MA 02139.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Sea Grant Program

MEMO

TO: Holly Turton, SGD

FROM: Therese Henderson, Production Assistant/Secretary tgh

DATE: 18 March 1986

Here is the copy of the Winter 1986 Quarterly Report that you had asked for. Sorry for the inconvenience; I suspect that you may well end up with more copies than you need - we are in the process of weeding out duplicates, but it takes awhile to get everything straightened out! The Spring 1986 QR should be back on track as far as your getting the right number of copies.

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