MARICULTURE AND OTHER USES FOR OFFSHORE OIL AND GAS PLATFORMS
RATIONALE FOR RETAINING INFRASTRUCTURE

TECHNICAL REPORT

STEVE KOLIAN AND PAUL W. SAMMARCO

Eco-Rigs of Eco-Endurance Center
Baton Rouge, Louisiana
USA

MARCH 2005
Mariculture and Other Uses for Offshore Oil and Gas Platforms: Rationale for Retaining Infrastructure

By Steve Kolian and Paul W. Sammarco

Eco-Rigs Technical Report

Eco-Endurance Center
12605 South Harrel’s Ferry Road, Suite 3
Baton Rouge, Louisiana 70816
USA

_Eco-Rigs is a Louisiana-based non-profit organization created to preserve offshore oil and gas platforms habitats for mariculture, recreational fishing and diving, and other eco-technologies that produce economic and environmental benefits to the citizens of Louisiana._
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Executive Summary

Purpose of Report

The purpose of this report is to examine the feasibility of utilizing retired oil and gas platforms after their profitable life in minerals production for marine aquaculture. The report examines the potential economic benefits that could result from a mariculture industry in Louisiana, characterizes the potential impact of mariculture on the marine ecosystem in the Gulf of Mexico, and reviews legal and regulatory considerations to establishing a mariculture industry using existing oil and gas platforms. Other potential future uses for retired oil and gas platforms are also identified, including renewable ocean energy production, greenhouse gas sequestration and recovery of “stranded” hydrocarbon resources.

The Louisiana continental shelf is home to nearly 3,600 federal offshore and 2,000 state coastal oil and gas platforms. When production from these platforms becomes unprofitable, under current federal regulations, operators are required to remove the structures (30 CFR 250.112 & LSA RS 30:4). Most offshore fields in water depths less than 600 feet will become unproductive within the next 10–15 years, requiring that 150–200 platforms be removed annually (Pulsipher et. al. 2001). Platform removals are currently costing the oil and gas industry $300–$400 million per year (NRC 1996), and it will eventually cost over $8 billion for the removal of all structures in shallower offshore waters.

The platforms could be utilized for a number of other applications after their profitable life in minerals production:
- Marine aquaculture; e.g., food fish (net-pens), coral and sponges, oyster depuration, ornamental fish
- Greenhouse gas sequestration
- Wind energy
- Ocean energy; e.g., current, wave, ocean thermal, salinity gradients, and bio-fuels
- Recreational fishing and diving parks
- Cooperative sea farms
- Natural gas storage and regasification (closed loop)
- Pipeline maintenance to help transport deep water oil and gas production.

With the anticipated pace of production decline, the speed of platform removal could increase significantly. The removal of offshore platforms and the dismantling of their associated pipeline systems would economically strand a large volume of platforms.

Platforms represent the only hard substrate across much of the Louisiana continental shelf, a region flooded by sediments from the Mississippi River and other tributaries.
Mariculture and Other Uses for Offshore Oil and Gas Platforms:
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The volume of crude oil and natural gas that could be produced with emerging oil and gas recovery technology. An estimated 67 percent of the crude oil and 45 percent of the natural gas in oil and gas fields in state and shallow federal offshore waters (< 200 m) will be "stranded" because the cost of extraction will exceed revenues using traditional production practices (ARI 2005).

Recovery rates and efficiencies, however, continuously improve with advances in technology. An analysis of 99 large state and federal offshore oil fields, representing 80 percent of the crude oil resource off the coast of Louisiana at < 200 m depth, shows that, with "state-of-the-art" carbon dioxide (CO₂)-enhanced oil recovery (EOR) technology, approximately 4.5 billion barrels of incremental oil (28 percent of this stranded resource) is technically recoverable, and with appropriate "risk mitigation" incentives and reasonable costs of delivered CO₂, as much as 3.6 billion barrels could be economically recoverable (ARI 2005).

Mariculture could provide an economic catalyst to affect the petroleum production economics by preventing platform shutdown of retiring platforms. Mariculture ventures or other applications could extend the life of these platforms until the "stranded" oil and gas becomes economically viable to produce. However, should the fields be abandoned and the platforms removed, the feasibility of returning to these fields with improved recovery technology would be economically prohibitive.

The potential economic benefits from maintaining this infrastructure could be substantial:

- Assuming that the 3.6 billion barrels of stranded oil resources are developed over a 40-year time frame, by 2025, this would amount to:
  - Incremental oil production of 200,000 to 250,000 barrels per day;
  - More than 8,000 jobs retained by the Louisiana oil and gas industry;
  - Increased economic activity amounting to $500 million per year to Louisiana; and
  - Increased state and federal revenues of over $250 million per year. Under current fiscal arrangements, more than 90 percent of this revenue will go to the federal government.

Offshore oil and gas production platforms support one of the most prolific ecosystems, by area, on the planet. Stanley and Wilson (2000) reported that 10,000–30,000 adult fish reside around a platform in an area about half the size of a football field. They create the only reef habitat across thousands of square miles of generally featureless, sometimes hypoxic, continental shelf (Sammarco et al. 2004). Over 80 species of federally managed protected fish, crustaceans, corals, soft corals, sponges, and sea turtles inhabit and/or forage around the offshore structures (Adams 1995, Beaver 2002, Rademacher and Render 2003, Sammarco 2004, and Walker 2004). They are essential habitat to protected and endangered species.

No formal legal structure exists to utilize retired platforms for purposes other than producing petroleum. The central economic concern of all parties interested in the conversion of these platforms to alternate uses is the long-term care and transfer of ownership and liability. Mariculture and other ventures on platforms will have to comply with the same state and
federal regulations and structural codes that oil and gas operators currently maintain. Several expenses will be germane to any venture utilizing retired offshore platforms. These include expenses associated with a platform removal bond, navigational aids, maintenance, liability insurance, and cathodic protection. Unfortunately, the high cost of the platform removal bond could well prohibit the economic success of many types of alternative applications.

Recommendation 1: Revise Outer Continental Shelf Lands Act (OCSLA) platform removal requirements and adjust codes for alternative uses; create OCSLA language to terminate leaseholder’s interest and liability; create clear legal foundation for transfer of ownership; create a federal trust fund to provide liability to the former oil and gas operators to ensure that they will not be sued; provide low interest loans to mariculture ventures and fishermen; and provide general performance bonds to mariculture platforms so that they could be eventually turned into artificial reefs and not blasted out of the water and hauled to shore.

Mariculture ventures face a complex array of regulatory and legal obstacles. Mariculture ventures will probably pursue several different culture applications on the same platform. In the 109th Congress, the federal government will propose a National Offshore Aquaculture Act that provides the Department of Commerce clear authority to regulate offshore aquaculture. The Gulf of Mexico Fisheries Management Council (Gulf Council) is currently drafting a Fisheries Management Plan (FMP) for Marine Aquaculture.

Recommendation 2: Endorse the upcoming legislation in the National Offshore Aquaculture Act and support efforts by the Gulf Council in drafting and approving their FMP for marine aquaculture.

This study focused primarily on five mariculture activities and recreational fishing that could potentially utilize Louisiana offshore platforms for operations. Mariculture activities of focus included net-pen operations, oyster depuration, culture and harvest of ornamental fish, coral, and sponge, and platform sea farming. The economic feasibility of the various mariculture applications on offshore platforms still needs to be documented.

Recommendation 3: Complete a comprehensive study on the economic feasibility and cost-benefits of mariculture and other applications utilizing platforms.

The greatest obstacle currently facing offshore mariculture facilities is the limited availability of marine fish fingerlings for stocking offshore cage operations. Most of the research efforts into fish farming in the United States have been directed toward freshwater species. Elsewhere around the globe, most notably in Japan, there have been numerous successful efforts to spawn and raise marine species for net-pen culture and sea farming. Several major technological hurdles exist, however, and the first important local obstacle is the absence of a fish hatchery in Louisiana.

Recommendation 4: Build a state-of-the-art marine fish hatchery in Louisiana.
All the platforms in the Gulf of Mexico are geo-referenced in a Minerals Management Service (MMS) database with more than 100 descriptive variables that could be combined with physical, biological, chemical, and ocean sediment databases. This information could be programmed into a geo-referenced model to help make decisions on retiring platforms. This could help address the following questions: should decommissioned platforms be used for mariculture or other applications, remain in place or be relocated for biological reasons, or moved for navigational concerns or user conflicts. Many variables could influence the placement of platforms. This GIS model would be the first technology item to help develop a defensible long-term plan for mariculture development in Louisiana’s offshore waters.

Recommendation 5: Create an ArcGIS platform computer program interface that will allow users to anticipate the lifespan of platforms in petroleum production and decide whether to relocate or leave the structures once they reach retirement.
In 2002, the United Nations Food and Agriculture Organization (FAO) reported that most capture fisheries around the world are fishing fully exploited stocks and cannot expect to increase the volume. They predicted a 40 percent increase in fishery product needs by 2020, increasing from 130 million metric tons in 2001 to 180 million metric tons by 2030. They concluded that population growth and an increase of per capita fish consumption will create a 50 million metric ton production gap by 2030 — a gap that aquaculture could potentially fill (FAO 2002).

Over the past three decades, aquaculture has progressed to become the fastest growing food production sector in the world (Jia et al. 2001). Aquaculture production processes have expanded, diversified, intensified, and advanced in technology.

Petroleum and seafood represent the first and second largest import commodities in the U.S., respectively. In 2002, the United States imported $10.1 billion of edible seafood and $9.6 billion of non-edible seafood, for a total of $19.7 billion on imports — representing an increase of $1.2 billion from 2001. Despite this large and growing demand for seafood, the United States currently only contributes to 2 percent of the worldwide aquaculture production (FAO 2002).

**Definition of Mariculture**

“Aquaculture is the cultivation of aquatic animals and plants in controlled or selected environments for commercial, recreational, or public purposes. Such organisms are raised primarily to supply seafood for human consumption, but they can also be used to enhance wild populations, for breeding programs in public aquariums and zoos, rebuilding populations of threatened and endangered species, baitfish production, and to produce other non-food products, such as pharmaceuticals.” (NOAA 2002)

**State-of-the-Art of Mariculture**

*Worldwide.* Offshore mariculture is expanding rapidly in countries such as Chile, Norway, Ireland, Spain, Taiwan, Korea, Philippines, and in Mediterranean countries such as Greece, Italy, Cyprus, and Turkey (Ryan et al. 2004). The European Union devotes over $400 million annually to the fisheries sector, which includes $260 million for aquaculture. Canada has just dedicated $75 million (Canadian dollars) to federal research and development. Even Vietnam is financing aquaculture development and diversification (National Marine Fisheries Service, 2002).
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**Japan.** As an island nation with limited land resources, Japan has traditionally focused on the sea for socio-economic development. The Japanese are changing their commercial fishing fleet from a “catch fishery” to a “culture fishery” or from “predatory” methods to “sustainable” methods (Grove et al. 1994). Japan has invested approximately $8 billion dollars into an ambitious marine fisheries enhancement program (Grove et al. 1994). In the 1970s, the government spent $67 million on research and planning alone (Bohnsack 1985; Mottet 1981). The Japanese employ a variety of mariculture techniques. One ambitious project designed and installed an offshore platform specifically for mariculture. Biologists train, release, and feed juvenile fish in the open ocean for eventual recapture (Grove et al. 1994). Some efforts have been more successful than others. Matsuda and Tsukamato (1998) reported that the Fukushima Prefecture has achieved a 30 percent recapture rate and is experiencing a cost-benefit ratio of more than 300 percent with their marine stock enhancement program. They also have installed an offshore platform to clean up a polluted bay using novel and non-carbon producing energy sources (Matsuda et al. 1999).

**United States.** To date, the United States has been slow to pursue large-scale mariculture operations off its shores. The most promising platform mariculture venture on the horizon is the Hubbs SeaWorld Research Institute’s Grace Mariculture Project off the California coast, utilizing an old oil and gas production platform. The Institute has 20 years experience with stock enhancement and aquaculture production. They are currently engaged in a lengthy permitting process for this facility, and expect to be permitted in the autumn of 2005. Hubbs SeaWorld Research Institute intends to first raise striped bass and, if methods prove successful, they plan to grow white sea bass, California halibut, California yellow tail, and bluefin tuna, as well as invertebrates such as abalone and mussels. They also plan to create an offshore hatchery on the Grace platform (GMP 2004).

**Gulf of Mexico.** Mariculture on platforms in the Gulf of Mexico has been explored offshore of Texas to a limited extent in offshore coastal waters. Several cage systems were tested; cage maintenance and production cost made it difficult to achieve project goals for this first-of-a-kind project (Kaiser 2003). (The one commercial venture by SeaFish, Inc. recently lost the right to use the offshore facility because the owner found new petroleum resources and restarted oil and gas production operations (Kaiser 2003)).

**Focus of this Report**

The items in the table below on the left were covered in detail in this report. Other applications (to the right) will not be covered in depth here. They are still, however, of interest and may have potential for development on offshore platforms. (See www.ecorigs.org for additional related information and videos of naturally occurring fish, corals, and other reef organisms.)

<table>
<thead>
<tr>
<th>Focus of this Report</th>
<th>Not Examined in this Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-pen or cage culture</td>
<td>Fish sanctuaries</td>
</tr>
<tr>
<td>Oyster depuration or oyster relaying</td>
<td>Artificial upwelling</td>
</tr>
<tr>
<td>Ornamental fish culture</td>
<td>Nursery habitat grounds</td>
</tr>
<tr>
<td>Recreational fishing and diving</td>
<td>Offshore fish processing</td>
</tr>
<tr>
<td>Coral and sponge culture</td>
<td>Research platforms</td>
</tr>
<tr>
<td>Sea farming</td>
<td>Fish hatcheries</td>
</tr>
</tbody>
</table>
Offshore Industries in Louisiana are in Decline

Louisiana's Oil and Gas Production are Declining

Louisiana derives a significant portion of its general revenue and an important portion of its economic and employment base from the oil and natural gas sector. However, production in Louisiana's shallow offshore waters (< 200 m water depth) has been in decline:

- Crude oil production has dropped from more than 630,000 barrels per day in 1992 to 380,000 barrels per day in 2003.
- Natural gas production has declined from 3.3 trillion cubic feet (Tcf) per year in 2002 to 2.3 Tcf per year in 2003.
- While increases in production from the deeper federal waters (> 200 depth meters) have helped offset declines in shallow-water production, Louisiana is nonetheless receiving decreasing revenues from offshore oil and gas production.

The Louisiana economy is also highly dependent on a wide variety of industries that depend on offshore oil and gas production. For example, Louisiana is the third largest consumer of natural gas in the U.S., and a large number of chemical industry jobs in Louisiana are highly dependent on the continued availability of adequate volumes of moderately priced natural gas.

Given the increasing maturity of Louisiana's offshore fields, along with the relatively slow pace of development in the deep-water areas, most analysts forecast a continued decline in oil and natural gas production from offshore Louisiana.

Given the anticipated pace of production decline, by 2020, most of the current platform inventory in the Gulf of Mexico could be abandoned.

Louisiana's Fishing Industry is Also in Decline

Each year, more and more fishing regulations are imposed on commercial and recreational fishermen in an effort to rebuild the stocks of exploited species. Federal regulations impose size, trip limits, and fishing seasons on sport fishermen. A recreational charter boat moratorium and another commercial reef fish moratorium are currently in effect in Louisiana's offshore waters. The commercial finfish sector is experiencing net-bans and an unyielding series of regulations on harvested fish.


Source: U.S. Department of Interior, Minerals Management Service and the Louisiana Department of Natural Resources


Source: U.S. Department of Interior, Minerals Management Service and the Louisiana Department of Natural Resources
A Substantial Portion of Louisiana’s Economic Foundation is at Risk

The oil and gas industry and the seafood and fishing industries are the two most important industries to the Louisiana economy. Unfortunately, for a variety of reasons, both of these industries are in decline.

**Oil and Gas Industry**
- Including the federal outer continental shelf (OCS), Louisiana is still the largest oil producing state and second-largest gas producing state in the U.S. despite rapidly declining production.
- The oil and gas exploration and production industry directly employs 50,000 people in Louisiana.
- The Louisiana industry facilitates the transport and distribution of nearly two billion barrels of crude oil and petroleum products and 4.5 Tcf of natural gas annually to consumers throughout the nation.

**Seafood and Fishing Industry**
- Louisiana continental shelf is home to 90% of the fisheries in the Gulf of Mexico (Globec 2000).
- Second-largest producer of seafood in the U.S.
- Generates $2.8 billion/yr in economic output and directly creates 31,400 jobs (Southwick 1997).
- Saltwater recreational fishing stimulates $745 million in economic output and creates 7,786 jobs (ASA 2001).

Offshore Oil and Gas Infrastructure is Significant and Widely Dispersed

For the approximately 3,600 platforms that exist in the federal offshore waters of Louisiana, more than 700 have been operating for more than 40 years (Minerals Management Service, 2004). With cathodic protection, these platforms can maintain their integrity for hundreds of years. Nonetheless, on average, from 150 to 200 platforms are removed per year, following federal guidelines written in the mid-1970s. To date, over 2,000 platforms have been removed (Minerals Management Service, 2004).

Connected to this production infrastructure are over 26,000 miles of oil and gas pipelines and gathering systems. Moreover, offshore oil and gas production operations support a vast spectrum of other activities in the state, including platform fabrication, drilling and related services, offshore transport and helicopter operations, and gas processing.

Offshore Oil and Gas Infrastructure is at Risk of More Rapid Abandonment

With the anticipated pace of production decline, the speed of platform removal could increase significantly. The removal of offshore platforms and the dismantling of their associated pipeline systems would economically strand a large volume of crude oil and natural gas that could be produced with emerging oil and gas recovery technology. A variety of future economic activity in the Gulf of Mexico could take advantage of this infrastructure, if it remains in place.
Substantial Future Oil and Gas Resource Potential Exists in the Louisiana Offshore

The decline of offshore oil and gas production and the increasing maturity of offshore oil and gas fields off the coast are Louisiana are causing field and platform abandonments that, unless mitigated or reversed, could lead to significant volumes of oil and gas being “stranded,” or left behind, in these fields. Tabulation of stranded oil and natural gas volumes in the Louisiana offshore (consisting of the Central Planning Area; < 200 depth meters) in the Gulf of Mexico federal waters and offshore Louisiana state waters) by the U.S. Department of Energy (DOE) (ARI 2005) shows that 56 percent of the original oil in-place and 33 percent of the original gas in-place will remain unrecovered with traditional technology and recovery practices:

- In Louisiana state waters, based on data from the Louisiana Department of Natural Resources and the U.S. Energy Information Administration (EIA), an estimated 60 percent of the crude oil and 44 percent of the natural gas will remain unrecovered with traditional practices.
- In offshore federal waters, less than 200 m deep, based upon Minerals Management Service (MMS) data for larger oil and gas fields, an estimated 55 percent of the original oil in-place (and 33 percent of the original gas in-place) will remain unrecovered without the introduction of improved recovery practices.

Important advances are being made in oil and gas extraction technologies that could enable the economic recovery of some of this stranded resource endowment. Perhaps the most promising advancement is CO$_2$-based enhanced oil recovery (EOR). This stranded oil resource represents the “prize” awaiting the application of more advanced recovery practices. However, should the fields be abandoned and the platforms removed, the feasibility of returning to these fields with improved technology would be economically prohibitive.
Estimates of “Stranded” Oil & Natural Gas in Louisiana Offshore Waters

<table>
<thead>
<tr>
<th></th>
<th>Crude Oil (Billion Bbls)</th>
<th>Natural Gas (Tcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>State</td>
<td>Federal</td>
</tr>
<tr>
<td>Original In-Place</td>
<td>3.6</td>
<td>24.5</td>
</tr>
<tr>
<td>Produced to Date</td>
<td>1.4</td>
<td>10.0</td>
</tr>
<tr>
<td>Remaining Proved</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>“Stranded” Resource</td>
<td>2.2</td>
<td>13.5</td>
</tr>
<tr>
<td>% Recovery, Traditional Practices</td>
<td>40%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Source: Advanced Resources (2004), based on Louisiana Department of Natural Resource data.

Substantial Portions of This “Stranded” Resource Could Be Economic to Develop and Produce

An analysis was made of 99 large state and federal offshore oil fields, representing 80 percent of the crude oil resource off the coast of Louisiana in < 200 m depth. This analysis shows that, with “state-of-the-art” CO₂-EOR technology, a significant fraction of the stranded oil in these fields — amounting to approximately 4.5 billion barrels of incremental oil (another 20 percent of the original oil in place, or 28 percent of the stranded resource) — is technically recoverable, as summarized below.

The economic recovery potential of this resource was assessed under several “scenarios” incorporating alternative oil price, CO₂ cost, and risk mitigation incentives.
Estimates of Currently Recoverable Oil Resources in the Louisiana Offshore Environment

<table>
<thead>
<tr>
<th>State Offshore</th>
<th>No. of Fields</th>
<th>OOIP (MM Bbls)</th>
<th>Technically Recoverable (MM Bbls)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>1,100</td>
<td>237</td>
</tr>
<tr>
<td>Federal Offshore</td>
<td>87</td>
<td>20,950</td>
<td>4,213</td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>22,050</td>
<td>4,450</td>
</tr>
</tbody>
</table>

Under Reference conditions (Scenario #1), with oil prices of $25 per barrel, delivered CO₂ costs at 5 percent of the oil price, and a hurdle rate of 25 percent before taxes [to account for the technical/economic risk associated with CO₂-EOR technology in offshore applications], no incremental resource is economically recoverable.

To improve the economic feasibility of using CO₂-EOR in these fields, two “risk mitigation” and cost-reduction options that could provide possible routes for better economic performance were evaluated:

**Scenario #1A – Reduced CO₂ Costs:**
An assumed CO₂ emission reduction incentive, combined with improved technology, could allow CO₂ to be delivered to the platform at reduced costs (3 percent of the oil price). This action, however, is not sufficient to encourage economic recovery from CO₂-EOR.

**Scenario #1B – Public/Private “Risk Mitigation”:** An assumed risk mitigation incentive, reducing risk to investors (15 percent rate of return (ROR) after taxes, achieved through significant field demonstration pilot projects), and royalty relief on incremental oil produced by CO₂-EOR (even when still relying on higher cost “EOR-ready” CO₂), would provide 1.3 billion barrels of economic oil recovery potential.

**Scenario #2:** When both “risk mitigation” and reduced CO₂ costs are combined, 3.6 billion barrels could be economically recoverable.

**Impacts of CO₂ Costs and Risk Sharing on CO₂-EOR Economics**

- **Scenario #1B – Low Risk, High CO₂ Costs:**
  - Fields: State 0, Federal 22
  - Resource (Bbbls): State 0, Federal 0

- **Scenario #1A – High Risk, Low CO₂ Costs:**
  - Fields: State 0, Federal 0
  - Resource (Bbbls): State 0, Federal 0

- **Scenario #2 – Low Risk, Low CO₂ Costs:**
  - Fields: State 2, Federal 66
  - Resource (Bbbls): State 0.2, Federal 3.4

*Assumes $25 per barrel of price.*
Economic Benefits of Producing Incremental Oil from CO₂-EOR

Assuming that 3.6 billion barrels are developed over a 40-year time frame, by 2025 this would amount to:

- Incremental production of 200,000 to 250,000 barrels per day;
- Over 8,000 jobs retained by the Louisiana oil and gas industry;
- Increased economic activity amounting to over $500 million per year to the Louisiana economy; and
- Increased state and federal revenues of over $250 million per year.

Substantial Stranded Gas Resources Also Exist on Louisiana’s Continental Shelf

Substantial volumes of stranded natural gas resources also exist at < 200 m depth off the Louisiana coast:

- Particular reservoir flow conditions, primarily a strong natural bottom water drive, preclude efficient recovery and, without a change in recovery techniques, could “strand” one-third or more of the gas in-place.
- An estimated 70 Tcf is stranded, with 42 Tcf in a series of large attractive fields.

No assessment has been performed of the economic recovery potential of stranded gas resources in offshore Louisiana. Nonetheless, given its large potential, production of this latent resource merits an assessment for potential economic feasibility.

Significant Undiscovered Gas Resource Potential Exists in Deep Formations off the Louisiana Coast

The MMS estimates that as much as 55 Tcf of technically recoverable natural gas exists in the shallow waters off the Gulf of Mexico at formation depths > 15,000 ft. MMS has recently announced financial incentives for the pursuit of these resources, providing royalty relief for the first 25 Bcf produced from deep gas wells. Existing platform infrastructure could be utilized to support production of these deep gas resources.
Pursuing the Undeveloped Offshore Oil and Gas Potential

It is essential that the infrastructure (platforms, wells, and pipeline system) for these large offshore oil fields and natural gas fields be maintained until the technology and/or economics of enhanced oil and natural gas recovery improves. This is essential for conserving this domestic hydrocarbon resource endowment. The economic recovery of this undeveloped offshore oil and gas resource will also depend upon:

- Future crude oil and natural gas prices;
- Cost of future supplies of CO$_2$ (perhaps influenced via incentives for reducing CO$_2$ emissions, such as the geologic sequestration of anthropogenic CO$_2$); and
- The economic risk associated with these projects, because of their technological challenges (perhaps influenced through government risk-sharing programs via fiscal incentives to encourage CO$_2$-EOR).

In addition, more comprehensive assessments of this potential are required, and policy makers and industry decision-makers must be informed of this potential.

**Sub-Sea Wells with Tiebacks to Existing Platforms Could Help Facilitate Deep Gas Development**

The concept behind the Canyon Express Project, which focuses on deep water natural gas development, could also be used for deep formation gas development. This first-of-its-kind deep water gas project in the Gulf of Mexico combines a central hub and subsea system with a 500 MMcf/day pipeline system that takes production from three different discoveries and transports the produced gas more than 50 miles to the existing Canyon Station platform for processing and transport to shore.

**“Canyon Express” Project**

<table>
<thead>
<tr>
<th>Sub-Sea Wells (#)</th>
<th>Field Size (Bcfe)</th>
<th>Water Depth (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aconcagua (MC* 305)</td>
<td>3–4</td>
<td>300</td>
</tr>
<tr>
<td>Camden Hills (MC 348)</td>
<td>2</td>
<td>500</td>
</tr>
<tr>
<td>King’s Peak (MC 217)</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

* MC = Mississippi Canyon
Other Potential Energy Opportunities Exist Offshore of Louisiana

In addition to oil and gas extraction and mariculture, the existing oil and gas infrastructure in the state of Louisiana could be used for a number of other applications. Some of these opportunities are described below.

Liquefied Natural Gas (LNG)

Some existing offshore oil and gas platforms could be converted to accommodate offshore LNG operations. This conversion could utilize existing platform operations to re-gasify LNG. Increasing imports of LNG are seen by most industry analysts as critical for supplying increasing U.S. demand for natural gas (NPC 2003).

Moreover, as gas production in Louisiana continues to decline, increased LNG imports could help utilize existing industry infrastructure in the state that would otherwise be under-utilized, such as gas-processing facilities and gas-gathering and transportation infrastructure. In addition, it can help provide continued low-cost natural gas to power generation and large industrial gas consumers in the state. Recent studies have shown that substantial economic benefits could accrue to the State of Louisiana from the development of LNG facilities off its coast (Dismukes 2004).

One concern associated with onshore LNG re-gasification facilities is the potential threat they pose to neighboring communities in the event of an accident or terrorist event. Offshore facilities located far from population centers pose a much more limited threat to coastal communities, however, there is concern that cooling waters may have a detrimental affect on fish larvae.

Carbon Sequestration

In a CO₂-EOR project, once oil production declines below a point where the revenues from this production do not cover the cost of operations, the project is discontinued. As mentioned earlier, in the case of an offshore project, under current federal regulations, the platform and associated equipment would need to be dismantled and removed.

Even after production has been discontinued, this same facility could be used to take CO₂ emissions from onshore industrial facilities and, using existing infrastructure, sequester this CO₂ back into the geological formations of depleted oil and gas fields and perhaps other deep formations, such as saline aquifers. An estimated 400 Tcf, or 22 gigatons, potential sequestration capacity exists in oil and gas reservoirs in the offshore Gulf of Mexico. This can allow for the removal of CO₂, a greenhouse gas, from the atmosphere. This use of these facilities for sequestering CO₂ can occur in parallel with offshore mariculture operations and would be expected not to interfere with them (ARI 2005).
**Wind Energy**

A number of wind energy developers are looking to the offshore Gulf of Mexico as a viable area for wind energy development. Existing offshore platforms are being used as part of this development. A recent study by a research group at Stanford University (Archer and Jacobson 2003) determined that the offshore Gulf of Mexico environment is characterized by some of the strongest sustained winds in the country. Offshore wind energy projects are already on-line in Denmark, Germany, and the United Kingdom, and over 3,000 megawatts (MW) of wind energy projects have been proposed off the New England coast. One project proposed for development off the coast of Massachusetts (www.capewind.org) has recently received a positive environmental assessment.

The fabrication of offshore wind energy facilities would involve most of the same skills and workforce capabilities currently associated with the fabrication of offshore oil and gas platforms, providing for the continued economic vitality for this important Louisiana industry.

Under most applications, platforms supporting wind energy production could also simultaneously support mariculture operations. However, no established regulatory framework for permitting and overseeing these offshore wind energy facilities currently exists.

**Ocean Energy**

Several scenarios to harness energy from the ocean have been entertained. Ocean Thermal Energy Conversion (OTEC) processes utilize the heat energy stored in the ocean to generate electricity. Wave, currents, and salinity gradients are also sources of energy that could be harnessed from the sea. A non-profit organization, Practical Ocean Energy Management Systems, Inc. discusses these energy technologies and lists installations already in operation in the U.S. and around the world (www.poemsinc.org/links.html). These applications require suitable sea states and water temperatures that may or may not be present at platform sites.

*Each wind turbine on offshore platforms anticipated to generate 1.5–3.6 megawatts of power (Louisiana Department of Natural Resources, 2004).*
The Louisiana continental shelf experiences population increases in algae during the spring and summer months. This is a direct result of nutrient enrichment derived from run-off from the Mississippi River and other tributaries. These algae could be harvested and processed into bio-fuels on offshore platforms and piped inshore using the existing pipeline system. The effluent from the system is aerated water. Planktonic algae (diatoms) contain the highest concentration of oils (bio-fuel) in the plant kingdom (Sheehan et. al. 1998). Waste products (proteins) could be used to supplement fish food in mariculture operations. There are about 800 platforms located in the hypoxic zone off the Louisiana coast, where these algal population increases occur. This technology is in the developmental stage. More research is needed to identify the species of algae present on the Louisiana continental shelf that is most suitable for this purpose. In addition, a mechanism to extract the algae needs to be developed.

These technologies are also compatible with mariculture operations; many engineering and economic issues, however, need to be addressed prior to implementation. Bottom Line: The economic viability of the energy development options under consideration for Louisiana’s offshore waters, the same as with many of the mariculture applications, are critically dependent on the availability and maintenance of the existing energy infrastructure in the offshore Gulf of Mexico.
**Net-Pen Culture**

The depth, current, and clarity of the water at many offshore platform locations (> 100 ft) present ideal conditions for accommodating large-scale mariculture production operations using net-pens. The platform provides a fixed base of operations for environmental sensors, systems control, and communications. The platforms are suitable for large-scale fish production and can be used to distribute food to many fish cages. The current limiting factor for long-term success of offshore mariculture is fingerling production. If a steady supply of juveniles is available, one offshore platform in 100–150 feet of water was estimated to facilitate nine large net-pens for finfish (Sea Grant 2001).

**Potential Culture Species**

The number of species available for mariculture production in Louisiana is currently limited to redfish and striped bass (P. Picard, pers. comm., Dixie Fish 2004). Some experimental production of mutton snapper and cobia has occurred in the Gulf (Watanabe 2001). Fish farmers in Taiwan have been raising cobia for over a decade and recently produced 4,500 tons of this species in 2003 (J. McVey, pers. comm.).

Numerous mariculture efforts around the world are producing oceanic species at commercial-scale levels, for species such as mahi-mahi, amberjack, tuna, pompano, and grouper (Ryan et al. 2004). The paucity of fingerling production in the Gulf of Mexico is partly due to technological limitations related to larval production and nutrition. Moreover, unfortunately, there are currently no incentives to produce fingerlings. In fact, at present, it is illegal to possess fish in net-pens (Magnuson Act) in the Gulf of Mexico exclusive economic zone (EEZ). This is clearly a regulatory issue that needs to be addressed directly by amending current legislation.

**Current Status of Mariculture in the U.S.**

Seafood is the second largest import item in the U.S. There is great need for fresh, warm-water species, such as those found in the Gulf of Mexico, and the commercial fishermen cannot meet the high demand. Finfish are heavily regulated in both the commercial and recreational fishing sectors. In addition to the trip limits, size limits, and seasons, there are moratoria on commercial reef fish permits and recreational charter boats as well as ear restrictions, net bans, and catch prohibitions on important recreational species.
Barriers to Implementation of New Mariculture Initiatives

Certain barriers are currently inhibiting the implementation of net-pen mariculture in the northern Gulf of Mexico:

- 30 CFR 250.112-15 currently requires oil and gas production platform to be removed one year after production ceases.
- No regulatory framework for mariculture currently exists.
- Permitting and monitoring are very expensive.
- No fish hatcheries currently exist to support mariculture production.
- No liability structure currently exists for the transfer of ownership and long-term care of offshore oil and gas platforms.

Role of Platforms in Offshore Net-Pen Mariculture

Because of concern over deteriorating water quality conditions and potential harmful impacts of fish farming, environmental interests have initiated efforts around the globe to move aquaculture activities offshore — away from the sensitive coastal zone (Ryan et al. 2004, Burgrove et al. 1994; Thompson 1996). Large-scale offshore net-pen mariculture operations address these environmental concerns by placing them in the presence of currents and sufficient water column depths to distribute and dilute mariculture wastes (Sea Grant 2004; Ryan 2004; Gowen et al. 1989).

Vision for the Future

The first requirement to initiate offshore net-pen mariculture operations in the Gulf of Mexico is a state-of-the-art fish hatchery to provide fingerlings. If a steady supply of juveniles is available locally, Louisiana mariculture ventures will have a higher probability of success. Even if one of these mariculture platforms were utilized for stock enhancement, it could potentially significantly increase the populations of highly regulated fish in the Gulf. The Grace Mariculture Project is planning to raise fingerlings on one platform off the California coast. Offshore fish hatcheries could overcome many of the technological hurdles facing fish larval and fingerling production and also maintain a healthy genetic protocol. An enormous gene pool is available right at the platforms' sites; from 10,000 to 30,000 fish reside off each platform (Stanley and Wilson 2000).

Potential Environmental Concerns Associated with Large Scale Net-Pen Operations

- Fish feed and fecal waste; i.e., carbon, nitrogen, sedimentation
- Escapement of fish and genetic integrity
- Fish disease and therapeutics
- Operational waste; e.g., paint, grease, anti-fouling agents, etc.
Oyster Depuration (Relaying)

Shellfish are known to be carriers of infectious and sometimes dangerous or lethal diseases. Their consumption is risky because they are often eaten raw or partially cooked. The bacteria Vibrio vulnificus occurs naturally in estuarine waters and may be found in oysters harvested from the Gulf of Mexico. While most individuals in good health are not affected by the organism, it can induce illness or prove fatal for individuals with compromised immune systems.

The presence of V. vulnificus is highly correlated with warm water temperature, and virtually all Gulf-harvested oysters contain some concentration of it in the warmer summer months.

Research has shown that populations of V. vulnificus in oysters can be significantly reduced by running (relaying) them offshore and suspending them in deep water for certain periods of time (Motes and DePaola 1996). Exposure of the oysters to cooler waters beneath the thermocline (>50 feet depth) that are naturally free of this bacterium allow the oysters to purge themselves over a 16-day period (Supan 2004). Oysters could be effectively relayed by containers (Supan 1991; Supan and Cake 1989), a method already approved by the National Shellfish Sanitation Program (NSSP) (NSSP 2003).

Current State of Oyster Regulations

1. The Interstate Shellfish Sanitation Conference (ISSC) now requires states to develop and implement a V. vulnificus Risk Management Plan (ISSC 2002).

2. The collective goal of these risk management plans is to reduce rates of V. vulnificus illness by 40 percent for 2005–2006, and 60 percent for 2007–2008.

3. While the Food and Drug Administration (FDA) supported this plan, the ISSC has not yet adopted it. Hence, there appears to be some uncertainty about what would happen after 2008 if the above goals are not reached.

4. The industry’s current capability to treat post-harvest oysters would be woefully inadequate if the state mandated treatment for its total oyster harvest, which averages approximately 200 million pounds of oysters and 12 million pounds of oyster meat annually (Supan 2004).

5. If the above goals are not achieved, additional measures would have to be implemented (U.S. GAO 2001). These measures would include, among others, “requiring that during the months of May through September; when V. vulnificus levels are known to be highest: 1) all oysters are subjected to post-harvest treatment to reduce V. vulnificus bacteria to a nondetectable level, and 2) all oysters are to be labeled for shucking by a certified dealer; or 3) shellfish growing areas are to be closed for the purpose of harvesting oysters intended for the raw market.”

This picture shows fishermen depurating oysters offshore in clean salty water from inshore waters. Regulations may require oysters to be treated. Two hundred million pounds of oysters are harvested annually in Louisiana. Offshore platforms could provide suitable equipment and facilities to depurate oysters at industrial levels.

“The oyster industry is approaching a significant crossroad in the next three years.”

– Dr. John Supan, 2004 Coordinator of Gulf Oyster Industry Initiative Program
Other methods to treat oysters of *V. vulnificus* kill the oyster and compromise the taste. Depuration keeps fresh oysters alive and improves the taste.

**Role of Offshore Platforms in Oyster Depuration**

If the FDA enforces *V. vulnificus* regulations, offshore platforms could play a critical role in producing a desirable oyster that meets these proposed standards. New federal regulations may require oysters to be treated. Two hundred million pounds of oysters are harvested annually in Louisiana. The industrial cranes and generators on offshore platforms could provide suitable equipment and facilities to depurate oysters at a level to support large-scale commercial production.

Moreover, many feel that oysters taste better after they have been placed in clean and cool salty water. The alternatives to oyster relaying offshore to meet the proposed standards include: 1) hydrostatic pressure, 2) a mild heat treatment known as cool pasteurization, and 3) cryogenic individual quick freezing; 4) exposure to gamma radiation (Diagne and Kiethly 2004). The first three options unfortunately compromise the taste of the oysters. Offshore platforms could supply the industrial equipment required to handle the massive weight of whole oysters, which yield to about 6 pounds of meat for every 100 pounds of shell (Diagne and Kiethly 2004).

**Barriers to Implementation**

A number of barriers currently exist that inhibit the implementation of potential oyster depuration in the offshore Gulf of Mexico. These include:

- The need for FDA approval of oyster depuration at retired oil and gas platforms, and
- The need for economic incentives to implement such activities, unless the ISSC adopts more protective measures.

**Vision for the Future**

The relatively rapid economic turnover of relaying equipment allows quick returns on capital investments and provides a more immediate cash flow for oyster depuration when compared to other forms of fish farming. Oyster depuration could be one of a suite of mariculture applications practiced simultaneously at offshore platforms. Offshore platforms could provide ideal staging areas for offshore oyster relaying a relatively simple and cost-effective mariculture operation (Supan 2004).

“Oyster Depuration” on offshore platforms purges harmful bacteria from coastal oysters by submerging in clean offshore water. Exposure beneath the thermocline of colder Gulf of Mexico waters (>50 ft depth) that are naturally free of *V. vulnificus* allows the oysters to purge themselves free of the bacteria over a 16-day period.
Recreational Fishing and Diving

Oil and gas platforms are a favored destination of Louisiana sport fishermen. Approximately 70 percent of the offshore fishing trips target the structures in the pursuit of fish (Stanley and Wilson 1989). The platforms are also picturesque diving spots. As mentioned above, almost all these structures are scheduled to be removed within the next 15 years, and this has already caused some concern among recreational fishing organizations in Louisiana. Sporting clubs and conservation efforts are interested in preserving these artificial reef habitats and promoting sustainable fishing practices. Retired platforms could potentially be converted into fishing and diving hotels (Reggio 1989). Large vessels capable of accommodating 100 fishermen could anchor near dozens of some of the largest artificial reefs in the world.

Current State of Artificial Reef Use for Recreational Fisheries

Artificial reef programs have attracted large investments and produced considerable economic contributions in Florida’s tourist fishing industry. In a survey of southeast Florida citizens (Johns et al. 2001), residents responded that they are willing to invest $26.63 million/yr to install and preserve artificial reefs. Their artificial reef program has created a $2.4 billion annual economic impact (Johns et al. 2001). Three cost-benefit studies from Gulf States on the economic benefits of artificial reefs indicate significant fiscal impacts from artificial reef programs.

Role of Offshore Platforms

Artificial reef programs for recreational fishermen and divers in many coastal states and around the world invest significant resources to build and install artificial reefs. The costs average about $140/m³ to build and install such reefs using reef balls, grouper ghettos, and sophisticated Japanese artificial reefs. Considering all Gulf platforms in waters >50 feet, the collective volume is 94,450,807 m³ (July 2004). Using these rates as a guide, the collective value of these platforms is $13.2 billion (Appendix A). Retired platforms clearly represent a valuable resource in the Gulf of Mexico, irrespective of their value as petroleum producers.

Barriers to Implementation

In addition to the numerous regulatory issues creating an obstacle to the use of platforms for mariculture mentioned above, on the whole, there is no immediate incentive for recreational fishermen to encourage the retention of the platforms. There are still 3,800 platforms in place and generally open access to them. The loss of platforms has not yet inspired a significant response from the recreational fishing sector, although some fishermen are beginning to notice platform removals and becoming strong advocates of their retention (McNemar 2003). Unfortunately, most inshore platforms are scheduled to be removed over the next 10–15 years.

Vision for the Future

A standing platform, with 20 or 30 large artificial reefs placed around it, would create an exceptional fishing spot. The standing platform could serve as a rendezvous for charter boats, recreational divers, and fishermen; and it could be accessed by helicopter, decreasing lost time in ship transit for passengers. Sport fishing and diving would be more cost-effective and comfortable. Recreational park facilities could provide live bait, fuel, ice, and operational gear to the charter boats and clients. The standing platform at a recreational park can also provide lodging to any recreational enthusiast who might be suffering from seasickness.

Economic Analysis of Artificial Reefs

<table>
<thead>
<tr>
<th>Area</th>
<th>Annual Economic Impact</th>
<th>Jobs</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast Florida</td>
<td>$2.4 billion</td>
<td>26,800</td>
<td>Johns et al., 2001</td>
</tr>
<tr>
<td>Northwest Florida</td>
<td>$415 million</td>
<td>8,100</td>
<td>Bell et al., 1998</td>
</tr>
<tr>
<td>Mississippi</td>
<td>$78 million</td>
<td>No data</td>
<td>Southwick et al., 1998</td>
</tr>
</tbody>
</table>
Ornamental Fish Culture

Attractive Caribbean fish inhabit the upper 90 feet of the blue water platforms. There are about 25 species of obligatory reef and cryptic species (p.v. Walker 2004; Rademaker and Render 2003), many of which are desirable aquarium fish. They are usually wide-bodied “poster-colored” demersal fish that reside on the platforms for the duration of their lives. These species are often sold in the U.S. aquarium trade market.

Current State of Fishery

The U.S. Commission on the Ocean (2004) noted that the U.S. is the world’s largest importer of ornamental coral reef resources and suggests that we have a responsibility to eliminate destructive harvesting practices of fish and other reef organisms. These “resources are destroyed by methods that destroy reefs and overexploit ornamental species.”

- The collection of marine tropical fishes and invertebrates for the ornamental fish industry has caused extensive damage to coral reef environments throughout Southeast Asia. Especially destructive is cyanide fishing, an illegal but extensively used fish collecting method in this region (Mackey and Chau 2001).
- Some estimates place the percentage of fish cultured in the ornamental fish market is ~10 percent, but it is generally accepted within the industry that the actual figure is considerably lower — somewhere between 2–5 percent (Mackey and Chau 2001).

Water clarity and temperature are important factors in cultivating ornamental fish. Suitable areas for raising ornamental fish are in the deeper waters offshore of Louisiana >200 ft.
Barriers to Implementation

There are no known fishery regulation barriers for ornamental fish. They are not currently managed by the Gulf of Mexico Fisheries Management Council (Gulf Council). Ornamental fish are not included in the Reef Fish Fisheries Management Plan for the Gulf of Mexico. The barriers to implementation that exist in this area no different than those germane to all ventures seeking to use platforms after their productive life in minerals production.

Role of Offshore Platforms

Reef dependent fish can be found from larval stages to adult stages (Hernandez et al. 2003) They feed, mate, nest, and spawn at platforms. All the necessities for survival are present at the platform. The offshore location provides a clean water source, and the platform offers a number of advantages to the mariculturist:

- Large larval and food supply are available naturally at the platforms;
- Large numbers of adult fish; and
- Large numbers of juvenile ornamental fish. These naturally occurring fish could be harvested and separated in tanks and raised to marketable size on the platform.

Potential Culture Species

Ornamental fish include a variety of angelfish such as the rock beauty, queen angelfish, French angelfish, blue angelfish, and townsend angelfish. Other species include damselfish, blue tang, creole fish, black durgon, and many other varieties. Videos taken by A. Walker show about 25 species of obligate reef fish, many of which are desirable in the aquarium trade.

Vision for the Future

The U.S. aquarium trade is an economically significant industry and there is tremendous potential for environmentally friendly sustainable sources of mariculture products. Raising ornamental fish could occur while cultivating corals, growing fish in pens, or at platform sea farms.
Culture of Coral, Sponge, and Medically Valuable Organisms

Platforms could potentially serve as excellent facilities to culture some rare, commercially valuable, deep-water invertebrates, such as deep-water sponges currently being used for producing powerful anti-cancer compounds (discodermalide; Gunasekera et al. 2002; Paul et al. 2002; Lin et al. 2004). Large plates could be seeded with coral larvae in the laboratory, and the spat could be reared to a point where they reach a size-refuge (Sammarco 1982), carrying a higher probability of survivorship to the adult stage (Heyward et al. 2002). They could then be transported offshore and attached on the platform (Sammarco et al., work in progress) at the appropriate depth for optimum growth for a period of up to 2–3 yrs.

Secondly, a large number of reef invertebrates such as sponges, bryozoans, gorgonians (sea fans), soft corals, etc. are known to live on offshore platforms (Gallaway & Lewbel 1981; Driessen 1989; Bright et al. 1991; Adams 1996; Boland 2002). The larvae of these organisms are carried by currents from their natal reefs around the Gulf of Mexico until they find suitable substrate upon which to settle (Lugo-Fernandez 1998; Sanvicente-Anorva et al. 2000; Lugo-Fernandez et al. 2001; Pederson and Peterson 2002). Many of these organisms are the same as those raised and sold commercially world wide in the ornamental aquarium trade (Ogawa and Brown 2001). Coral and sponge culture could simultaneously include both raising target organisms of specific value to commerce or research, and harvesting wild organisms occurring naturally on the platform legs.

Current State of Coral Reefs on a Global Scale

Coral reefs, and particularly coral populations themselves around the world are suffering high levels of mortality due to over-fishing, under-grazing, nutrient enrichment, deforestation and resultant runoff, pollution, increased sea surface temperatures, which induce mass coral bleaching, chemical pollution, physical disturbance, disease — both bacterial and fungal (Shinn 2003; Sammarco 1996; Wilkinson 1999; Gardner et al. 2003; Whittingham et al. 2003; McClanahan et al. in press). The federal protection of corals from harvest (see Sammarco 2003) combined with the international agreements not to trade them (Harriot 2003) also restricts their supply to scientists to conduct research on many of the causes of these ill effects and investigate possible mitigation techniques. The mariculture of corals would help to meet the demand for scientific research in the U.S. and elsewhere. This would also help to supply a need for corals to be introduced on damaged reefs during reef restoration activities on U.S. coral reefs, particularly in the Florida Keys (Sammarco 1996; Becker and Mueller 1999; Sammarco et al. 1999; Zobrist 1999).

The habitat range of coral on the platforms is believed to be limited to blue water; however, recent investigations reveal that coral is found in more turbid waters closer to shore.
**Role of Offshore Platforms**

The purpose of culturing marine invertebrates such as those on platforms would be three-fold. Firstly, organisms such as these are in great demand within the ornamental aquarium trade. Many, such as corals and soft corals, are protected from harvest or seizure by federal legislation. Secondly, they are protected from international trade by treaty. This is due to the excessive harvesting that has occurred in past years, decimating populations in certain tropical countries possessing coral reefs (Bruckner 2001; Daw et al. 2001; Simpson 2001; Tissot and Hallacher 2003). Mariculture of these organisms would provide a domestic supply for them, obviating the need for importation of Indo-Pacific soft corals and the like. This would serve an additional function in that there is growing concern about the accidental or purposeful release of these Indo-Pacific ornamental species into coastal waters (Gulko 2001; Semmens et al. 2004), with the possible impact of introducing yet more harmful species introductions (Minchin 1999; Englund and Baumgartner 2000; Shiganova 2002). Thirdly, the mariculture of such local organisms would also initiate a new industry for the northern Gulf of Mexico, creating a new source of employment and revenue in the region and the nation. The demand for the organisms already exists; at this point, however, most of the supply is coming from overseas and represents lost revenue to the U.S. (Sammarco 2003).

**Potential Culture Species**

In recent studies, it has been determined that scleractinian corals are expanding their geographic range within the northern Gulf of Mexico (Sammarco et al. 2003). In addition, from an ongoing study, it is also known that ahermatypic corals may be found extensively on platforms within 30 km of the shoreline in the far-western Gulf and within 120 km of the coast in the central-western Gulf (Sammarco et al., submitted). Platforms at the edge of the continental shelf in the northern Gulf of Mexico plus those just off the edge of the shelf are now known to be able to support coral populations. We know that the biogeographic range of corals in the Gulf of Mexico for both hermatypic (reef-building) and ahermatypic (non-reef-building) corals extends as far west as the Matagorda Island and Brazos, South Addition regions, as far north as the inner West Cameron region, and as far south as 210 kms offshore near the Flower Garden Banks region (Sammarco 2003). The central and eastern regions of the northern Gulf of Mexico are scheduled to be surveyed soon to determine the limits of this group in this region.
Vision for Future

The ocean is Earth’s last great untapped reserve. Many reef organisms possess natural chemical compounds which are unique to a given species (Faulkner 2000). These are called complementary or secondary compounds (Sammarco and Coll 1997). It is from these types of compounds that many valuable pharmaceuticals are derived (Shu 1998; Duckworth 2001; Dey et al. 2002; Haefner 2003). Marine coral, sponges, mollusks, algae, and bacteria may possess bioactive compounds that can make a significant contribution to the health and nutritional industries (Pomponi 1999). Simple and abundant marine algae, let alone a host of other organisms which occur on the platforms, represent potential sources of pharmaceuticals, agricultural chemicals, food, industrial chemical feedstocks, and other useful products.

Some of the organisms that produce bio-active compounds, such as certain sponges, occur in deep water, are unreachable by SCUBA and occur only rarely in their natural environment (Duckworth 2001). They require highly expensive equipment — such as manned submersibles associated with large tender ships. Some of the valuable compounds isolated from these species, which have been shown to be highly effective in the treatment of certain types of cancer, occur in very low concentrations within their tissues (S. Pomponi, pers. comm.). In addition, they are so large and complex that it would be prohibitively expensive to synthesize and manufacture them, or even make functional derivatives in the laboratory (closely related compounds that function in the same way as the original, natural compound, but are patentable). Because of this, even the testing of these compounds for bioactivity and potential biomedical use requires quantities of these organisms which are extremely difficult and expensive to obtain (Duckworth 2001). Nonetheless, they are required in order to extract appropriate amounts and this is causing a marked decline in some source populations.

Offshore platforms offer a unique mechanism by which to culture organisms such as sponges, and could obviate the need for expensive deepwater harvesting. Sponges in general are quite easy to grow in their natural environment and could easily be cultured at the required depths on these platforms. All of these activities would produce revenue in addition to that derived from fish mariculture. In addition, the activities may be conducted in parallel without jeopardizing other mariculture activities on the same platform.
Sea Farms

The “sea farm” plan is a plan to incorporate the scores of platforms scheduled to be retired (150–200/year) into a large mariculture production system to raise a diverse range of organisms. The decommissioned structures could be submerged as artificial reefs or left standing to provide a number of services. The scene below depicts the utilization of standing platforms for fish hatcheries and nutrition. They can be used for power, maintenance and supplies, fish unloading and transport to shore, and invertebrate culture. Crab, lobster, scallops, coral, sponge, and other cryptic and attaching invertebrates could be raised on the submerged structures at the sea farms. Oyster relaying, ornamental fish culture, and net-pens are other mariculture options at sea farms.

Potential Culture Species

The location of the system will determine what species are suitable to culture. A sensible sea farming strategy is to diversify the number of culture species and limit the harvest to sustainable levels. Focusing on raising a single species may stress the local ecosystem. If pressure on a particular species becomes too great, stocking and feeding fish at the sea farm may supplement the exploited stocks. Japan leads the world in sea farming innovation, and the Japanese are already practicing all the mariculture technologies discussed in this text and culturing dozens of species (Grove 1994; Matsuda 1998).

Current State

In Japan, sea farming is commonly practiced. They have embraced sea farming in an effort to transform their commercial fishing fleet from a predatory fishery into a culture fishery (Grove et al. 1994). In the U.S., Mote Marine laboratory is currently involved in a marine enhancement program that utilizes artificial reefs with the stocking of red snapper (Leber et al. 2002). Hatchery-reared snapper are released at the artificial reef sites. The release sites are then revisited and examined three months later to determine the fidelity of the red snapper to the artificial reefs (Ziemann et al. 2004). The research is still in the experimental stage.
The U.S. has quite a few stock enhancement programs and most coastal states have an artificial reef program; however, outside of the experimental project in Florida, there are no sea farming operations that combine these technologies. The largest U.S. stock enhancement project is Alaska’s salmon stock-enhancement program which receives $156M/yr in governmental funding (McIlwain 2003) and which reportedly produced $270M in commercial landings of salmon in 2001 (National Marine Fisheries Service, 2002). In the U.S., cooperative stock enhancement projects between the public and private sectors are pioneering practices for red drum (in Florida, South Carolina, and Texas); Pacific threadfin, mullet, and snapper (in Hawaii); red snapper (Alabama, Florida, and Mississippi); white seabass (California); summer flounder (North Carolina); cod (Maine); lingcod (Washington); snook (Florida); and winter flounder (New Hampshire). These initiatives, however, are mostly in the research phase (National Marine Fisheries Service, 2002).

**Barriers to Implementation**

Sea farming carries regulatory concerns that are beyond the scope of this report. The question of ownership fish in the water column is of keen concern to fishery managers. Harvest quotas are also a constant source of contention in the fishing community. The issue of “ownership” comes to the forefront, because wild fish can easily swim into a culture area and culture fish can swim out.

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**Potential Environmental Concerns Associated with Large Scale Sea Farm Operations**

- Fish feed waste
- Escapement of fish and genetic impact on wild populations

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The Japanese are world leaders in sea farming technology and they are striving to transform their fishery from a “capture fishery” to a “culture fishery” (Grove 1994).
Role of the Platforms

Platform jackets are 10 times larger and stronger than the best Japanese artificial reefs. The platforms are durable and could easily be modified in numerous ways to accommodate many different mariculture applications. Reggio (1989) reported that, if left as is, the structures should last 300 years as artificial reefs on the ocean floor. They could remain standing indefinitely if cathodic protection and structural integrity were maintained. However, they would have to be repaired after hurricanes (ChevronTexaco, pers. comm.)

Vision for the Future

The sea farm could create a foundation upon which a multitude of different fishery management operations could flourish. The commodities that are commercially viable today may be insignificant to the discoveries that will be found in the future. A great deal of research and planning is needed to fully assess the implementation of a platform sea farm. They will be developed gradually over the years as decommissioned structures become available in the area.

Endangered species, coral and sponge and protected fish and crustaceans colonize the platform’s submerged structure.

Platforms produce some of the most prolific ecosystems, by area, on the planet. Sea farming systems could transform our fishing techniques from predatory methods to sustainable methods of harvest.
Environmental Stewardship

Environmental and Ecological Issues

The following is a list of general environmental and ecological concerns associated with mariculture.

- **Fish feed and fecal waste.** The decomposition of feed and organic wastes, fish respiration, and nitrification of metabolic wastes can lower dissolved oxygen levels in the water column in and down current of the net-pens. Dissolved oxygen and organic enrichment are interrelated in that organic enrichment fuels bacterial decomposition and results in oxygen depletion. The decay of solid waste may also result in alterations in the benthic community due to burial and chemical changes affected within the sediments.

- **Escapement of fish and genetic integrity.** The principal problems that have developed are: 1) replacement of indigenous species by the introduction or escapement of non-indigenous species into the wild (Blankenship and Leber 1995; Stickney 2002; Leber 2001 and Blaylock et al. 2000); and 2) the threat of altered natural gene pools from the introduction or escapement of hatchery-produced fishes with limited genetic diversity into the wild (NRC 2002; Blankenship and Leber 1995; Trinigali and Leber 1999; Traniguchi 2004).

- **Use of native indigenous species.** It is recommended to culture only indigenous species. A sound genetic protocol of indigenous species addresses many of the genetic integrity concerns with escapement and stock enhancement (Leber 2002).

- **Fish disease.** Introduction of diseases from hatchery-produced fish to wild fish can occur. Naturally occurring diseases, toxic alga blooms, stress from low oxygen, cold stress, nipping, or degraded feeds can all potentially cause mortality of fish reared in cages.

- **Use of wild caught fish to feed culture fish.** Harvesting populations of ground fish or menhaden to feed culture fish may add fishing pressure on wild fish. Louisiana shelf is home to the Mississippi “fertile crescent” where 90 percent of the fisheries in the Gulf of Mexico (GLOBEC 2001) are located, including large populations of ground fish and menhaden.

Platforms provide offshore habitat for marine turtles. Their forage and prey organisms are readily available all over the platforms.
- Effects of mariculture on communities associated with platforms. The factors of concern include discharges from large net-pen operations that could exert environmental stress on the fish and invertebrates already resident on the platform.
- Operational waste. These types of wastes fall into two categories — routine discharges of sanitary waters, and potential spills of materials such as fuels, paints, and anti-fouling compounds, etc.

### Mariculture Applications

<table>
<thead>
<tr>
<th>Mariculture System</th>
<th>Potential Problems</th>
<th>State of Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net-pen culture</td>
<td>TSS, NH₃, BOD, therapeutics, chemical agents, genetic integrity of wild stocks,</td>
<td>Disease and pollution problems decrease with increased depth, current, and distance from shore</td>
</tr>
<tr>
<td></td>
<td>operational waste, and site selection</td>
<td></td>
</tr>
<tr>
<td>Ornamental fish</td>
<td>By-catch</td>
<td>Offshore culture is non-existent, all aquaculture has occurred inshore</td>
</tr>
<tr>
<td>Coral and sponge</td>
<td>Species competition</td>
<td>Widely practiced in Florida</td>
</tr>
<tr>
<td>Oyster relaying</td>
<td>TSS, fecal, and site selection</td>
<td>The relaying or depuration process is approved by FDA, however, relaying to offshore platforms will probably require FDA approval</td>
</tr>
<tr>
<td>Sea farm</td>
<td>TSS, genetic integrity of wild fish, operational waste, site selection</td>
<td>Commonly practiced in Japan but virtually unknown in the U.S.</td>
</tr>
</tbody>
</table>

TSS=total suspended solids  
NH₃=ammonia  
BOD=biological oxygen demand

What to Do About Environmental Concerns

A number of relatively straightforward actions could be pursued to help alleviate or minimize many of these environmental concerns. These include:
- Culture only native fish;
- Establish Best Management Practices (BMPs) and safety and environmental protocols for mariculture operations; and
- Move mariculture activities to sites offshore to deep water, swift currents, and far from land, to minimize impacts to environments nearer to shore.

Environmental Benefits Associated with Leaving Offshore Structures in Place

Leaving offshore platforms and oil and gas infrastructure in place, rather than removing these platforms within one year after the cessation of production, could result in a number of environmental benefits, both locally and globally.
- These platforms and their associated pipeline infrastructure could provide the foundation for facilitating the permanent sequestration of as much as 22 gigatons of greenhouse gases into depleted oil and gas formations, with additional potential capacity in deep saline aquifers (ARI 2005).
- Existing platforms and infrastructure could provide low-cost facilities to support a number of non-CO₂ producing energy sources, such as wind, current, ocean thermal, wave, bio-fuels, etc.
- The mariculture of corals would assist in the restoration of damaged natural coral habitats. It would also help to protect coral reefs elsewhere in the world from exploitation and destruction by reducing the demand for importation of ornamental organisms for the aquarium trade, simultaneously reducing import demand and bolstering domestic revenue sources.
These structures could help support the development of offshore LNG re-gasification facilities, remote from coastal communities in area of reduced threat from accidents or security risks.

In the future, it is possible that these platforms would be made available again to recover stranded offshore oil resources and increase domestic petroleum supplies, reducing the need for petroleum imports.

Many of these platforms can provide facilities for a wide range of future viable industries, each of which could carry substantial environmental benefits with them, both locally and globally.

In this light, the current federal requirement that offshore platforms be removed within one year of the cessation of production requires a close look at re-drafting and amendment.

Need for Action

Oil and gas platforms represent a source of hard substratum in the euphotic zone in shallow water in the northern Gulf of Mexico, which otherwise would be extremely limited. At present, 150–200 platforms are being removed each year. These artificial reefs provide habitat for endangered species such as sea turtles, coral, and federally protected fish and invertebrates. Many of these platforms can provide facilities for a wide range of future viable industries, each of which could carry substantial environmental benefits with them, both locally and globally.

In this light, the current federal requirement that offshore platforms be removed within one year of the cessation of production requires a close look at re-drafting and amendment.

The Hawksbill Turtle has been on the endangered species list since 1970.

This Sperm Whale was filmed next to a platform. The whale was sighted swimming around a deep-water floating structure in 1,000 m of water among a large school of squid (Walker 2004).
Socio-Economic Implications

The domestic oil and gas industry currently spends on the order of $300 to $400 million per year removing offshore platforms (NRC 1996). It will eventually spend over $10 billion to remove and haul to shore all platforms currently in the Gulf of Mexico.

The Role of Platforms in Supply Future Domestic Energy Requirements

With the advent of new drilling technology, leaving the infrastructure in place for mariculture could provide future opportunities to recover oil and natural gas resources that are currently stranded, as well as natural gas reserves found at depths greater than 15,000 feet below the sea surface (Minerals Management Service, 2003). Leaving the existing 26,000 miles of pipeline in place could provide a conduit to service potential future LNG re-gasification facilities and CO₂ sequestration operations, while simultaneously reducing the concentration of atmospheric gases attributed to global warming. In addition, offshore facilities could provide some of the infrastructure to support future offshore energy production from wind and OTEC power generating systems.

The potential economic benefits from maintaining this infrastructure could be substantial:

- Assuming that the 3.6 billion barrels of stranded oil resources are developed over a 40-year time frame, by 2025 this would amount to:
  - Incremental production of 200,000 to 250,000 barrels per day;
  - More than 8,000 jobs retained by the Louisiana oil and gas industry;
  - Increased economic activity amounting to $500 million per year to Louisiana (ARI 2005); and
  - Increased state and federal revenues of more than $250 million per year, with greater than 90 percent, under current fiscal arrangements, going to the federal government.

- A recent study by the Louisiana State University Center for Energy Studies showed a potential $2.2 billion impact associated with the construction of LNG facilities in Louisiana and the Gulf of Mexico, with nearly 14,000 jobs created from the construction of these facilities, and 1,600 associated with their operation. Annual economic benefits could be on the order of $220 million per year (Dismukes et al. 2004)

- Benefits could also be derived from developing stranded and deep undiscovered natural gas resources, as well as from the development of offshore wind and OTEC power generation systems.
Potential Economic Benefits from Mariculture Operations

Mariculture ventures on platforms will have to comply with the same state and federal regulations and structural codes that oil and gas operators currently maintain, not to mention navigational aids required by the U.S. Coast Guard. Several expenses will be germane to any venture utilizing retired offshore platforms. These include expenses associated with a platform removal bond, navigational aids, maintenance, liability insurance, and cathodic protection. Unfortunately, the high cost of the platform removal bond could well prohibit the economic success of many types of mariculture applications. Cost-sharing of these expenses with companies sponsoring activities other than mariculture could help to offset these expenses and make mariculture operations economically viable.

The recent publication “Farming the Deep Blue” (Ryan 2004) described many successful international open ocean mariculture ventures; at present, however, there are very few of these operations in U.S. waters. A few offshore mariculture sites are currently operating in the state waters of Hawaii, Puerto Rico, and New Hampshire (Bridger and Reid 2001). Mariculture on platforms in the Gulf of Mexico has been explored in Texas offshore waters. Several cage systems have been tested there, but cage maintenance and production cost made it difficult to achieve project goals (Kaiser 2003). In one case, a commercial venture (SeaFish, Inc.) lost its right to use the platform because it was brought back into production again (Kaiser 2003).

Net-Pens

In the U.S., limited economic literature exists for mariculture operations in the open ocean environment. One particular study of interest (Waldemar Nelson Int. 1998; NOAA-Sea Grant College 2001), reported that the use of offshore production platforms for net-pen culture of red drum would be technically feasible. In an economic analysis of raising fish in net-pens, the construction of a fish hatchery was essential to project viability. An evaluation of start-up, capital, and operating costs revealed that an initial investment of $12 million would be required to execute the project as outlined in the feasibility study. The base-case evaluation estimated employing over 20 individuals and a net cash flow of $17 million by year seven.

Japanese reefs are large and designed to last 30 years. Platforms are 10 times larger and stronger and we spend about as much money removing platform as the Japanese spend installing artificial reefs.

Ornamental Fish Culture

The opportunity for environmentally friendly mariculture products in the U.S. aquarium trade is substantial. The U.S. imported $45 million (wholesale) in 1998 in live ornamental fish (Adams et al. 2001). More research is needed, however, to determine the economic feasibility of ornamental fish culture.

Ornamental Coral Culture

Hundreds of coral colonies are now known to exist on many offshore platforms (Sammarco et al. 2004). Some of these can be harvested directly. In addition, by using an onshore breeding facility, thousands of small colonies can be cultured on settlement plates deployed on the platform and harvested annually or semi-annually on a rotating basis (Sammarco, work in progress). The proceeds from this could range from $120,000 to $1.2 million annually (Porter 2004).
Mariculture production will almost certainly be more evolutionary than revolutionary in nature. That is, the first such operations will be experimental in nature and will require an environmental adjustment period (Gramling 2004).

Net-pen mariculture production of cobia, redfish, and mutton snapper would have little effect on the commercial fishermen. Redfish are illegal to possess in the Gulf Exclusive Economic Zone (EEZ) and cannot be harvested with gill nets in state waters. Cobia regulations limit the harvest to two fish per trip, and the Louisiana average annual landing (1995–1997) of cobia is 70,371 pounds (Horst 1998). Mutton snapper are caught at offshore platforms but are not harvested and sold in significant numbers in Louisiana (Horst 1998). At this time, commercial fishermen do not harvest ornamental coral, sponge, and fish in Louisiana; thus, the culture of these organisms would not compete with traditional fisheries. Oyster depuration is a post-harvest treatment and does not present any threat to traditional oyster fisheries. Sea farming will rely on fishermen to harvest the fish, corals, and sponges, and manage the oysters and net-pens. Sea farming will present job opportunities for commercial fishermen.

<table>
<thead>
<tr>
<th>Area</th>
<th>Annual Economic Impact</th>
<th>Jobs</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast Florida</td>
<td>$2.4 billion</td>
<td>26,800</td>
<td>Johns at al., 2001</td>
</tr>
<tr>
<td>Northwest Florida</td>
<td>$415 million</td>
<td>8,100</td>
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</tr>
<tr>
<td>Mississippi</td>
<td>$78 million</td>
<td>No data</td>
<td>Southwick et al., 1998</td>
</tr>
</tbody>
</table>

Sea Farming

The Japanese spend approximately $140/m³ to build and install artificial reefs. Platforms in the Gulf of Mexico are >10 times stronger and larger than these Japanese artificial reefs. Considering all the platforms in waters >60 ft depth, their collective value as artificial reefs could equal nearly $14 billion (see Appendix). Since it is more cost-effective to leave the structures offshore, a savings on removal cost would accrue if operators were able to re-deploy them as artificial reefs. The sea farming production system discussed here would be the first of its kind in the Gulf of Mexico; therefore, any information regarding current investment and production represents an estimate only. Three studies performed in Gulf States on the potential economic benefits of artificial reefs (see table), however, indicate significant economic impacts from artificial reef programs.
Regulatory Assessment

Obtaining permits to utilize a retired platform for net-pen mariculture will be a challenge. There are currently no legal mechanisms available at the state or federal level to transfer the use of a platform from oil and gas production operations to another application. A single federal jurisdiction over mariculture activities on offshore platforms has not been established.

Regulatory Changes Required to Use Platforms for Non-Petroleum Operations in Federal Waters

Currently, no legal structure currently exists at the state or the federal level to permit retired platforms for purposes other than producing petroleum. The Outer Continental Shelf Lands Act (OCSLA) regulations (30 CFR 250.112) mandate that the owner/operator of an offshore platform removes it and return the site to pre-production conditions within one year after production has ceased. It is important to note that, despite this, it is still currently possible to extend the removal date by submitting a “right of use of easement” to allow utilization of an offshore platform for mariculture purposes under 30 CFR 250.7. The National Fishing Enhancement Act (1985) Public Law 98.623, title II (1984) provides for the redeployment of retired platforms for artificial reefs. Artificial reef sites require a Corps of Engineers (COE) Section 10 permit to install obstructions in navigable waters.

Legal issues must be resolved to transfer ownership of an offshore structure from an oil and gas company to a mariculture venture. The OCSLA will have to be modified.

Regardless of what method is used to extend the life of an offshore platform for mariculture use, MMS will still require the operator to remove the platform if the company dissolves. The high cost of the surety bond could easily prohibit the economic success of many types of mariculture applications. If a mariculture venture fails, a federal indemnification program is needed to assure that the mariculture facilities are redeployed into artificial reefs. The program would alleviate the need to remove the structure and therefore, the platform removal bond.

Former Louisiana U.S. Congressman David Vitter (now a U.S. Senator) introduced the Rigs to Reefs Act of 2003 (H.R. 2654), which proposed to authorize the use of decommissioned offshore production platforms for mariculture purposes in the Exclusive Economic Zone (EEZ). The proposed legislation would exempt oil and gas companies from platform removal requirements and offer tax credit incentives for using platforms for mariculture. Such legislation could be most helpful in providing the authority to move forward with the development of mariculture operations in the Gulf of Mexico.
**Recommended Actions**

To address the issues raised above, the following actions are recommended:

- Revise OCSLA platform removal requirements and adjust codes for alternative uses;
- Create OCSLA language to terminate leaseholder’s interest and liability;
- Create clear legal foundation for transfer of ownership;
- Create a federal trust fund to cover liability exposure for the participating oil and gas operators. In addition, limit the liability to further deter frivolous suits.
- Provide low interest loans to mariculture ventures and fishermen and provide general performance bonds to turn default mariculture platforms into artificial reefs and maintain navigational aids.

**Specific Regulatory Changes Recommended for Net-Pen Mariculture Operations in Federal Waters**

No specific federal legislation currently exists permitting offshore net-pen mariculture. The Magnuson Act, which authorizes the Gulf Council to manage federal fisheries in the Gulf of Mexico, was not originally drafted with mariculture in mind. The federal agencies directly involved in mariculture, however, have created procedures allowing a mariculture project to commence through the issuance of a one-year Exempted Fishing Permit (EFP).

**Sea Farms**

Sea farms will require the same permits as net-pen facilities. It is anticipated that there will be many management issues associated with the various types of mariculture that can co-occur on sea farms. For example, with respect to stocking and feeding fish, how would cultured fish be distinguished from the wild stock? With no method to distinguish the organisms, ownership is impossible to demonstrate. What regulations and operational procedures would be needed for recreational and commercial harvesters at such a facility?

**Ornamental Fish and Invertebrates**

Ornamental fish are not regulated by the Gulf Council and can be harvested without permits. Coral and sponge can be raised and collected from artificial structures. National Oceanic and Atmospheric Administration (NOAA) Fisheries issues “Live Rock” permits for culturing from natural substrate in coastal and offshore waters. In fact, several live-rock ventures are currently operating in the federal waters offshore of Florida (Fisheries Management Plan [FMP] Coral).

**New Gulf Council Fisheries Management Plan for Mariculture**

New regulations for mariculture in the Gulf are currently being drafted by the Gulf Council in their FMP for Mariculture. This represents an important step forward in providing for mariculture in the Gulf of Mexico. The FMP is currently in revision and is anticipated to be submitted for approval in 2006.
New NOAA Fisheries Mariculture Legislation

NOAA is presently drafting a National Offshore Aquaculture Act to address many of the confounding regulatory and legal issues facing marine aquaculture in federal waters. If approved, the draft NOAA legislation would be a significant advancement in mariculture management. The current draft legislation addresses many profound regulatory obstacles and will help to streamline permitting. Moreover, the new regulations will exempt mariculture activities from the Magnuson Act. It is anticipated that in the 109th Congress, the Executive Branch will present this Act, providing the Department of Commerce with clear authority to regulate offshore aquaculture.

The Alabama-Mississippi Sea Grant Legal program suggested that one avenue that could provide for sustainable offshore aquaculture is the consolidation of aquaculture leases into a single area to be known as a Marine Aquaculture Zone (MAZ). Zoning has been a useful land-based tool in the U.S., setting aside particular areas for industry development. The creation of a MAZ requires that one federal agency be responsible for: the management of the zone; issuance of leases of the water column and seafloor in the zone; and issuance of a permit which would incorporate the concerns of other relevant federal and state agencies (Fletcher and Neyrey 2001).

<table>
<thead>
<tr>
<th>Mariculture Operation</th>
<th>Changes Required</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ornamental fish</td>
<td>None</td>
<td>No permit needed. Ornamental fish are not regulated in Gulf Council’s Reef Fish FMP.</td>
</tr>
<tr>
<td>Coral and sponge</td>
<td>None</td>
<td>NOAA Fisheries/Gulf Council already has satisfactory permitting system.</td>
</tr>
<tr>
<td>Oyster depuration</td>
<td>None</td>
<td>The depuration process is approved by the FDA, however, it is assumed that depuration at retired oil and gas platforms will need approval from FDA*.</td>
</tr>
</tbody>
</table>

*The National Shellfish Sanitation Program (NSSP) addresses this and other public health issues within the Interstate Shellfish Sanitation Conference (ISSC). The ISSC now requires states to develop and implement a Vibrio vulnificus Risk Management Plan. The collective goal of these risk management plans is to reduce rates of V. vulnificus illness by 40% for 2005-2006, and 60% for 2007-2008.

NOAA’s general council ruled that mariculture constituted fishing activities and is therefore subject to Gulf Council’s regulations that were designed for fishing vessels. If the venture involves raising regulated fish, the nature of mariculture will most likely breach a number of fishing regulations:

- possession of fish in excess of bag limits or trip limits;
- possession of fish below the legal size limits; and
- sale of regulated fish during closed season.

An exempted fishing permit (EFP) is required for mariculture ventures to exempt them from the Gulf Council’s regulations.
Current federal and state regulations require that offshore oil and gas platforms be removed within one year after cessation of production. About 150 to 200 platforms are scheduled to be removed annually for the next 20 years (MMS). The vast majority of these platforms on the Louisiana continental shelf will be gone in 10–15 years at this rate of removal. The oil and gas industry is spending $300–$400 million a year removing these platforms (NRC 1996) and will eventually spend over $10 billion for onshore dismantling and disposal.

In contrast, offshore platforms currently provide a foundation for one of the most prolific ecosystems, by area, on the planet. Stanley and Wilson (2000) reported that 10,000–30,000 adult fish reside in an area about half the size of a football field. Coral, sponges, endangered species, and "protected" fish and invertebrates colonize the platform’s submerged structure. Platforms create reef habitat that would otherwise not exist over tens of thousands of square miles of soft bottom on the northern continental shelf of the Gulf of Mexico.

Maintaining this existing offshore infrastructure for future economic applications could help preserve habitat that is critical to many organisms, as well as provide substantial opportunities in a variety of areas, including:

- Providing infrastructure for a wide variety of mariculture applications;
- Economizing and increasing domestic seafood production;
- Reducing exploitation of natural coral reefs internationally;
- Helping to facilitate the incremental recovery of additional crude oil and natural gas reserves in the future;
- Providing future facilities for LNG storage and offloading;
- Supporting drilling in the future of deep natural gas formations below existing oil and gas fields;
- Providing opportunities for the sequestration of greenhouse gases;
- Facilitating and hosting the development of wind, wave, current, ocean thermal, and other renewable energy sources.

In Japan, Norway, Spain, Germany, and Ireland, offshore platforms have already been installed for purposes other than petroleum production. These countries are utilizing offshore platforms to culture fish, generate carbon-free energy, and mitigate pollution. All the mariculture applications discussed in this report are already being practiced in Japan.
Moreover, the potential economic benefits from maintaining this infrastructure could be substantial:

- Assuming that the 3.6 billion barrels of stranded oil resources are developed over a 40-year time frame, by 2025 this would result in
  - An incremental production of 200,000 to 250,000 barrels per day;
  - More than 8,000 jobs retained by the Louisiana oil and gas industry;
  - Increased economic activity amounting to $500 million per year to Louisiana; and
  - Increased state and federal revenues of greater than $250 million per year, with more than 90 percent, under current fiscal arrangements, going to the federal government.

Little is known about the economic viability of mariculture on oil and gas platforms; however, the economic impact of artificial reefs programs in the Gulf States has been found to produce a considerable influence on the local economies:

<table>
<thead>
<tr>
<th>Area</th>
<th>Annual Economic Impact</th>
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<td>$78 million</td>
<td>No data</td>
<td>Southwick et al., 1998</td>
</tr>
</tbody>
</table>

The United States is spending billions of dollars removing oil and gas platforms while other countries are installing offshore platforms for purposes other than petroleum production. Collectively, we need to energize discussions at the local levels in the areas of stewardship and governance to help promote the rational utilization of these offshore platforms for future, viable applications. Moreover, a comprehensive framework for reviewing, and in some cases revamping, national ocean policies is required.

Accomplishing this will allow for the continued economic viability and growth of several industries — oil and gas production and fishing and seafood production — critically important to the State of Louisiana and to our nation.


Beaver C.R. 2002. Fishery productivity and trophodynamics of platform artificial reefs in the northwestern Gulf of Mexico. PhD dissertation, Dept. Oceanography, Texas A&M University at College Station, College Station, TX.


Louisiana Department of Natural Resources (LDNR). 2004. History and Recent Developments in Louisiana Wind Energy. Louisiana Department of Natural Resources, Technology Assessment Division, Baton Rouge, LA. (internal report).


Puerto Rico Sea Grant. 2004. Offshore cage culture: Environmental impact and perceptions by the local fishing community. Sea Grant Semi-Annual Progress Report, NOAA-NMFS-SK Award Number NA17FD2370, NOAA National Sea Grant (grant number NA16RG1611), University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico.


Cost to Build Artificial Reefs: Estimation of Volume of Oil and Gas Structures in Gulf of Mexico

The Gulf of Mexico platforms are magnitudes larger and more durable than Japanese designs. The size and the construction materials and installation expense affect the cost of deploying artificial reefs. They are sold in units of volume usually in units of cubic meters. In literature review, a range was found between $67/m³ - $320/m³ with $140/m³ (Table 1) the average cost. Platform jackets closely resemble some of the most expensive artificial reefs, however, the other designed artificial reefs tend to have a more complex structure and more surface area-decks have a tremendous amount of surface area. The construction materials of other designed artificial reefs consist of reinforced cement, plastic and cement, and steel (steel being the most expensive). The structural integrity of a platform is significantly stronger than other designed artificial reefs and should survive longer on the ocean floor — 30 years for Japanese artificial reefs (Grove 1994) and 300 years for platform jackets (Reggio 1989).

Description of Calculations to the Model

In order to calculate the volume and value of offshore oil and gas platforms in the Gulf, a model was developed to generate estimates based on MMS data. The number of platforms used in the model does not include 4-pile platforms. It does not include platforms in water depths of less than 50ft nor does it include caissons or well heads from any depths. The search was filtered to exclude any platforms with a removal date. The results include only major platforms. This search resulted in 3,942 major platforms in all water depths and was filtered 2,265 in water depths greater than 50ft. The source of information is gathered from the MMS Platform Master Database and Report MMS Aug 2004. (1) Oil and gas structures are made of two basic components: a jacket and a deck. The jacket supports the deck above water and it raises to about 10 ft. above sea level where it joins with the deck. So when a platform is in 50 ft of water it is really 60 ft in height and so 60 ft is used in the volume equation instead of 50 ft for a platform in 50 ft of water. (2) 55 platforms are in water depths between 500 ft–1,400 ft and instead of calculating each increment of 10, all the platforms used a factor of 500 ft for the height in the volume equation.

Table 1. Estimation of cost to build and install artificial reefs.

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost of reef $/m³</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reef Ball 2004</td>
<td>$320.00</td>
<td><a href="http://www.reefball.com/ofmas.htm">www.reefball.com/ofmas.htm</a></td>
</tr>
<tr>
<td>Grove 1989</td>
<td>$67.00</td>
<td>Japanese artificial reef</td>
</tr>
<tr>
<td>NAKANO Takafumi 2001</td>
<td>$133.00</td>
<td>Artificial Reef Project Kyoei Sangyo Ltd</td>
</tr>
<tr>
<td>Bell 1989</td>
<td>$110.00</td>
<td>USA reef installation</td>
</tr>
<tr>
<td>Nagahata 1991</td>
<td>$150.00</td>
<td>small reef 400m³</td>
</tr>
<tr>
<td>Nagahata 1991</td>
<td>$93.00</td>
<td>medium reef 50,000m³</td>
</tr>
<tr>
<td>Nagahata 1991</td>
<td>$108.67</td>
<td>large 150,000m³</td>
</tr>
<tr>
<td>AVE</td>
<td>$140.24</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Results from modeling volume of offshore platforms and cost to build and install equivalent volume.

<table>
<thead>
<tr>
<th>Water Depth (ft)</th>
<th>Vol. of one major platform jacket (m³)</th>
<th>Vol. of all major platform jackets in depth range (m³)</th>
<th>Estimated cost to build and install $/m³</th>
<th>Value of one major platform jacket @ estimated cost</th>
<th>Value of all major jackets in depth range</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>12,489</td>
<td>3,771,624</td>
<td>140</td>
<td>1,748,435</td>
<td>528,027,336</td>
</tr>
<tr>
<td>70</td>
<td>14,407</td>
<td>2,838,256</td>
<td>140</td>
<td>2,017,034</td>
<td>597,355,777</td>
</tr>
<tr>
<td>80</td>
<td>16,282</td>
<td>797,802</td>
<td>140</td>
<td>2,279,435</td>
<td>111,692,314</td>
</tr>
<tr>
<td>90</td>
<td>18,113</td>
<td>2,406,968</td>
<td>140</td>
<td>2,536,756</td>
<td>337,255,486</td>
</tr>
<tr>
<td>100</td>
<td>19,901</td>
<td>3,960,164</td>
<td>140</td>
<td>2,786,115</td>
<td>557,223,003</td>
</tr>
<tr>
<td>110</td>
<td>35,067</td>
<td>4,278,142</td>
<td>140</td>
<td>4,909,344</td>
<td>596,939,920</td>
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Total of major platforms 2,265 94,450,806.86 $13,223,112,961

Grand total $13,223,112,961
Calibration Data

Calibration data is provided by the Wood Group Production Services. The data matched up pretty well within 20% above and below the numbers predicted in the model. See data below:

**CALCULATION OF PLATFORM JACKET VOLUME**

**ASSUMPTIONS:**
- LEG SPACING: 45'
- LEG BATTER: 1 FOOT ON 8 FEET
- JACKET HEIGHT ABOVE MLW: 10'

**FOR 100' WATER DEPTH**
- AREA OF TOP OF JACKET: $45 \times 135' = 6075$ SQ. FT.
- AREA BOTTOM OF JACKET:
  \[ 110' \times 13.75 = 13.75 \times (45 + 13.75 + 13.75) = 11781.25 \text{ SQUARE FT.} \]
- AVERAGE AREA = $\frac{(6075 + 11781.25)}{2} = 8928.125$ =
- VOLUME = $8928.125 \times 110' = 982,093.75 \text{ CU. FT.}$
- VOLUME IN CUBIC METERS = $982,093.75 \times 0.02832 = 27,812.895$
  OR 27,813 CUBIC METERS

**SIMILAR CALCULATIONS FOR THE OTHER WATER DEPTHS REQUESTED RESULT IN THE FOLLOWING:**

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**Volume of Offshore Platforms**

![Volume of Offshore Platforms](image)

- 28
- 47
- 72
Produced by Eco-Rigs
A Louisiana Non-Profit Organization

For More Information, Please Contact:

Steve Kolian
stevekolian@hotmail.com
225-910-0304

Paul Sammarco
psammarco@lumcon.edu
985-851-2876

Please visit www.towersoflife.com/ecorigs for more information on the marine organisms inhabiting offshore oil and gas platforms in the Gulf of Mexico.