Final

OCEAN DISCHARGE CRITERIA EVALUATION

Ocean Era, Inc. - Velella Epsilon

Net Pen Aquaculture Facility

Outer Continental Shelf

Federal Waters of the Gulf of Mexico

NPDES Permit Number

FL0A00001

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U.S. Environmental Protection Agency

Region 4

Water Division

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List of Acronyms

BES	Baseline Environmental Survey
BMP	Best Management Practices
BOEM	Bureau of Ocean and Energy Management
CAAP	Concentrated Aquatic Animal Production
CFR	Code of Federal Regulations
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DEP	Department of Economic Opportunity
DWH	Deep Water Horizon
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed Conversion Ratio
FCMP	Florida Coastal Management Program
FDA	U.S. Food and Drug Administration
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FMP	Fishery Management Plan
FWC	Florida Fish and Wildlife Conservation Commission
GMFMC	Gulf of Mexico Fishery Management Council
HAB	Harmful Algal Blooms
HAPC	Habitat Area of Particular Concern
ITI	Infaunal Tropic Index
MAS	Multi-anchor Swivel
MMS	Minerals Management Service
MMPA	Marine Mammal Protection Act
NCCOS	National Ocean Service National Centers for Coastal Ocean Science
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
ODC	Ocean Discharge Criteria
ODMDS	Ocean Dredge Material Disposal Site
OTC	Oxytetracycline
PSMP	Protected Species Monitoring Plan
SAFMC	South Atlantic Fishery Management Council
SOD	Sediment Oxygen Demand
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
VE	Velella Epsilon
WQS	Water Quality Standards

1.0 Introduction

1.1 Proposed Agency Action

Ocean Era, Inc. (applicant) is proposing to operate a pilot-scale marine aquaculture facility (proposed project) in federal waters of the Gulf of Mexico (Gulf). Clean Water Act (CWA) Section 402 authorizes the Environmental Protection Agency (EPA) to issue National Pollutant Discharge Elimination System (NPDES) permits to regulate the discharge of pollutants into waters of the United States. The EPA action is the issuance of a NPDES permit that authorizes the discharge of pollutants from an aquatic animal production facility that is considered a point source into federal waters of the Gulf.

1.2 Evaluation Purpose

The purpose of this Ocean Discharge Criteria (ODC) Evaluation is to identify pertinent information relative to the ODC and address the EPA's regulations for preventing unreasonable degradation of the receiving waters for the discharges covered under this NPDES permit. CWA Sections 402 and 403 require that a NPDES permit for a discharge into the territorial seas (coast to 12 nautical miles, or farther offshore in the contiguous zone or the ocean), be issued in compliance with EPA's regulations for preventing unreasonable degradation of the receiving waters. Before issuing a NPDES permit, discharges must be evaluated against EPA's published criteria for a determination of unreasonable degradation. The NPDES implementing regulations at 40 CFR § 125.121(e) defines unreasonable degradation of the marine environment as the following:

1. Significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities
2. Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms, or
3. Loss of aesthetic, recreational, scientific or economic values, which is unreasonable in relation to the benefit derived from the discharge.

This ODC evaluation addresses the 10 factors for determining unreasonable degradation as required by 40 CFR § 125.122. It also assesses whether the information exists to make a "no unreasonable degradation" determination, including any recommended permit conditions that may be necessary to reach that conclusion. The following ten factors are specified at 40 CFR § 125.122 for determining unreasonable degradation:

1. The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged;
2. The potential transport of such pollutants by biological, physical or chemical processes;
3. The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act (ESA), or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;
4. The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism;

5. The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs;
6. The potential impacts on human health through direct and indirect pathways;
7. Existing or potential recreational and commercial fishing, including fin fishing and shell fishing;
8. Any applicable requirements of an approved Coastal Zone Management plan;
9. Such other factors relating to the effects of the discharge as may be appropriate; and
10. Marine water quality criteria developed pursuant to CWA Section 304(a)(1).

If, on the basis of all available information, the EPA determines that the discharge will not cause unreasonable degradation of the marine environment after application of any necessary conditions, an NPDES permit containing such conditions can be issued. If it is determined, on the basis of the available information, that the discharge will cause unreasonable degradation of the marine environment after application of all possible permit conditions, the EPA may not issue an NPDES permit which authorizes the discharge of pollutants. If the EPA has insufficient information to determine that there will be no unreasonable degradation of the marine environment, there shall be no discharge of pollutants into the marine environment unless the director of the EPA determines that:

1. Such discharge will not cause irreparable harm to the marine environment during the period in which monitoring is undertaken, and
2. There are no reasonable alternatives to the on-site disposal of these materials, and
3. The discharge will be in compliance with all permit conditions established pursuant to 40 CFR § 125.123(d).

1.3 ODC Evaluation Report Overview

The ODC Evaluation focuses on the sources, fate, and potential effects from discharges at a small-scale marine aquaculture facility on various groups of marine aquatic life. It also assesses whether the information exists to make a "no unreasonable degradation" determination, including any recommended permit conditions that may be necessary to reach that conclusion. Each section of the ODC Evaluation addresses one of the 10 factors used in making a determination about whether the discharge will cause unreasonable degradation as shown in Table 1.1.

Table 1.1 – Summary of the ODC Topics

Section	ODC Factor	Description
3	2	Physical and chemical oceanography relevant to the action area
4	1 and 10	Characteristics, composition, and quantities of materials that potentially will be discharged from the facility; transport and persistence of pollutants in the marine environment
5	3 and 4	Biological overview of the affected environment
6	7	Information on commercial and recreational fisheries in the receiving water environment
7	5 and 8	Florida Coastal Zone Management Plan (CZMP) and Special Aquatic Sites
8	10	Federal Water Quality Criteria and State Water Quality Standards Analysis
9	1, 2, and 6	Potential impacts on human health, and describes the toxicity and potential for bioaccumulation of contaminants
10	Summary	Evaluation of the ODC

2.0 Proposed Project Information

2.1 Proposed Project

The proposed project would allow the applicant to operate a pilot-scale marine aquaculture facility with up to 20,000 almaco jack (*Seriola rivoliana*) being reared in federal waters for a period of approximately 12 months (total deployment of the cage system is 18 months). Based on an estimated 85 percent survival rate, the operation is expected to yield approximately 17,000 fish. Final fish size is estimated to be approximately 4.4 lbs/fish, resulting in an estimated final maximum harvest weight of 80,000 lbs (or 74,800 lbs considering the anticipated survival rate). The fingerlings will be sourced from brood stock that are located at Mote Aquaculture Research Park (Sarasota, FL) and were caught in the Gulf near Madeira Beach, Florida. As such, only F1 progeny will be stocked into the proposed project.

One support vessel will be used throughout the life of the project. The boat will always be present at the facility except during certain storm events or times when resupplying is necessary. The support vessel would not be operated during any time that a small craft advisory is in effect for the proposed action area. The support vessel is expected to be a 70 foot (ft) long Pilothouse Trawler (20 ft beam and 5 ft draft) with a single 715 HP engine. The vessel will also carry a generator that is expected to operate approximately 12 hours per day. Following harvest, cultured fish would be landed in Florida and sold to federally-licensed dealers in accordance with state and federal laws. The exact type of harvest vessel is not known; however, it is expected to be a vessel already engaged in offshore fishing activities in the Gulf.

A single cage, that is offshore strength fully enclosed submersible fish pen will be deployed on an engineered multi-anchor swivel (MAS) mooring system. The engineered MAS will have up to three anchors for the mooring, with a swivel and bridle system. The cage material for the proposed project is constructed with rigid and durable materials (copper mesh net with a diameter of 4-millimeter (mm) wire and 40 mm x 40 mm mesh square). The mooring lines for the proposed project will be constructed of steel chain (50 mm thick) and thick rope (36 mm) that are attached to a floating cage which will rotate in the prevailing current direction; the floating cage position that is influenced by the ocean currents will maintain the mooring rope and chain under tension during most times of operation. The bridle line that connects from the swivel to the cage will be encased in a rigid pipe. Structural information showing the MAS and pen, along with the tethered supporting vessel, is provided in Appendix A. The anchoring system for the proposed project is being finalized by the applicant. While the drawings in Appendix A show concrete deadweight anchors, it is likely that the final design will utilize appropriately sized embedment anchors instead.

The cage design is flexible and self-adjusts to suit the constantly changing wave and current conditions. As a result, the system can operate floating on the ocean surface or submerged within the water column of the ocean; however, the normal operating condition of the cage is below the water surface. When a storm approaches the area, the entire cage can be submerged by using a valve to flood the floatation system with water. A buoy remains on the surface, marking the net pen's position and supporting the air hose. When the pen approaches the bottom, the system can be maintained several meters above the sea floor. The cage system is able to rotate around the MAS and adjust to the currents while it is submerged and protected from storms near the water surface. After storm events, the cage system is made buoyant, causing the system to resume normal operational conditions. The proposed project cage will have at least one properly functioning global positioning system device to assist in locating the system in the event it is damaged or disconnected from the mooring system.

In cooperation with the National Marine Fishery Service (NMFS), a protected species monitoring plan (PSMP) has been developed for the proposed action to protect all marine mammal, reptiles, sea birds, and other protected species. Monitoring will occur throughout the life of the project and is an important minimization measure to reduce the likelihood of any unforeseen potential injury to all protected species including ESA-listed marine animals. The data collected will provide valuable insight to resource managers about potential interactions between aquaculture operations and protected species. The PSMP also contains important mitigative efforts such as suspending vessel transit activities when a protected species comes within 100 meters (m) of the activity until the animal(s) leave the area. The project staff will suspend all surface activities (including stocking fish, harvesting operations, and routine maintenance operations) in the unlikely event that any protected species comes within 100 m of the activity until the animal leaves the area. Furthermore, should there be activity that results in an entanglement or injury to protected species, the on-site staff would follow the steps outlined in the PSMP and alert the appropriate experts for an active entanglement.[1]

2.2 Proposed Action Area

The proposed project would be placed in the Gulf at an approximate water depth of 130 ft (40 m), generally located 45 miles southwest of Sarasota, Florida. The proposed facility will be placed within an area that contains unconsolidated sediments that are 3 – 10 ft deep (see Table 2.1). The applicant will select the specific location within that area based on diver-assisted assessments of the sea floor when the cage and MAS are deployed. More information about the proposed project boundaries are shown in Appendix B. The proposed action area is a 1,000-meter radius measured from the center of the MAS.

The facility potential locations were selected with assistance from the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service National Centers for Coastal Ocean Science (NCCOS). The applicant and the NCCOS conducted a site screening process over several months to identify an appropriate project site. Some of the criteria considered during the site screening process included avoidance of corals, coral reefs, submerged aquatic vegetation, and hard bottom habitats, and avoidance of marine protected areas, marine reserves, and habitats of particular concern. This siting assessment was conducted using the Gulf AquaMapper tool developed by NCCOS.[2]

Upon completion of the site screening process with the NCCOS, the applicant conducted a Baseline Environmental Survey (BES) in August 2018 based on guidance developed by the NMFS and EPA.[3] The BES included a geophysical investigation to characterize the sub-surface and surface geology of the sites and identify areas with a sufficient thickness of unconsolidated sediment near the surface while also clearing the area of any geohazards and structures that would impede the implementation of the aquaculture operation. The geophysical survey for the proposed project consisted of collecting single beam bathymetry, side scan sonar, sub-bottom profiler, and magnetometer data within the proposed area. The BES report noted that there were no physical, biological, or archaeological features that would preclude the siting of the proposed aquaculture facility at one of the four potential locations shown in Table 2.1.

Table 2. 1 – Target Area With 3' to 10' of Unconsolidated Sediments

Location	Latitude	Longitude
Upper Left Corner	27° 7.70607' N	83° 12.27012' W
Upper Right Corner	27° 7.61022' N	83° 11.65678' W
Lower Right Corner	27° 6.77773' N	83° 11.75379' W
Lower Left Corner	27° 6.87631' N	83° 12.42032' W

[1] A PSMP has been developed by the applicant with assistance from the NMFS Protected Resources Division. The purpose of the PSMP is to provide monitoring procedures and data collection efforts for species (marine mammals, sea turtles, seabirds, or other species) protected under the MMPA or ESA that may be encountered at the proposed project.

[2] The Gulf AquaMapper tool is available at: https://coastalscience.noaa.gov/products-explorer/

[3] The BES guidance document is available at: http://sero.nmfs.noaa.gov/sustainable_fisheries/Gulf_fisheries/aquaculture/

3.0 Physical Environment

3.1 Physical Oceanography

The Gulf is bounded by Cuba on the southeast; Mexico on the south and southwest; and the United States (U.S.) Gulf Coast on the west, north, and east. The Gulf has a total area of 564,000 square kilometers (km^2). Shallow and intertidal areas (water depths of less than 20 m) compose 38 percent of the total area, with continental shelf (22 percent), continental slope (20 percent), and abyssal (20 percent) composing the remainder of the basin.

The Gulf is separated from the Caribbean Sea and Atlantic Ocean by Cuba and other islands and has relatively narrow connections to the Caribbean and Atlantic through the Florida and Yucatan Straits. The Gulf is composed of three distinct water masses, including the North and South Atlantic Surface Water (less than 100 m deep), Atlantic and Caribbean Subtropical Water (up to 500 m deep), and Sub Antarctic Intermediate Water.

3.1.1 Circulation

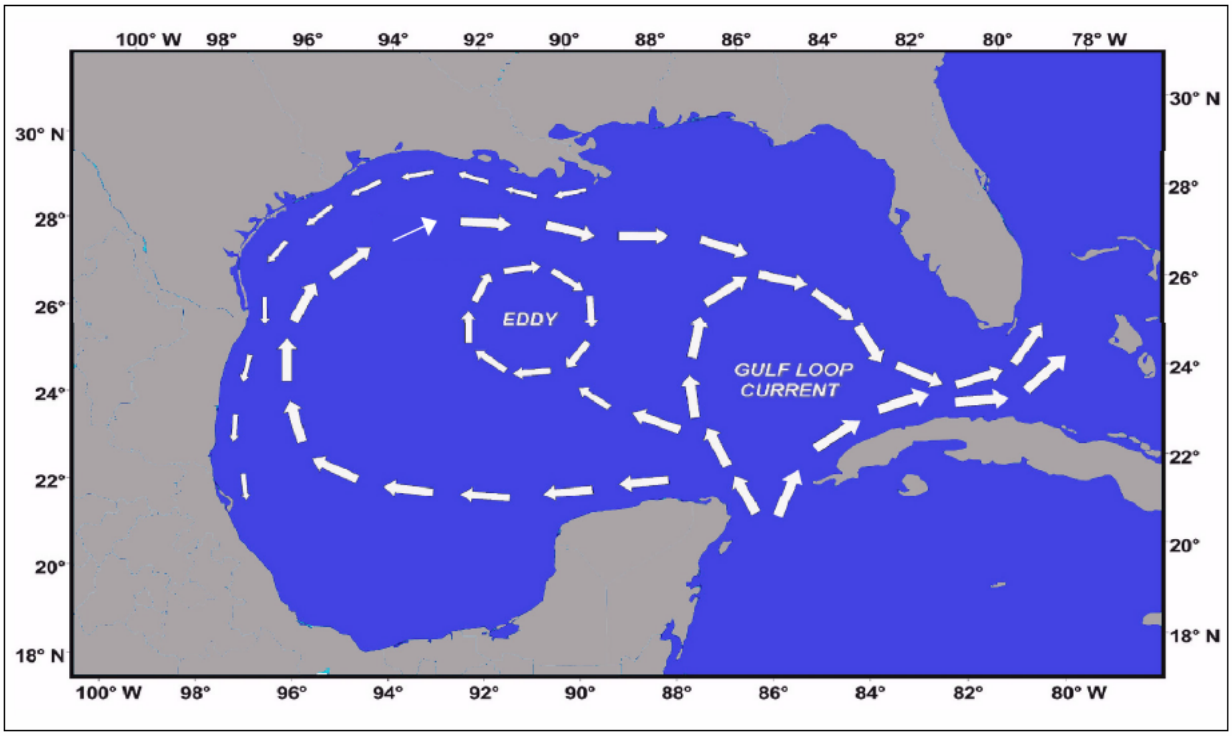
Circulation patterns in the Gulf are characterized by two interrelated systems, the offshore or open Gulf, and the shelf or inshore Gulf. Both systems involve the dynamic interaction of a variety of factors. Open Gulf circulation is influenced by eddies, gyres, winds, waves, freshwater input, density of the water column, and currents. Offshore water masses in the eastern Gulf may be partitioned into a Loop Current, a Florida Estuarine Gyre in the northeastern Gulf, and a Florida Bay Gyre in the southeastern Gulf (Austin, 1970).

The strongest influence on circulation in the eastern Gulf is the Loop Current (Figure 3.1). The location of the Loop Current is variable, with fluctuations that range over the outer shelf, the slopes, and the abyssal areas off Mississippi, Alabama, and Florida. Within this zone, short-term strong currents exist, but no permanent currents have been identified (MMS, 1990). The Loop Current forms as the Yucatan Current enters the Gulf through the Yucatan Straits and travels through the eastern and central Gulf before exiting via the Straits of Florida and merging with other water masses to become the Gulf Stream (Leipper, 1970; Maul, 1977). Currents associated with the Loop Current and its eddies extend to at least depths of 700 m with surface speeds as high as 150-200 centimeters (cm/s), decreasing with depth (BOEM, 2012).

In the shelf or inshore Gulf region, circulation within the Mississippi, Alabama, and west Florida shelf areas is controlled by the Loop Current, winds, topography, and tides. Freshwater input also acts as a major influence in the Mississippi/Alabama shelf and eddy-like perturbations play a significant role in the west Florida shelf circulation. Current velocities along the shelf are variable. Brooks (1991) found that average current velocities in the Mississippi/Alabama shelf area are about 1.5 cm/s, and east-west and northeast/southwest directions dominate. MMS (1990) data showed that winter surface circulation is directed along shore and westward with flow averaging 4 cm/s to 7 cm/s. During the spring and summer, the current shifts to the east with flow averaging 2 cm/s to 7 cm/s. The mean circulation on the west Florida shelf is directed southward with mean flow ranging from 0.2 cm/s to 7 cm/s (MMS, 1990).

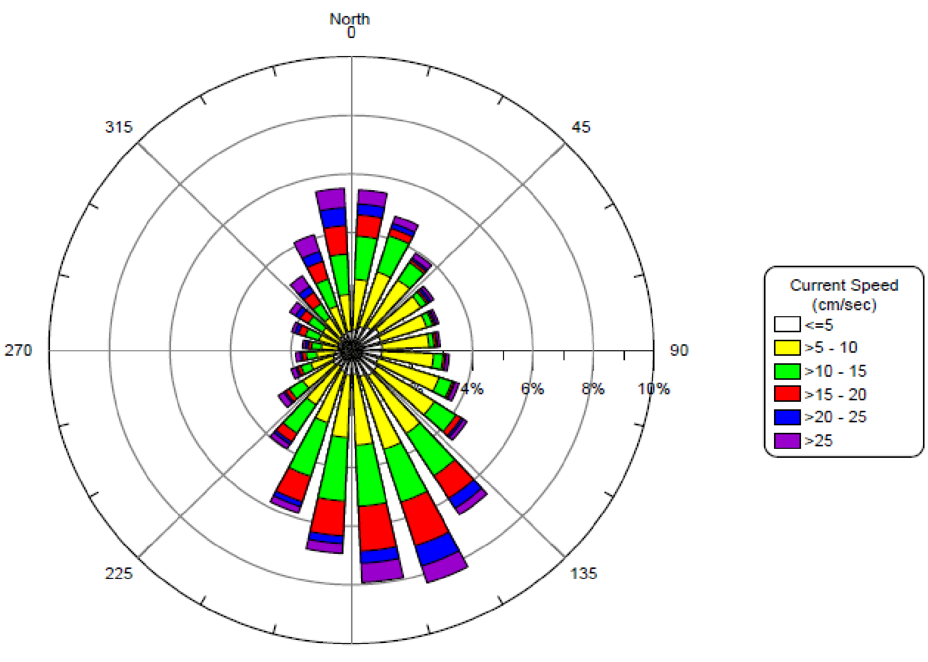
An EPA study of ocean currents at the Tampa Ocean Dredged Material Disposal Site, which lies 18 miles due west of Tampa Bay, FL was conducted between 2008-2009 (EPA, 2012). The study showed that current flow off the west FL coast is predominately in the south-southwest direction (Figure 3.2). Winter months appear to be dominated by south-southwest currents, whereas north-northeast currents dominated the spring months. The median surface current was 13 cm/s whereas the median bottom currents were 7 cm/s. The depth average median current velocity was 9 cm/s.

Figure 3. 1 - Major current regime in the Gulf



Source: NOAA 2007

Figure 3. 2 - Depth average current rose diagram for the Tampa ODMDS showing current speeds and direction. (EPA, 2012)



Wind patterns in the Gulf are primarily anticyclonic (clockwise around high-pressure areas) and tend to follow an annual cycle; winter winds from the north and southeast and summer winds from the northeast and south. During the winter, mean wind speeds range from 8 knots to 18 knots. Several examples of mean annual wind speeds in the eastern Gulf are 8.0 millibars (mb) in Gulf Port, Mississippi; 8.3 mb in Pensacola, Florida; and 11.2 mb in Key West, Florida (NOAA, 1986).

The tides in the Gulf are less developed and have smaller ranges than those in other coastal areas of the United States. The range of tides is 0.3 meters to 1.2 meters, depending on the location and time of year. The Gulf has three types of tides, which vary throughout the area: diurnal, semidiurnal, and mixed (both diurnal and semidiurnal). Wind and barometric conditions will influence the daily fluctuations in sea level. Onshore winds and low barometric readings, or offshore winds and high barometric readings, cause the daily water levels either to be higher or lower than predicted. In shelf areas, meteorological conditions occasionally mask local tide induced circulation. Tropical storms in summer and early fall may affect the area with high winds (18+ meters per second), high waves (7+ meters), and storm surge (3 to 7.5 meters). Winter storm systems also may cause moderately high winds, waves, and storm conditions that mask local tides.

3.1.2 Climate

The Gulf is influenced by a maritime subtropical climate controlled mainly by the clockwise wind circulation around a semi-permanent, high barometric pressure area alternating between the Azores and Bermuda Islands. The circulation around the western edge of the high-pressure cell results in the predominance of moist southeasterly wind flow in the region. However, winter weather is quite variable. During the winter months, December through March, cold fronts associated with outbreaks of cold, dry continental air masses influence mainly the northern coastal areas of the Gulf. Tropical cyclones may develop or migrate into the Gulf during the warmer season, especially in the months of August through October. In coastal areas, the land-sea breeze is frequently the primary circulation feature in the months of May through October. (BOEM, 2012)

3.1.3 Temperature

In the Gulf, sea surface temperatures range from nearly isothermal (29 - 30^{o}C) in August to a sharp horizontal gradient in January, ranging from 25^{o}C in the Loop core to values of 14-15^{o}C along the shallow northern coastal estuaries. A 7^{o}C sea surface temperature gradient occurs in winter from north to south across the Gulf. During summer, sea surface temperatures span a much narrower range. The range of sea surface temperatures in the eastern Gulf tends to be greater than the range in the western Gulf, illustrating the contribution of the Loop Current.

Eastern Gulf surface temperature variation is affected by season, latitude, water depth, and distance offshore. During the summer, surface temperatures are uniformly 26.6^{o}C or higher. The mean March isotherm varies from approximately 17.8^{o}C in the northern regions to 22.2^{o}C in the south (Smith, 1976). Surface temperatures range as low as 10^{o}C in the Louisiana-Mississippi shelf regions during times of significant snow melt in the upper Mississippi valley (MMS, 1990).

At a depth of 1,000 m, the temperature remains close to 5^{o}C year-round (MMS, 1990). In winter, nearshore bottom temperatures in the northern Gulf are 10^{o}C cooler than those temperatures offshore. A permanent seasonal thermocline occurs in deeper off shelf water throughout the Gulf. In summer, warming surface waters help raise bottom temperatures in all shelf areas, producing a decreasing distribution of bottom temperatures from about 28^{o}C at the coast to about 18-20^{o}C at the shelf break.

The depth of the thermocline, defined as the depth at which the temperature gradient is a maximum, is important because it demarcates the bottom of the mixed layer and acts as a barrier to the vertical transfer of materials and momentum. The thermocline depth is approximately 30 m in the eastern Gulf during January (MMS, 1990). In May, the thermocline depth is about 46 m throughout the entire Gulf (MMS, 1990).

3.1.4 Salinity

Characteristic salinity in the open Gulf is generally between 36.4 and 36.5 parts per thousand (ppt). Coastal salinity ranges are variable due to freshwater input, draught, etc. (MMS, 1990). During months of low freshwater input, deep Gulf water penetrates the shelf and salinities near the coastline range from 29-32 ppt. High freshwater input conditions (spring-summer months) are characterized by strong horizontal gradients and inner shelf salinity values of less than 20 ppt (MMS, 1990).

3.2 Chemical Composition

Of the 92 naturally occurring elements, nearly 80 have been detected in seawater (Kenisha, 1989). The dissolved material in seawater consists mainly of eleven elements. These are, in decreasing order, chlorine, sodium, magnesium, calcium, potassium, silicon, zinc, copper, iron, manganese, and cobalt (Smith, 1981). The major dissolved constituents in seawater are shown in Table 3.1. In addition to dissolved materials, trace metals, nutrient elements, and dissolved atmospheric gases comprise the chemical makeup of seawater.

Table 3. 1 - Major dissolved constituents in seawater with a chlorinity of 19‰ and a salinity of 34‰

Dissolved substance (Ion or Compound)	Concentration (grams per kilogram)	Percent (by weight)
Chloride (Cl^-)	18.98	55.04
Sodium (Na^+)	10.56	30.61
Sulfate (SO_4^{2-})	2.65	7.68
Magnesium (Mg^{2+})	1.27	3.69
Calcium (Ca^{2+})	0.40	1.16
Potassium (K^+)	0.38	1.1
Bicarbonate (HCO_3^-)	0.14	0.41
Bromide (Br^-)	0.07	0.19
Boric Acid (H_3BO_3)	0.03	0.07
Strontium (Sr^{2+})	0.01	0.04
Fluoride (F^-)	0.00	0.00
Totals	34.48	99.99

3.2.1 Micronutrients

In Gulf waters, generalizations can be drawn for three principal micronutrients; phosphate, nitrate, and silicate. Phytoplankton consume phosphorus and nitrogen in an approximate ratio of 1:16 for growth. The following nutrient levels and distribution values were obtained from MMS (1990): phosphates range from 0 ppm to 0.25 ppm, averaging 0.021 ppm in the mixed layer, and with shelf values similar to open Gulf values; nitrates range from 0.0031 ppm to 0.14 ppm, averaging 0.014 ppm; silicates range predominantly from 0.048 ppm to 1.9 ppm, with open Gulf values tending to be lower than shelf values.

In the eastern Gulf, inner shelf waters tend to remain nutrient deficient, except in the immediate vicinity of estuaries. On occasions when the loop current occurs over the Florida slope, nutrient rich waters are upwelled from deeper zones (MMS, 1990).

3.2.2 Dissolved Gases

Dissolved gases found in seawater include oxygen, nitrogen, and carbon dioxide. Oxygen is often used as an indicator of water quality of the marine environment and serves as a tracer of the motion of deep-water masses of the oceans. Dissolved oxygen values in the mixed layer of the Gulf average 4.6 milligrams per liter (mg/l), with some seasonal variation, particularly during the summer months when a slight lowering can be observed. Oxygen values generally decrease with depth to about 3.5 mg/l through the mixed layer (MMS, 1990). In some offshore areas in the northern Gulf, hypoxic (<2.0 mg/l) and occasionally anoxic (<0.1 mg/l) bottom water conditions are widespread and seasonally regular (Rabalais, 1986). These conditions have been documented since 1972 and have been observed mostly from June to September on the inner continental shelf at a depth of 5 to 50 meters (Renauld, 1985; Rabalais et al., 1985).

4.0 Discharged Materials

The composition, characteristics, and quantities of materials that will or potentially will be discharged from the facility under the NPDES permit are considerations under Factor 1 of the 10 factors used to determine whether unreasonable degradation may occur. The materials to be discharged under NPDES permit to the Gulf from the proposed project will consist of uneaten fish food pellets and fish wastes.

4.1 Fish Feed

Much of the discussion in this section was developed from information concerning large production scale fish farms. It is important to note that the proposed project under consideration for this permit will be a small demonstration project. The proposed project will grow out a maximum of 20,000 fish that would be grown to 1.8-2.0 kg for one year. The total maximum biomass assuming no mortality is estimated to be approximately 36,288 kg. Fish will be fed a commercially available grow out diet with 43 percent protein content. The total maximum daily feed ration at harvest is equivalent to 399 kg at harvest. Maximum daily excretion of total ammonia nitrogen is estimated at 18-19 kg and maximum total solids production is 161 kg. A total of 66,449 kg of feed will be used for production of each cohort of fish to achieve a feed conversion ratio (FCR) of 1.8.

The quantities of food supplied per unit of fish depend on the type of food used, size of the fish, and the water temperature. A typical salmon farm producing 340 metric tons (748,000 lbs) of fish annually will feed 340 to 680 metric tons (748,000-1,496,000 lbs) of food (Wash Dept. Fisheries, 1989). Fish cultured around the world are fed a variety of foods, ranging from minced trash fish, to semi-moist pellets of minced fish and various binders, to dry pellets. Semi-moist or dry pellets are used extensively in U.S. fish farms and consist of a combination of fish meal and vegetable matter, mixed with vitamins, essential oils and other organic material. Some studies have shown that when feeding methods are optimized, there is generally no significant difference between pelletized artificial feeds and the use of trash fish regarding the discharge of nutrients and solid materials from cages (Hasan, 2012). Table 4.1 shows the composition of several commonly used prepared fish diets. Typical average levels of protein, fats and carbohydrates in fish feeds ranges from 18-50 percent, 10-25 percent and 15-20 percent respectively, depending on targeted species (Waldemar Nelson International, 1997; Craig, 2009). The proposed permit prohibits the discharge of un-pelletized wet feeds.

The effectiveness of cultured fish feeding methods and diets are measured by calculating a FCR - the ratio of food fed (dry weight) to fish produced (wet weight). Typically, average FCR's range from 1:1 for salmonid fishes to 2:1 for some freshwater species (Hasan and Soto, 2017). That is, for every pound of fish produced, 1 to 2 lbs of feed were introduced into the water. In some laboratory experiments, FCR's of less than 1:1 have been achieved, and most fish farmers now claim values between 1 and 1.5. The amount fed during any period depends primarily upon the type of food used, the size of the fish, and the water temperature. Farmed fish are typically fed 1-4 percent of their body weight per day. Though protein content may vary, generally, fish feed includes about 7.7 percent nitrogen (Edwards, 1978) and 37.7 percent organic carbon (Waldemar Nelson International, 1997).

Modern feeds are designed to reduce solid wastes by improving digestibility, ingredient selection and nutrient balance (Cho and Bureau, 2001). Even with the highest FCRs, a portion of fish feed is not eaten and settles to the bottom. Feed wastage has proven difficult to ascertain in field conditions. However, several studies in Europe have suggested that a range of 1 to 30 percent of the feed may be lost (Gowen et al 1988; Pencsak et al., 1982). Dry feed consistently showed the least amount of wastage (1 to 5 percent) while 5 to 10 percent of moist fish foods were lost (Gowen and Bradbury, 1987). In Puget Sound farms, fish growers report that food wastage is typically less than 5 percent (Weston, 1986). Specific studies of food wastage at a commercial salmon farm in Sooke Inlet, B.C., showed that hand feeding, the most common practice in Puget

Sound, resulted in wastage of 3.6 percent. The use of automatic feeders increased wastage to 8.8 percent (Cross, 1988).

Since food pellets do not decompose appreciably as they settle to the bottom, they are unlikely to experience substantial reduction in nitrogen or carbon, either through solution or microbial activity, before depositing on the bottom (Collins, 1983; Gowen and Bradbury, 1987). Thus, any food particles or pellets lost during feeding will retain their nutrients essentially unaltered. Development of slower settling feeds, which are available to the fish in the pens for longer periods, and feeds with more uniform size have reduced wastage. However, the amount of wastage is still highly dependent upon the care used by the fish farmer during feeding.

Table 4. 1 – Nutritional composition of commonly used prepared fish diets [4]

Source	Fish Species	Feed Brand	Feed Type	% Protein	% Fats	% Carbohydrates
BioProducts, Inc (EPA, 1991)	Salmon	Biodry 3000	Dry	44.5	15.0	14.7
Moore-Clark Co. (EPA, 1991)	Salmon	Select Ext.	Dry	45.0	22.0	14.0
BioProducts, Inc (EPA, 1991)	Salmon	Biomoist F.3	Moist	39.0	13.5	11.8
Moore-Clark Co. (EPA, 1991)	Salmon	Oregon Moist	Dry	35.0	11.0	13.0
Ziegler Bros. (Ellis, 1996)	Grouper	Trout Grower	Dry	43.5	5.9	34.8
Rangen, Inc. (Ellis, 1996)	Grouper	Salmon Grower	Dry	52.7	15.2	13.8
Dainichi Corp. (Ellis, 1996)	Grouper	Carn. Fish Diet	Dry	55.6	7.8	20.7
Oceanic Institute (Ellis, 1996)	Grouper	Mahi ex.diet	Dry	61.8	14.2	12.9
Corey Feed Mills	Salmon	Fundy Choice	Dry	43.0	30.0	11.0
Aquaculture 1997 v. 151	Grouper	-	Dry	43.0	14.0	8.0
Oceanic Institute, 1993	Mahi-Mahi	OI prepared diet	Dry	60.0	12.0	10.0
Williams, 1985	Pompano	Menhaden oil diet	Dry	42.0	12.0	7.0
Burris Mill & Feed	Hybrid Bass	Grower	Dry	42.0	7.0	19.0
Burris Mill & Feed	Red Drum	Grower	Dry	42.0	7.0	19.0
Burris Mill & Feed	Red Drum	Grower	Dry	40.0	10.0	30.0
Mean				**45.9**	**13.1**	**16.0**

4.2 Fish Wastes

Of the feed consumed, about 10 percent is lost as solid wastes and 30 percent lost as liquid wastes (Butz and Vens-Capell, 1982; Craig, 2009). Unlike feed pellets, fish feces are more variable in size and density. Consequently, the settling rate of these particles will vary greatly, but will be less than that of feed pellets. The composition of the feces is dependent upon the chemical composition of the feed and its digestibility. Gowen and Bradbury (1987) estimated from the literature that about 30 percent of the consumed carbon would be excreted in the feces, along with about 10 percent of the consumed nitrogen.

[4] Source: Modified from Waldemar Nelson International, 1997.

Estimates of the total particulate matter emanating from net pens, for eventual deposit on the sea floor, have been calculated. Weston (1986), assuming an FCR of 2:1 with 5 percent wastage and a third of the consumed food being lost as feces, estimated that 733 kg (1,600 lbs) of sediment would be produced for every metric ton (2200 lbs) of fish grown. The Institute of Aquaculture (1988) estimated sediment production of 820 kg (1800 lbs), assuming 20 percent wastage and a 30 percent loss as feces.

A discharge limitation will be placed in the NPDES permit to state that fish food and metabolic wastes discharged from the facility shall not cause unreasonable degradation of the environment beneath the facility and/or the surrounding area as defined in 40 CFR § 125.122(a).

5.0 Biological Overview

This chapter describes the biological communities and processes in the eastern Gulf in general and in the specific area of the proposed facility which may be exposed to pollutants, the potential presence of endangered species, any unique species or communities of species, and the importance of the receiving water to the surrounding biological communities.

5.1 Primary Productivity

Primary productivity is "the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms in the form of organic substances which can be used as food materials" (Odum, 1971). Primary productivity is affected by light, nutrients, and zooplankton grazing, as well as other interacting forces such as currents, diffusion, and upwelling. The producer organisms in the marine environment consist primarily of phytoplankton and benthic macrophytes. Since benthic macrophytes are depth/light limited, primary productivity in the open ocean is attributable primarily to phytoplankton. The productivity of nearshore waters can be attributed to benthic macrophytes--including seagrasses, mangroves, salt marsh grasses, and seaweeds--and phytoplankton.

There are numerous methods for estimating primary productivity in marine waters. One method is to measure chlorophyll content per volume of seawater and compare results over time to establish a productivity rate. The chlorophyll measurement, typically of chlorophyll a, gives a direct reading of total plant biomass. Chlorophyll a is generally used because it is considered the "active" pigment in carbon fixation (Steidinger and Williams, 1970). Another method, the C^{14} (radiocarbon) method, measures photosynthesis (a controversy exists as to whether "net", "gross", or "intermediate" photosynthesis is measured by this method; Kennish, 1989). The C^{14} method introduces radiolabeled carbon into a sample and estimates the rate of carbon fixation by measuring the sample's radioactivity. The units used to express primary productivity are grams of carbon produced in a column of water intersecting one square meter of sea surface per day (g $C/m^2/d$), or grams of carbon produced in a given cubic meter per day (g $C/m^3/d$).

C^{14} uptake throughout the Gulf is 0.25 g $C/m^3/hr$ or less, and chlorophyll measurements range from 0.05 to 0.30 mg/m^3 (ppb). Eastern regions of the Gulf are generally less productive than western regions, and throughout the eastern Gulf, primary productivity is generally low. However, outbreaks of "red-tide" caused by pathogenic phytoplankton may occur in the mid- to inner-shelf. Also, depth-integrated productivity values in the area of the Loop Current (primarily the outer shelf and slope) are actually higher than western and central Gulf values. Enhanced productivity occurs in areas affected by upwelling. Near the bottom of the euphotic zone, chlorophyll and productivity values are about an order of magnitude greater, probably due to the often intruded, nutrient-rich Loop undercurrent waters (MMS, 1990).

Productivity measurements in the oceanic waters of the Gulf include: 0.1 g $C/m^2/d$ yielding 17 g $C/m^2/yr$ or 86 million tons of phytoplankton biomass (MMS, 1983); 103-250 g $C/m^2/yr$ (Flint and Kamykowski, 1984); 103 g $C/m^2/yr$ (Flint and Rabalais, 1981). For comparisons, the following data on primary productivity are presented for coastal wetland systems as compiled by Thayer and Ustach (1981):

- Salt Marshes, 200-2000 g $C/m^2/yr$
- Mangroves, 400 g $C/m^2/yr$
- Seagrasses, 100-900 g $C/m^2/yr$
- *Spartina alterniflora,* 1300 g $C/m^2/yr$
- *Thalassia*, 580-900 g $C/m^2/yr$
- Phytoplankton, 350 g $C/m^2/yr$

Biomass (chlorophyll a) measurements in the predominantly oceanic waters of the Gulf include: 0.05-0.30 mg Chl a/m^3 (MMS, 1983a); 0.05-0.1 mg Chl a/m^3 (Yentsch, 1982); 0.22 mg Chl a/m^3 (El-Sayed, 1972); and 0.17 mg Chl a/m^3 (Trees and El-Sayed, 1986). For the eastern Gulf, biomass (chlorophyll a) measurements include the following (Yoder and Mahood, 1983):

- Surface mixed layer values of 0.1 mg/m^3;
- Subsurface measurements at 40-60 m ranged from 0.2 to 1.2 mg/m^3;
- Average integrated values for the water column over the 100-200 m isobath was 10 mg/m^2; and
- Average integrated values for the water column greater than 200 m isobath was 9 mg/m^2.

5.2 Phytoplankton

5.2.1 Distribution

Phytoplankton distribution and abundance in the Gulf is difficult to measure. Shipboard or station measurements cannot provide information about large areas at one moment in time, and satellite imagery cannot provide definitive information about local conditions that may be important. Due to fluctuations in light and nutrient availability and the immobility of phytoplankton, distribution is temporally and spatially variable. Seasonal fluctuations in location and abundance are often masked by patchy distributions which human sampling designs must attempt to interpret. In addition, methods for measurement of chlorophyll or uptake of carbon cannot always resolve all questions concerning variability among or within species under different conditions, or those concerning the effects of grazing on abundance.

As mentioned in the previous section, phytoplankton occupy a niche at the base of food chain as primary producers of our oceans. Herbivorous zooplankton populations require phytoplankton for maintenance and growth -- generally 30-50 percent of their weight each day and surpassing 300 percent of their weight in exceptional cases (Kennish, 1989). In the Gulf, phytoplankton are also often closely associated with bottom organisms, and may also contribute to benthic food sources for demersal feeding fish.

Phytoplankton seasonality has been explained in terms of salinity, depth of light penetration, and nutrient availability. Generally, diversity decreases with decreased salinity and biomass decreases with distance from shore (MMS, 1990).

5.2.2 Principal Taxa

The principal taxa of planktonic producers in the ocean are diatoms, dinoflagellates, coccolithophores, silicoflagellates and blue-green algae (Kennish, 1989).

Diatoms

Many specialists regard diatoms as the most important phytoplankton group, contributing substantially to oceanic productivity. Diatoms consist of single cells or cell chains, and secrete an external rigid silicate skeleton called a frustule. In 1969, Saunders and Glenn reported the following for diatom samples collected 5.6 to 77.8 kilometers (km) from shore in the Gulf between St. Petersburg and Ft. Myers, Florida. Diatoms averaged 1.4 x $10^7\mu^2$/l surface area offshore, 13.6 x $10^7\mu^2$/l at intermediate locations and 13.0 x $10^8\mu^2$/l inshore. The ten most important species in terms of their cellular surface area were: Rhizosolenia alata, R. setigera, R. stolterfothii, Skeletonema costatum, Leptocylindrus danicus, Rhizosolenia fragilissima, Hemidiscus hardmanianus, Guinardia flaccida, Bellerochea malleus, andÉrataulina pelagica.

Dinoflagellates

Dinoflagellates are typically unicellular, biflagellated autotrophic forms that also supply a major portion of the primary production in many regions. Some species generate toxins and when blooms reach high densities, mass mortality of fish, shellfish, and other organisms can occur (Kennish, 1989). Notably, Gymnodinium breve is responsible for most of Florida's red tides and several of the Gonyaulax species are known to cause massive blooms (Steidinger and Williams, 1970). Table 5.1 lists species and varieties of dinoflagellates found to be abundant during the Hourglass Cruises (a systematic sampling program in the eastern Gulf.)

Table 5. 1 - Significant Dinoflagellate Species of the Eastern Gulf [5]

Species	Biomass Value (μ^3)
Amphibologia bidentata	67,039 - 95,406
Ceratium carriense	637,219 - 1,115,367
C. carriense var. *volans*	622,206 - 1,196,643
C. contortum var. *karstenii*	943,121 - 1,655,573
C. extensum	189,709 - 323,546
C. furca	23,157 - 43,369
C. fusus	34,463 - 154,722
C. hexacanthum	687,593 - 1,384,016
Ceratium hircus	211,709
C. inflatum	145,897 - 221,276
C. massiliense	543,762 - 1,002,222
C. trichoceros	104,110 - 357,437
C. tripos var. *atlanticum*	518,659 - 964,436
Dinophysis caudata var. *pedunculata*	92,153 - 231,405
Gonyaulax splendens	51,651
Prorocentrum crassipes	329,540
P. gracile	25,773
P. micans	65,412

Coccolithophores

Coccolithophores are unicellular, biflagellated algae named for their characteristic calcareous plate, the coccolith, which is embedded in a gelatinous sheath that surrounds the cell. Phytoplankton of offshore Gulf are reported to be dominated by coccolithophores (Iverson and Hopkins, 1981).

Silicoflagellates

Silicoflagellates are unicellular flagellated (single or biflagellated) organisms that secrete an internal skeleton composed of siliceous spicules (Kennish, 1989). Perhaps because of their small size (usually less than 30 µm in diameter) little specific information relative to Gulf distribution and abundance, is available for this group.

Blue Green Algae

Blue green algae are prokaryotic organisms that have chitinous walls and often contain a pigment called phycocyanin that gives the algae their blue green appearance (Kennish, 1989). On the west Florida shelf, inshore blooms of the blue green algae Oscillatoria erethraea sometimes occur in spring or fall.

[5] Source: Steidinger and Williams, 1970.

5.3 Zooplankton

Like phytoplankton, zooplankton are seasonal and patchy in their distribution and abundance. Zooplankton standing stocks have been associated with the depth of maximum primary productivity and the thermocline (Ortner et al., 1984). Zooplankton feed on phytoplankton and other zooplankton, and are important intermediaries in the food chain as prey for each other and larger fish.

As in many marine ecosystems, zooplankton fecal pellets contribute significantly to the detrital pool. The ease of mixing in Gulf coastal waters may make them extremely important to nutrient circulation and primary productivity, as well as benthic food stocks. Also contributing to the detrital pool is the concentration of zooplankton in bottom waters, coupled with phytoplankton in the nepheloid layer during times of greater water stratification.

Copepods are the dominant zooplankton group found in all Gulf waters. They can account for as much as 70 percent by number of all forms of zooplankton found (NOAA, 1975). In shallow waters, peaks occur in the summer and fall (NOAA, 1975), or in spring and summer, (MMS, 1983a). When salinities are low, estuarine species such as *Acartia tonsa* become abundant.

The following information on zooplankton distribution and abundance in the eastern Gulf is summarized from Iverson and Hopkins (1981):

- During Bureau of Land Management-sponsored studies, small copepods predominated in net catches over the shelf regions of the eastern and western Gulf.
- During Department of Energy-sponsored studies at sights located over the continental slope of Mobile and Tampa Bays, small calanoids such as *Parcalanus*, and *Clausocalanus* and cyclopoids such as *Farralanula, Oncaea*, and *Oithona* predominated at the 0-200 m depths; and larger copepods such as *Eucalanus, Rhincalnus,* and *Pleuromamma* dominated at 1,000 m depths. Euphausiids were also more conspicuous. Night-time samples taken near Tampa showed larger crustaceans such as Lucifer and Euphasia. Biomass data for the same site revealed a decrease in zooplankton with increasing depth. The mean cumulated biomass value for the upper 1,000 m was 21.9 ml/m^2.
- Studies funded by the National Science Foundation in the east-central Gulf found diurnal patterns of distribution in the upper 1,000 m, with increases in the 50 m range at night and in the 300-600 m zone during the day, most likely attributable to vertical migration. In the upper 200 m, in addition to copepods, group such as chaetognaths, tunicates, hydromedusae, and euphausiids were significant contributors to the biomass.

Icthyoplankton studies for the eastern Gulf conducted during 1971-1974 found fish eggs to be more abundant in the northern half and fish larvae to be more abundant in the southern half of the eastern Gulf. Mean abundances were 5,454 eggs/m^2 and 3,805 larvae/m^2 in the northern Gulf and 4,634 eggs/m^2 and 4,869 larvae/m^2 in the southern Gulf. Eggs were more abundant in waters less than 450 meters deep, whereas larvae were more abundant in-depth zones greater than 50 meters (Houde and Chitty, 1976).

5.4 Habitats

5.4.1 Seagrasses

Seagrasses are vascular plants that serve a variety of ecologically important functions. As primary producers, seagrasses are a direct food source and also contribute nutrients to the water column. Seagrass communities serve as a nursery habitat for juvenile fish and invertebrates and seagrass blades provide substrate for epiphytes. Species such as *Thalassia testudinum* have an extensive root system that stabilize substrate, and broad ribbon-like blades that increase sedimentation. Seagrasses mainly occur in shallow, clear, highly saline waters. Seagrass beds do not occur in the proposed activity area.

Approximately 1.25 million acres of seagrass beds are estimated to exist in exposed, shallow, coastal/nearshore waters and embayments of the Gulf**.** About 3 percent of these beds are in Mississippi. Florida with Florida Bay and coastal Florida accounting for more than 80 percent. True seagrasses that occur in the Gulf are shoal grass, paddle grass, star grass, manatee grass, and turtle grass. Although not considered a true seagrass because it has hydroanemophilous pollination (floating pollen grains) and can tolerate freshwater, widgeon grass is common in the brackish waters of the Gulf. (BOEM, 2012).

5.4.2 Offshore Habitats

Offshore habitats include the water column and the sea floor. The west Florida Shelf extends seaward of Tampa Bay approximately 200 km to a depth of 200 m and consists mainly of unconsolidated sediments punctuated by low-relief rock outcroppings and several series of high relief ridges. The seafloor on the west Florida shelf in the proposed project area consists mainly of course to fine grain sands with scattered limestone outcroppings making up about 18 percent of the seafloor habitat. These limestone outcroppings provide substrata for the attachment of macroalgae, stony corals, octocorals, sponges and associated hard-bottom invertebrate and fish communities (EPA, 1994).

5.5 Fish and Shellfish Resources

The distribution of fish resources in the eastern Gulf are highly dependent on a variety of factors including habitat type, chemical and physical water quality variables, biological, and climatic factors. The Gulf contains both a temperate fish fauna and a tropical fauna arrayed into inshore and offshore habitats depending on latitude. To the south of the 20°C winter isotherm, approximately middle Florida, the more tropical fish fauna occupies inshore habitats replacing the temperate fauna. To the north the tropical fauna is pushed further offshore to avoid cold winter temperature and by increased competition by temperate species able to tolerate cooler waters. In the northern Gulf where temperate species dominate inshore, a well-developed tropical fauna occurs on offshore structures, particularly reefs (Hoese and Moore, 1977). During warm weather the early life stages of the tropical fauna move further inshore around piers and jetties.

The temperate fish and invertebrate fauna of the north-central Gulf tend to be dominated by estuary dependent species such as sciaenids (i.e., croaker, red and black drum, spotted seatrout), menhaden, shrimp, oysters and crabs. These species require the transportation of early life stages into estuaries for grow out into mature adults or juveniles and migration out to shelf environments. Shellfish resources in the Gulf tend to be more estuarine dependent than finfishes. Gulf shellfish habitats range from brackish wetlands to nearshore shelf environments. Of the 15 penaeid shrimp species found in the Gulf the brown, white and pink shrimp are the most important. Adults of these species spawn in offshore marine waters and the free-swimming post larvae move into estuaries to remain through their juvenile stages. Juvenile shrimp move back offshore to molt into adults.

Reef fish assemblages may consist of mainly temperate species in the more northern Gulf with increasing dominance of more tropical fish species, typically associated with coral reefs, further offshore and in the more southern portions of the Gulf. Natural reef habitat in the eastern Gulf ranges from low relief (>1 m) live bottom, high relief ridge habitats along the Florida shelf break and pinnacle formations of the Florida Middle Grounds on the west Florida shelf. Man-made or artificial reef habitats also exist from oil and gas platforms, sunken vessels and a variety of other structures placed intentionally for fisheries enhancement. These structures comprise critical habitats for many important commercial and recreational fishes such as groupers and snappers.

Pelagic fish species are distributed by water column depth and relationship to the shore. Coastal pelagic fish are those that move mainly around the continental shelf year-round, singly or in schools of various size. These include some commercially important groups of fishes including sharks, anchovies, herring, mackerel, tuna, mullet, bluefish and cobia. Oceanic pelagic fish occur at or seaward of the shelf edge throughout the Gulf. Oceanic pelagic fish include many larger species such as sharks, tuna, bill fishes, dolphin and wahoo.

Extensive discussions of reef and migratory fish species in the Gulf can be found in the Final Programmatic Environmental Impact Statement. Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf (NOAA 2009).

A 2010 survey of the Tampa Ocean Dredge Material Disposal Site (ODMDS) that is approximately 18 miles west of Tampa Bay, identified 29 species of demersal fishes associated with the high relief habitat created by the dredged material spoil mound, with only 9 species on nearby natural low-relief hard bottom habitat. Abundances of fishes on natural low-relief hard bottom in the area were also significantly smaller than on the spoil mound (EPA, 2011).

5.6 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act of 1972 (MMPA). There are 22 marine mammal species that may occur in the Gulf (i.e., one sirenian species (a manatee), and 21 cetacean species (dolphins and whales)) based on sightings and/or strandings (Schmidly, 1981; NOAA, 2009). Three of the marine mammals (sperm whales, Gulf Bryde's whale, and manatees) are also currently protected under the ESA.

Cetaceans (whales, dolphins, and porpoises) are the most common. Six of the seven baleen whales in the Gulf are currently listed as threatened or endangered and of the 20 toothed whales present only the sperm whale is endangered. During 1978 to 1987, a total of 1,200 cetacean strandings/sightings was reported for Alabama, Florida and Mississippi to the Southeastern U.S. Marine Strandings Network. Ninety percent of these stranding/sighting occurred off Florida coasts (the Florida figure reflects strandings from both the Gulf and the Atlantic waters (NOAA, 1991). The cetaceans found in the Gulf include species that occur in most major oceans, and for the most part are eurythermic with a broad range of temperature tolerances (Schmidly, 1981). An introduced species of pinniped, the California sea lion, occurred in small numbers only in the feral condition, however no sightings of this species has been reported in the Gulf since 1990.

Most of the Gulf cetacean species reside in the oceanic habitat (greater than or equal to 200 m). However, the Atlantic spotted dolphin (*Stenella frontalis*) is found in waters over the continental shelf (10-200 m), and the common bottlenose dolphin (*Tursiops truncatus truncatus*) (hereafter referred to as bottlenose dolphins) is found throughout the Gulf, including within bays, sounds, and estuaries; coastal waters over the continental shelf; and in deeper oceanic waters. Bottlenose dolphins in the Gulf can be separated into demographically independent populations called stocks. Bottlenose dolphins are currently managed by NOAA Fisheries as 36 distinct stocks within the Gulf. These include 31 bay, sound, and estuary stocks, three coastal stocks, one continental shelf stock, and one oceanic stock (Hayes et al., 2017).[6]

More extensive discussions about marine mammals for the proposed project are within the Environmental Assessment (EA) for the proposed project. Additionally, more information about marine mammals in the Gulf can be found in the Final Programmatic Environmental Impact Statement (EIS) Fishery Management Plan for Regulating Offshore Marine Aquaculture in the Gulf (NOAA, 2009), the EA for the EPA Oil and Gas general

[6] Marine Mammal Stock Assessment Reports and additional information on these species in the Gulf are available on the NOAA Fisheries Office of Protected Species website: www.nmfs.noaa.gov/pr/sspecies/.

NPDES permit (EPA, 2016), and in recent Bureau of Ocean and Energy Management (BOEM) EIS documents (BOEM, 2012).

5.7 Endangered Species

The USFWS and NMFS evaluate the conditions of species and their populations within the United States. Those species populations considered in danger of extinction are listed as endangered species pursuant to the Endangered Species Act of 1973. In addition, Section 7(a)(2) of the ESA requires federal agencies to ensure that their action do not jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Table 5.2 provides the list of ESA-listed species that were considered by the EPA and could potentially occur in or near the proposed action area.

More information about endangered species can be found in the Biological Evaluation for the proposed project. Overall, potential impacts to the ESA-listed species considered by the EPA are expected to be extremely unlikely and insignificant due to the small size of the facility, the short deployment period, unique operational characteristics, lack of geographic overlap with habitat or known migratory routes, or other factors that are described in the below sections for each species.

Threatened and endangered species that occur in the Gulf are discussed extensively in the 2016 EPA Environmental Assessment for the EPA Oil and Gas general NPDES permit (EPA, 2016), BOEM EIS documents (BOEM, 2013), and the Final PEIS for Offshore Marine Aquaculture in the Gulf (NOAA, 2009).

Table 5.2 – Federally Listed Species, Listed Critical Habitat, Proposed Species, and Proposed Critical Habitat Considered for the Proposed Action

Species Considered		ESA Status	Critical Habitat Status	Potential Exposure to Proposed Action Area
Birds				
1	Piping Plover	Threatened	Yes	No
2	Red Knot	Threatened	No	No
Fish				
1	Giant Manta Ray	Threatened	No	Yes
2	Nassau Grouper	Threatened	No	Yes
3	Oceanic Whitetip Shark	Threatened	No	Yes
4	Smalltooth Sawfish	Endangered	No	Yes
Invertebrates				
1	Boulder Star Coral	Threatened	No	No
2	Elkhorn Coral	Threatened	No	No
4	Mountainous Star Coral	Threatened	No	No
5	Pillar Coral	Threatened	No	No
7	Staghorn Coral	Threatened	No	No
6	Rough Cactus Coral	Threatened	No	Yes
3	Lobed Star Coral	Threatened	No	Yes
Marine Mammals				
1	Blue Whale	Endangered	No	Yes
2	Bryde's Whale	Endangered	No	Yes
3	Fin Whale	Endangered	No	Yes
4	Humpback Whale	Endangered	No	Yes
5	Sei Whale	Endangered	No	Yes
6	Sperm Whale	Endangered	No	Yes
Reptiles				
1	Green Sea Turtle	Threatened	No	Yes
2	Hawksbill Sea Turtle	Endangered	Yes	Yes
3	Kemp's Ridley Sea Turtle	Endangered	No	Yes
4	Leatherback Sea Turtle	Endangered	Yes	Yes
5	Loggerhead Sea Turtle	Threatened	Yes	Yes

6.0 Commercial and Recreational Fisheries

6.1 Overview

Though the Gulf Region includes Alabama, Louisiana, Mississippi, Texas, and West Florida, much of the following discussion will focus on Gulf states in the eastern portion of the Gulf. Federal fisheries in this region are managed by the Gulf Fishery Management Council (GMFMC) and the NMFS under seven fishery management plans (FMPs): Red Drum, Shrimp, Reef Fish, Coastal Migratory Pelagic Resources (with SAFMC), Spiny Lobster (with SAFMC), Corals, and Aquaculture. The coastal migratory pelagic resources and spiny lobster fisheries are managed in conjunction with the South Atlantic Fishery Management Council (SAFMC).

Several of the stocks or stock complexes covered in these fishery management plans, are currently listed as overfished: gray snapper, greater amberjack, and lane snapper.[7] Other impacts to commercial fisheries in the Gulf in recent years include a number of hurricanes, especially with major storms making landfall in Louisiana and Texas in 2005 (Hurricanes Katrina and Rita) and 2008 (Hurricanes Gustav and Ike). Locally, these storms severely disrupted or destroyed the infrastructure necessary to support fishing, such as vessels, fuel and ice suppliers, and fish houses.[8]

The Deepwater Horizon oil spill in 2010 severely affected fisheries in the Gulf. Large parts of the Gulf, including state and federal waters, were closed to fishing during May through October, 2010. Both Alabama and Mississippi reported less than half and Louisiana about three quarters of their annual shrimp landings compared to the average of the previous three years. The impacts of the spill remain under study and the long-term consequences of the oil spill on fish stocks and the fishing industry have yet to be fully assessed.

6.2 Commercial Fisheries

Information from the NMFS in 2013 shows that commercial fishermen in the Gulf Region landed 1.4 billion pounds of finfish and shellfish, earning $937 million in landings revenue (NMFS, 2014; NMFS, 2015). In 2014 1.1 billion pounds were landed at a value of over $1.0 billion. From 2003 to 2013, most of the commercial fisheries revenue and catch (91 percent and 96 percent respectively) was dominated by ten key species or species groups (Table 6.1).

Commercially important species groups in the Gulf include oceanic pelagic (epipelagic) fishes, reef (hard bottom) fishes, coastal pelagic species, and estuarine-dependent species. Landings revenue in 2012 was dominated by shrimp ($392 million) and menhaden ($87 million). These species comprised 63 percent of total landings revenue, and 90 percent of total landings in the Gulf Region. Other invertebrates such as blue crab, spiny lobster, and stone crab also contributed significantly to the value of commercial landings. Other finfish species that contributed substantially to the overall commercial value of the Gulf fisheries included red grouper, red snapper, and yellowfin tuna. In terms of landing weight, Atlantic menhaden far surpassed other commercial fish species in the Gulf, accounting for approximately 73 percent of the total weight of landed commercial species in 2013 (Table 6.2). However, Atlantic menhaden accounted for only about 10 percent of the total value of the Gulf commercial fishery. The portion of commercial fishery landings that occurred in nearshore and offshore waters of the Gulf States is presented in Table 6.3

In 2013, the eastern Gulf Region's seafood industry generated $527 million in sales in Alabama, $268 million in sales in Mississippi, and $15 billion in sales in Florida Table 6.4). Florida generated the largest employment, income, and value-added impacts, generating 78,000 jobs, $2.9 billion, and $5.1 billion, respectively. The

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[7] Updated information on fishery stock is available at: www.fisheries.noaa.gov/national/population-assessments/fishery-stock-status-updates

[8] Current information on US fisheries can be found at: www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/

smallest income impacts were generated in Mississippi ($200 million) and the smallest employment impacts were also generated in Mississippi (6,432 jobs) (NMFS, 2015).

Table 6.1 - Key Gulf Region Commercial Species or Species Groups

Shellfish	Finfish
Crawfish	Groupers
Blue Crab	Menhaden
Oysters	Mullets
Shrimp	Red Snapper
Stone Crab	Tunas

Table 6.2 - Total Weights and Values of Key Commercial Fishery Species in the Gulf Region in 2013 [9]

Species	Weight (thousands of lbs)	Value (Thousands of dollars)	% Weight	% Value
Menhaden	1,020,244	95,277	73.3	10.2
Shrimp	204,527	503,842	14.7	53.8
Blue crab	46,543	61,264	3.3	6.5
Oyster	19,230	76,729	1.4	8.2
Crayfish	19,823	16,593	1.4	1.8
Mullets	13,482	13,222	0.01	0.01
Stone crab	3,778	24,762	0.003	2.6
Groupers	7,280	23,396	0.005	2.5
Red snapper	5,286	20,493	0.004	2.2
Tuna	2,107	7,352	0.002	0.008
Total	1,392,364	936,660	-	-

Table 6.3 - Value of Gulf Coast Fish Landings by Distance from Shore and State for 2012 ($1,000) [10]

State	Distance from Shore	
	0-3 miles	3-200 miles
Florida (Gulf)	$ 64,727	$ 75,232
Alabama	$ 15,870	$ 27,195
Mississippi	$ 29,767	$ 19,509

In 2013 1.4 billion pounds of finfish and shellfish were landed in the Gulf Region. This was a 6.7 percent decrease from the 1.5 billion pounds landed in 2004 and a 7.0 percent increase from the 1.3 billion pounds

[9] NMFS, 2015.

[10] https://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/other-specialized-programs/preliminary-annual-landings-by-distance-from-shore/index

landed in 2012. Finfish landings experienced a 9.6 percent decrease between 2012 and 2013 while shellfish landings experienced a 1.6 percent decrease over the same period (Table 6.5).

From 2004 to 2013, species or species groups with large changes in landings include tunas (decreasing 46 percent), groupers (decreasing 39 percent), and oysters (decreasing 23 percent). Species or species groups with large changes in landings between 2012 and 2013 include crawfish (increasing 66 percent), and red snapper (increasing 24 percent) (NMFS, 2015).

The Deep-Water Horizon event had immediate effects on the Gulf fishing industry between April and November 2010, with up to 40 percent of Federal waters being closed to commercial fishing in June and July (CRS 2010). Portions of Louisiana, Alabama, Mississippi, and Florida state waters have also been closed. These areas are some of the richest fishing grounds in the Gulf for major commercial species such as shrimp, blue crab, and oysters, and as prices for these items have increased, imports of these species have likely taken the place of lost Gulf coast production. NOAA continued to reopen areas to fishing once chemical tests revealed levels of hydrocarbons or dispersants in commercial species were not of concern to human health.

It cannot be determined from these data whether the decreases in fin and shell fish landings were the result of reduced stock sizes, changes in stock geographic distribution or changes in fishing effort, however studies are currently on going and it is not known at this time whether there are long term affects to fisheries due to the spill.

Table 6.4 - 2013 Economic Impacts of the Eastern Gulf Region Seafood Industry (thousands of dollars)[11]

State	Jobs	Landings Revenue	Sales	Income	Value Added
Alabama	$ 12,090	$ 55,434	$ 526,767	$ 200,494	$ 265,580
Mississippi	$ 6,432	$ 46,618	$ 268,367	$ 107,340	$ 138,779
Florida	$ 78,378	$ 148,058	$ 15,319,435	$ 2,878,309	$ 5,136,623

Table 6.5 - Total Landings and Landings of Key Species/Species Groups From 2010 to 2013 (thousands of pounds)[12]

Landings	2010	2011	2012	2013
Finfish & other	810,649	1,472,798	987,374	1,092,148
Shellfish	261,419	319,752	305,821	300,216
Total landings	1,072,068	1,792,550	1,293,195	1,392,364

6.3 Recreational Fisheries

The NMFS (2015) estimates that in 2013, over 3.3 million recreational anglers took 25 million fishing trips in the Gulf Region. The key fish species or species groups making up most of the recreational fishery in the Gulf are listed in Table 6.6.

Of the three eastern Gulf states, western Florida had the highest number of anglers and fishing trips in 2013 (15.9 million), followed by Alabama (2.8 million), and Mississippi (1.8 million) (Table 6.7). Almost 67 percent

[11] NMFS, 2015

[12] NMFS, 2015

of the fishing trips in the Gulf coast left out of west Florida, followed by Alabama (7 percent), and Mississippi (5 percent). 41.8 percent of the total recreational fish landings (by weight) in the Gulf occurred in Florida, 12.8 percent 33 in Alabama, and 5.3 percent in Mississippi.

In Mississippi, nearly all landings were made in inland waters (98.6 percent). While the inland catch was important in Alabama (50.0 percent) and Florida (44.0 percent), the offshore catch was larger in these states, with 34.1 percent of the total catch landed up to 5 km (3 mi) from shore, and 16 percent at more than 5 km (3 mi) in Alabama and 28.7 percent at less than 16 km (10 mi), and 27.3 percent at more than 16 km (10 mi) in Florida.

Recreational fishing contributes to the Gulf state economies mainly through employment, expenditures (fishing trips and durable good), and sales. Table 6.8 shows the economic impacts of recreational fisheries by Gulf state. Recreational fishing activities generated over 87,000 full- and part-time jobs in Alabama, Mississippi and West Florida, and over $10.0 billion in sales.

Table 6.6 - Key Gulf Region Recreational Species [13]

Atlanta Croaker	Gulf and Southern Kingfish
Sand and Silver Seatrout	Spotted Seatrout
Sheepshead porgy	Red Drum
Red Snapper	Southern Flounder
Spanish Mackerel	Striped Mullet

Table 6.7 - Estimated Number of People Participating in Eastern Gulf Marine Recreational Fishing in 2013 (thousands)[14]

Location	Coastal	Non-coastal	Out of state	Total
West Florida	1,813	NA	2,538	4,351
Alabama	279	224	549	1,050
Mississippi	171	67	101	339
Gulf Total	2,263	291	3,098	5,740

Table 6.8 - 2013 Economic Impacts of Recreational Fishing Expenditures in the Eastern Gulf (thousands of dollars)[15]

Location	Trips	Jobs	Sales	Income	Value Added
Alabama	$ 2,862	$ 10,163	$ 927,409	$ 358,769	$ 569,144
Mississippi	$ 1,761	$ 1,583	$ 146,333	$ 53,602	$ 87,684
West Florida	$ 15,949	$ 76,236	$ 9,086,311	$ 3,423,836	$ 5,341,420
Total	$ 20,572	$ 87,982	$ 10,160,053	$ 3,836,207	$ 5,998,248

[13] NMFS, 2015
[14] NMFS, 2015
[15] NMFS, 2015

7.0 Coastal Zone Management Consistency and Special Aquatic Sites

This chapter addresses two of the 10 ODC: (5) The existence of special aquatic sites including, but not limited to marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas and coral reefs, and (8) Any applicable requirements of an approved Coastal Zone Management plan.

7.1 Coastal Zone Management Consistency

The Coastal Zone Management Act (CZMA) requires that any Federally-licensed or permitted activity affecting the coastal zone of a state that has an approved coastal zone management program (CZMP) be reviewed by that state for consistency with the state's program (16 USC § 1456(c)(A) Subpart D). Under the Act, applicants for Federal licenses and permits must submit a certification that the proposed activity complies with the state's approved CZMP and will be conducted in a manner consistent with the CZMP. The state then has the responsibility to either concur with or object to the consistency determination under the procedures set forth by the Act and their approved plan.

Consistency certifications are required to include the following information (15 CFR § 930.58): "A detailed description of the proposed activity and its associated facilities, including maps, diagrams, and other technical data; a brief assessment relating the probable coastal zone effects of the proposal and its associated facilities to relevant elements of the CZMP; a brief set of findings indicating that the proposed activity, its associated facilities, and their effects are consistent with relevant provisions of the CZMP; and any other information required by the state."

The states of Mississippi, Alabama, and Florida have federally approved CZMP. Each Gulf state has specific requirements in their CZMA plans that outline procedures for determining whether the permitted activity is consistent with the provision of the program.

Discharges covered by the proposed permit will occur in Federal waters outside the boundaries of the coastal zones of the State of Florida. However, because these discharges could create the potential for impacts on state waters, consistency determinations for the individual NPDES permit will be prepared by the proposed project and submitted to the State of Florida. The following summaries describe the requirements of the state's management plan for consistency determination. The permit applicant must provide the necessary data and information for the state to determine that the proposed activities comply with the enforceable policies of the states' approved program, and that such activities will be conducted in a manner consistent with the program.

7.2 Florida Coastal Management Program

The Florida Coastal Management Program (FCMP) was approved by NOAA in 1981 and is codified at Chapter 380, Part II, F.S. The State of Florida's coastal zone includes the area encompassed by the state's 67 counties and its territorial seas. The FCMP consists of a network of 24 state statutes administered by eight state agencies and five water management districts.

The review of federal activities is coordinated with the appropriate state agency. Each agency is given an opportunity to provide comments on the merits of the proposed action, address concerns, make recommendations, and state whether the project is consistent with its statutory authorities in the FCMP. Regional planning councils and local governments also may participate in the federal consistency review process by advising the Department of Economic Opportunity (DEO) on the local and regional impact of proposed federal actions. Comments provided by regional planning councils and local governments are considered by the DEO in determining whether the proposed federal activity is consistent with specific sections of Chapter 163, Part II, F.S., that are included in the FCMP. If a state agency determines that a proposed activity is inconsistent, the agency must explain the reason for the objection, identify the statutes the activity conflicts with and identify any alternatives that would make the project consistent.

Federal consistency reviews are integrated into other review processes conducted by the state depending on the type of federal action being proposed. The Florida State Clearinghouse administered by the Florida Department of Environmental Protection (FDEP) Office of Intergovernmental Programs, is the primary contact for receipt of consistency evaluations from federal agencies. The Clearinghouse coordinates the state's review of applications for federal permits other than permits issued under Section 404 of the CWA and Section 10 of the Rivers and Harbors Act. As the designated lead coastal agency for the state, the FDEP communicates the agencies' comments and the state's final consistency decision to federal agencies and applicants for all actions other than permits issued under CWA Section 404 and Section 10 of the Rivers and Harbors Act.

7.3 Special Aquatic Sites

Special aquatic sites are "geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region" (40 CFR § 230.3). Areas of high relief ridges and outcroppings occur on the west Florida Shelf (Figure 7-1). These include the Madison-Swanson Marine Reserve, Florida Middle Grounds, Pulley Ridge, Steamboat Lumps Special Management Area, and Sticky Ground Mounds (BOEM, 2013).

7.3.1 Madison-Swanson/Steamboat Lumps Marine Reserves/The Edges

Madison-Swanson and Steamboat Lumps Marine Reserves are at two ends of a line of ridges beginning north of Tampa Bay along the 100 m isobath. Madison-Swanson and Steamboat Lumps were protected initially in 2002 and are now established Marine Protected Areas; no-take marine reserves sited on gag spawning aggregation areas where all fishing is prohibited (219 square nautical miles). With the addition of The Edges, during seasonal closures, Madison-Swanson and Steamboat Lumps cover 600 square miles.

7.3.2 Florida Middle Grounds HAPC (1984)

These reefs consist of a series of both high and low relief limestone ledges and pinnacles that exceed 15 meters (49 feet) in some areas. The area consists of roughly 348 nm^2 of this hardbottom region 150 kilometers (93 miles) south of the panhandle coast and 160 kilometers (99 miles) northwest of Tampa Bay. It is a Habitat Area of Particular Concern protected by preventing use of any fishing gear interfacing with bottom.

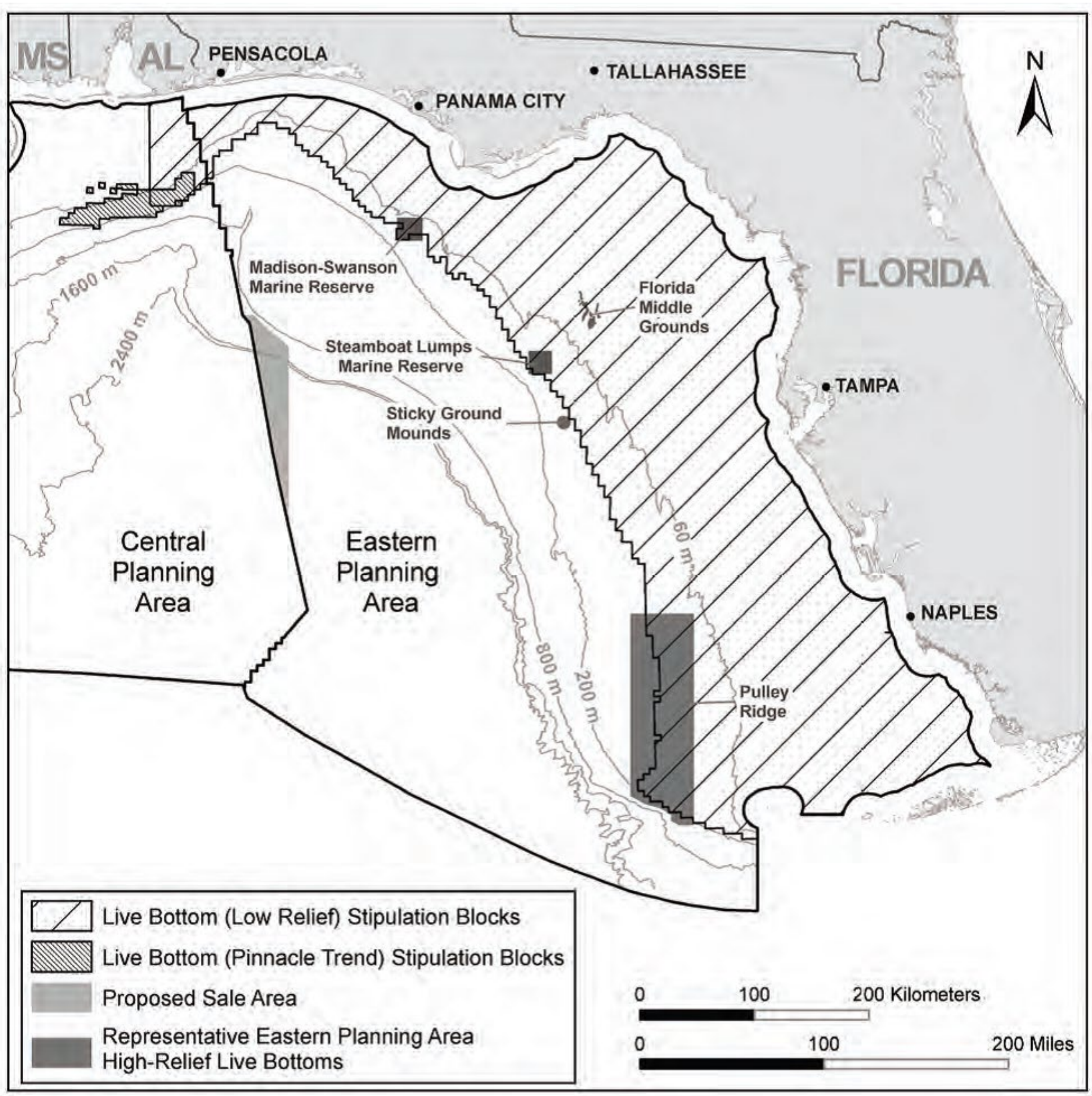
7.3.3 Pulley Ridge

Pulley Ridge is the deepest known photosynthetic coral reef off the continental United States. The area contains a near pristine, deep water reef characteristic of the coral reefs of the Caribbean Sea which are located in the southern quadrant of Pulley Ridge. These coral reefs occupy an area of about 111 square nautical miles. In 2005, a section of Pulley Ridge was designated as Habitat Area of Particular Concern (HAPC), which prohibited bottom anchoring by fishing vessels, bottom trawling, bottom longlines, buoy gear, and all trap/pot use in the area.

7.3.4 Sticky Ground Mounds

Shelf-margin carbonate mounds in water depths of 116–135 m in the eastern Gulf along the central west Florida shelf, off Tampa Bay. Various species of sessile attached reef fauna and flora grow on the exposed hard grounds. Some taller species (e.g., sea whips and other gorgonians) appear to survive this intermittent sand movement and accretion. Surveys on the southwest Florida Shelf revealed that the biotic cover on the live bottom patches is generally low and that the patches tend to be dominated by either algae or encrusting invertebrates (Woodward Clyde Consultants and CSA, 1984).

Figure 7. 1 – High Relief Live Bottom Areas in the Central and Eastern Gulf[16]



[16] BOEM, 2015

8.0 Federal Water Quality Criteria and Florida Water Quality Standards

Factor 10 of the 10 factors used to determine no unreasonable degradation requires the assessment of Federal marine water quality criteria and applicable state water quality standards (WQS).

8.1 Federal Water Quality Criteria

Pursuant to CWA § 303(c), the implementing regulations in 40 CFR § 131 establish the requirements for states and tribes to review, revise and adopt WQS. The regulations also establish the procedures for EPA to review, approve, disapprove and promulgate WQS pursuant to the CWA. State WQS apply within the jurisdictional waters of the state. For marine waters, state WQS apply within three nautical miles of shore. There are no WQS that apply for marine waters in the Gulf seaward of the three nautical mile boundary.

Section 304 of the CWA requires EPA to develop criteria for ambient water quality that accurately reflect the latest scientific knowledge on the impacts of pollutants on human health and the environment.[17] EPA designs aquatic life criteria to protect both freshwater and saltwater organisms from short-term and long-term exposure. Aquatic life criteria are based on how much of a chemical can be present in surface water before it is likely to harm plant and animal life. EPA's Section 304(a) criteria are not laws or regulations; they are guidance that states or Tribes may use as a starting point when developing their own WQS.

8.2 Florida Water Quality Standards

The proposed facility will be located approximately 45 miles seaward of Sarasota Bay, Florida, beyond the jurisdictional waters of the State of Florida. The WQS promulgated by Florida are not applicable to the proposed project because the project is within federal waters of the Gulf; however, some information about Florida's WQS is presented below.

WQS for the surface waters of Florida are established by the Department of Environmental Regulation in the Official Compilation of Rules and Regulations of the State of Florida, Chapter 62-302: Surface Water Quality Standards (Effective March 27, 2018).[18] Minimum criteria apply to all surface waters of the state and require that all places shall at all times be free from discharges that, alone or in combination with other substances or in combination with other components of discharges, cause any of the following conditions.

- Settleable pollutants to form putrescent deposits or otherwise create a nuisance
- Floating debris, scum, oil, or other matter in such amounts as to form nuisances
- Color, odor, taste, turbidity, or other conditions in such degree as to create a nuisance
- Acute toxicity (defined as greater than 1/3 of the 96-hour LC_{50})
- Concentrations of pollutants that are carcinogenic, mutagenic, or teratogenic to human beings or to significant, locally occurring wildlife or aquatic species
- Serious danger to the public health, safety, or welfare.

These general criteria of surface water apply to all surface waters except within zones of mixing. A mixing zone is defined as the surface water surrounding the area of discharge "within which an opportunity for the mixture of wastes with receiving waters has been afforded." Effluent limitations can be set where the analytical detection limit for pollutants is higher than the limitation based on computation of concentration in the receiving water.

[17] Current federal water quality criteria are found here: www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
[18] https://floridadep.gov/dear/water-quality-standards

The antidegradation policy of the standards that applies in Florida waters requires that new and existing sources be subject to the highest statutory and regulatory requirements under Sections 301(b) and 306 of the CWA. In addition, water quality and existing uses of the receiving water shall be maintained and violations of WQS shall not be allowed.

As discussed in Section 3, all point source wastewater discharges are subject to a NPDES permit. Potential impacts from fish wastes will be determined by water quality and benthic monitoring to ensure that no unreasonable degradation of the marine environment will occur in accordance with Section 403 of the CWA.

9.0 Potential Impacts

This section summarizes the potential impacts to receiving waters of the Gulf that might occur as a result of the discharges from the proposed project. Also discussed in this section is the transport and persistence (Factor 2) and the toxicity and bioaccumulation potential (Factors 1 and 6) of pollutants discharged from the proposed facility.

9.1 Overview

Net pen aquaculture and its resultant discharges may have effects on water and sediment quality and the plant and animal communities living in the water column and those in close association with, on or in the sediments. The major discharges, uneaten fish food and fish metabolic wastes, are likely to have their greatest impacts on the water column, benthos and related communities.

The two major factors which determine the geographic distribution and severity of impacts of net pens on the water column, seafloor sediments and benthic communities are farm operations management and siting.

Farm Operations Management

1. Loading. The biomass of fish reared in the pens is proportional to the amount of organic matter deposited from the pens. The greater the density of fish, the more concentrated the deposition of organic waste.
2. Pen size. Larger pens, with the same loading, deposit sediments over a relatively smaller area (Earll et al 1984). Thus, the effects are more concentrated, however, the size of the area affected is less.
3. Pen configuration. Pen configuration and orientation to the predominant currents can significantly affect the dispersion of wastes.
4. Feed type. Different feeds have different settling rates. Slower rates allow greater dispersion. In addition, feed that has lower carbon and nitrogen levels and higher digestibility will produce less organic matter on the bottom.
5. Feeding method. Feeding methods can affect both wastage of feed and utilization of that feed by the fish. In one study, hand feeding resulted in 3.6 percent wastage, and up to 27.0 grams per meter squared per day (g/m2/day) organic matter deposition on the bottom. The use of automatic feeders resulted in wastage of 8.8 percent and a maximum deposition of 88.1 g/m2/day (Cross, 1988).

Siting

1. Water depth and current velocity. In deeper water and faster currents, the dispersion of wastes will be greater.
2. Bottom current velocity. High bottom current velocities can erode and disperse resuspended sediments regardless of dispersion in the total water column.
3. Bottom sediments and community. The benthic community will also affect the impact. Areas of high biological productivity may be able to assimilate higher organic deposition. However, adverse impacts may have greater significance due to the importance of such productive areas. Conversely, areas having few organisms may have less assimilative capacity, but creation of an azoic zone may have less effect on the biological community

9.2 Water Column Impacts

The water quality around coastal fish farms is affected by the release of dissolved and particulate inorganic and organic nutrients. Water column effects around fish farms include a decrease in dissolved oxygen and increases in biological oxygen demand, and nutrients (P, total C and organic and inorganic N) (Penczak et al., 1982). Degradation of water quality parameters is greatest within the fish culture structures and improves rapidly with distance from holding pens. Recent studies have documented only limited water column impacts due to rapid dispersal (Holmer, 2010). The health of the fish stocks is a self-limiting control on water column pollution. Another review found that though the probability of any measurable impact from an offshore farm appears to significantly decrease with distance from the farm, such information suffers from a general lack of robustness and should be quantified with better systematic and standardized reporting with respect to physical farm characteristics (Froehlich et. al., 2017).

9.2.1 Turbidity

Turbidity, an indication of water clarity, may be affected by fish farming operations. The loss of fish food and feces is the largest source of increase in turbidity around net pens. Net cleaning can also significantly increase turbidity down current of net pens. Turbidity will likely be most affected by cage siting with current velocities and tidal influence the major factors. A study in the Puget Sound reported that floating net pens did not affect turbidity (NMFS 1983). Turbidity ranged from 0.5 to 2.0 NTU throughout the study, but measurements were not taken during net cleaning. In other studies, suspended solid concentrations and light attenuation (due to turbidity) were found to be insignificant or localized.

9.2.2 pH

The effects of fish farming on water column pH was studied by Pease (1977) who reported that a net-pen facility in a poorly flushed, log rafting area (Henderson Inlet, Washington) did not affect pH. Pease also reported that tidal factors were the primary factor regulating pH at all sites.

9.2.3 Temperature

The operation of floating net pens would not affect water temperatures in the Gulf. Net pens have no features that would measurably change heat loss or heat gain in surrounding waters.

9.2.4 Fecal Coliforms

Fecal coliform bacteria are produced in the digestive tracts of warm-blooded animals. Net pens do not directly affect ambient (existing) fecal coliform concentrations in surrounding waters because fecal coliforms are not produced in fish. However, fecal coliform levels could indirectly increase near net pens from increased marine bird and mammal activity or human activity.

9.2.5 Nutrients

Nutrient addition to the Gulf is of concern because they contribute to certain harmful algal blooms (HABs). HABs are on the rise in frequency, duration, and intensity in the Gulf, largely because of human activities (Corcoran, et.al., 2013). Of the more than 70 HAB species occurring in the Gulf, the best-known is the red tide organism, *Karenia brevis*, which blooms frequently along the west coast of Florida. Macronutrients, micronutrients and vitamins characteristic of fish farms are growth-promoting factors for phytoplankton. The primary nutrients of interest in relation to net pens are nitrogen and phosphorus; both may cause excess growth of phytoplankton and lead to both aesthetic and water quality problems. Generally, in marine waters, phytoplankton growth is either light or nitrogen limited, and phosphorus is not as critical a nutrient as it is in fresh water (Ryther and Dunstan, 1971; Welch, 1980). However, it has been shown that because nutrient fluctuations in the Gulf can be significant due to the large inputs from river systems, both nitrogen limitation and phosphorus limitation can happen in different locations, but during the same time frame (Turner and Rabalais, 2013)

Nitrogen may be categorized as: (1) inorganic (nitrate, nitrite and ammonia and nitrogen gas); and (2) organic (urea and cellular tissue). Most of the organic matter in waste food and feces from net pens is composed of organic carbon and nitrogen (Liao and Mayo, 1974; Clark et al., 1985). About 22 percent of the consumed nitrogen is retained within the fish tissue and the remainder (78 percent) is lost as excretory and fecal matter (Gowen and Bradbury 1987). In a summary of nitrogen budgets in marine cage aquaculture, Islam (2005) reported that 68–86 percent of the nitrogen input as feed is eventually released to the environment. In a recent study, it was determined that about 63 percent of nitrogen fed at a rainbow trout *Oncorhynchus mykiss* farm was lost as dissolved nitrogen (Norði et al., 2011).

Approximately 87 percent of the metabolic waste nitrogen is in the dissolved form of ammonia and urea; the remainder (13 percent) is lost with the feces (Hochachaka, 1969). Salmon will produce approximately 0.22 to 0.28 grams of all forms of dissolved nitrogen per day per kilogram of fish produced annually (Ackefors and Sodergren, 1985; Penczak et al., 1982; Warren-Hansen, 1982). Ammonia and urea are essentially interchangeable as phytoplankton nutrients. Immediately downstream of most net pens (5-30 m) the concentration of ammonia diminishes greatly. This decrease is probably due to the natural microbial process of nitrification (oxidation of ammonia to nitrites and nitrates). Rapid rates of nitrification are expected in any well-oxygenated aquatic environment (Harris 1986). The effects of these factors on phytoplankton near fish farms are variable and not enough scientific evidence is available to suggest that macronutrients and micronutrients from fish farming, or the proposed project, can be directly related to the occurrence of red tides.

9.2.6 Ammonia Toxicity

Toxic chemicals would not be introduced into the net pens from fish stock or food. Ammonia in the un-ionized form (NH_3) is toxic to fish at high concentrations depending on water temperature and pH (EPA, 1986). High ammonia levels in fish excrement have been shown to raise ambient (existing) ammonia concentrations. Normal concentrations of ionized and un-ionized ammonia in Gulf waters are very low, with some variability. A small percentage of the ammonia originating from net pens typically about 2 percent, will be of the toxic, un-ionized form.

Near-field studies in Washington state (Milner-Rensel, 1986; Rensel, 1988 b,c) have shown increased concentrations of ammonia immediately downstream or within the net pens. Total ammonia values typically have increased from 3 to 55 percent above the low background levels. The highest observed concentrations were only a small fraction of the maximum four-day, chronic exposure level recommended by EPA (1986). A long-term study, under worst-case conditions in southern Puget Sound, found that the greatest concentration of total ammonia observed at any time was 0.176 mg/l, equivalent to 0.006 mg/l un-ionized ammonia, well below chronic exposure threshold (Pease, 1977).

In summary, increases in dissolved nitrogen (including ammonia) are typically seen within salmon net pens. Immediately downstream, nitrogen or ammonia levels may also be elevated compared to ambient, upstream values. However, results are variable (Price and Morris, 2013). In some cases, concentrations were greater or much less than expected compared to predicted values based on freshwater hatchery data. However, even within the net pens, toxic concentrations of un-ionized ammonia were not approached. Net pen fish culture in open Gulf waters will be characterized by relatively large volumes of water passing through cages per unit of fish production. This results in much greater dilution of waste products such as ammonia in net pens when compared to freshwater hatcheries or municipal sewage discharges (Weston, 1986).

9.2.7 Phosphorus

Although nitrogen is generally considered to be the limiting macro-nutrient in many ocean waters, increasing phosphorus levels in coastal waters due to anthropogenic sources is also of concern because some marine systems can be phosphorus limited. Increased phosphorus may, along with nitrogen, contribute to algal blooms and coastal eutrophication. Like nitrogen, the principal sources of phosphorus from fish farms are uneaten food, fecal matter and metabolic wastes. A review of phosphorus budgets of marine cage aquaculture reported that an average of 71.4 percent of the phosphorus in feed was released into the environment, the amounts depending on species cultured, feed type, and feeding efficiency (Islam, 2005). Though fewer studies looked at phosphorus impacts, of those that did, a number showed measurable increases in dissolved phosphorus around net pens, several showed statistically significant increases (Price and Morris, 2013).

9.2.7 Dissolved Oxygen

Dissolved oxygen consumption by fish, and by microbial decomposition of fish wastes and excess food, could significantly reduce water column dissolved oxygen concentrations near the pens. Most of the microbial decomposition is associated with solids that settle to the bottom (Institute of Aquaculture, 1988). Thus, the greatest potential for oxygen consumption would be from fish respiration near the surface and microbial decomposition near the bottom.

The total effect of oxygen consumption from net-pen operations on dissolved oxygen concentrations near the pens is highly variable. The loss of dissolved oxygen depends on the water exchange rate near pens, fish density, and fish feeding rate. If the water exchange rate near the pens is high, there will be less reduction of dissolved oxygen. If the fish density and fish feeding rate are high, there will be increased dissolved oxygen.

In general, the dissolved oxygen requirements of fish raised in net pens limit the impact net pens can have on the environment. The lowest oxygen levels caused by net pens are likely to occur within the net pens and immediately down current. Thus, the impact of low dissolved oxygen is likely to affect the net-pen operation before having an effect on the surrounding environment.

9.3 Organic Enrichment Impacts to Seafloor Sediments

Numerous studies have shown that organic enrichment of the seabed is the most widely encountered environmental effect of culturing fish in cages (Karakassis et al., 2000, Karakassis et al., 2002, Price and Morris, 2013). The spatial patterns of organic enrichment from fish farms varies with physical conditions at the sites and farm specifics and has been detected at distances from meters to several hundred meters from the perimeter of the cage array (Mangion et al., 2014). Studies of fish farms in the Mediterranean showed that the severe effects of organic inputs from fish farming on benthic macrofauna are limited to up to 25 m from the edge of the cages (Lampadariou et al., 2005) although the influence of carbon and nitrogen from farm effluents in sea floor can be detected in a wide area about 1,000 m from the cages (Sara et al., 2004). The impacts on the seabed beneath the cages were found to range from very significant to relatively negligible depending on sediment type and the local water currents, with silty sediments having a higher potential for degradation.

Sedimentation rates are often 1-3 orders of magnitude higher at fish farms compared to unaffected areas of the coast (Brown et al., 1987; Hall et al., 1990). Weston and Gowen (1988) found the greatest sediment deposition occurred in the direction of the dominant current. Sediment traps under the pens estimated deposition of 52.1 kilograms dry weight per meter squared per year (kg dry wt./m^2/yr) and 29.7 kg dry wt./m^2/yr at the pen perimeter.

Sedimentation effects from net pens are the result of two major factors, additional particulate organic input and inorganic sediment deposition. An additional factor contributing to sedimentation is organic matter that grows on nets and is dislodged from the net during cleaning. This source contributes relatively little to the total sedimentation generated by a net-pen operation (Weston, 1986). The organic input from these sources affects both the chemical composition of the sediments and the responses of the organisms in the sediment (Pearson and Rosenberg, 1978). A review of more recent studies pertaining to nutrient and organic carbon loading to sediments from fish farms around the world can be found in Price and Morris (2013).

One of the main impacts of organic enrichment to seafloor sediments is the stimulation of sediment metabolism, i.e., increased microbial activity, sediment oxygen demand and nutrient release (Holmer, 1991). High organic loading to the sea floor may result in the development of anoxic and reducing conditions and the production of toxic gases, i.e., ammonia, methane and hydrogen sulfide (H_2S).

In undisturbed sediments, oxygen is only able to penetrate a short distance depending upon sediment porosity, bioturbation (activity of burrowing organisms), and current velocity, which controls the rate at which oxygen is renewed at the sediment surface. Oxygenated sediments are typically light tan to light grey in color. Below this oxic layer, sediments are oxygen depleted (anoxic). Anoxic sediments are characterized by their dark black color, and the production of hydrogen sulfide gas. With increasing organic loading, the demand for oxygen for microbial processes and reoxidation of reduced mineralization products increases.

Sediment oxygen demand (SOD) near fish farms can exceed the diffusive oxygen influx and the anoxic layer moves closer to the surface (Brown et al., 1987). Studies have shown that sediment oxygen demand of sediments enriched by fish-farming activities can be 2-5 times higher than in control areas (Hargrave, et al., 1993). In these cases, the organic material often forms a layer over the original sediments. In stagnant areas of poor circulation, oxygen demand by the anoxic sediments will reduce the dissolved oxygen in the overlying water. Anaerobic metabolism of sediments becomes important in organic matter decomposition near farms (Hall et al., 1990). Studies show that soleplate reduction is the terminal process for organic oxidation. Anaerobic decomposition of the organic matter under these conditions may also lead to production of methane in sufficient quantities to produce visible bubbles at the surface. At this point hydrogen sulfide will reach concentrations that allow its distinctive "rotten egg" smell to be detected in the water. H_2S is highly toxic, making these sediments toxic, and at higher concentrations can lead to mortality of fish in pens.

The oxidation-reduction (redox) potential (positive = oxic; negative = anoxic) gives a relative indication of the degree of enrichment. Negative oxidation-reduction (redox) values, indicating a strong possibility of anaerobic conditions and the production of H_2S, are common in sediments near and beneath net pens (Brown et al., 1987). As organic matter continues to accumulate oxygen penetration into sediments are decreased and redox potential values become more negative. Mats of white supplied oxidizing bacteria *Beggiatoa spp*. covering the seafloor beneath salmonid cages have been observed (Hall et al. 1990).

It is estimated that only about 10 percent of the organic matter deposited from net pens each year is broken down through microbial decomposition (Aure and Stigebrandt, 1990), and decomposition has been shown to be inversely related to accumulation. Of the total carbon, nitrogen and phosphorous deposited to sediments, around 79 percent, 88 percent and 95 percent respectively will accumulate and become unavailable to the environment. Release of phosphorous to the environment is insignificant when deposits are greater than 7 cm. Nitrogen mineralization is very slow in normally anaerobic sediments beneath net pens where bioturbation and epifaunal reworking of sediments is minimized. In some studies, it was shown that nitrogen cycling, nitrification (converting ammonium to nitrate) and denitrification (converting nitrate to N_2 gas) ceased. Most of the nitrogen is released to the water as ammonium and dissolved organic nitrogen.

A review of 41 papers (Kalantzi and Karakassis, 2006) covering a wide range of cultured species, habitats, site characteristics and farm management practices concluded that their analysis suggests that the impact radius at fish farms generally decreases with increased depth, at low latitudes and over fine sediment. The authors, however, state that applying common standards over large geographic areas is challenging due to the complex interplay of site characteristics among the studies they reviewed. A 2012 study of a farm in Norway in 190 meters of water showed that despite deep water and low water currents, sediments underneath the farm were heavily enriched with organic matter, resulting in stimulated biogeochemical cycling concluding that water depth alone may not be sufficient (Valdemarsen, et.al., 2012). In another review of 64 studies of benthic fish farm impacts, Giles (2008) developed a quantitative assessment of the relationships between impact parameters and site and farm characteristics. The analysis showed that benthic impact was a function of fish density, farm volume, food conversion ratio, water depth, current strength and sediment mud content. The analysis also suggested that fish farm impacts were confined to a radius of about 40 to 70 m around the farms, however, the inability to satisfactorily model parameters as a function of distance from farms demonstrated the complexity of the spatial distribution of the farms studied.

9.4 Organic Enrichment Impacts to Benthic Communities

The deposition of uneaten fish feed and feces may affect benthic communities in several ways. The accumulation of organic and inorganic particulates may impact benthic flora and fauna. Significant changes in the proportion of the fine sediment fractions can alter the microstructure of the habitat supporting macroinfauna and meiofauna communities resulting in changes in both structure and function. High sedimentation rates may interfere with feeding mechanisms of deposit and filter feeders. Benthic epifauna and flora may be buried at very high rates of sedimentation. Sedimentation rates are often 1-3 orders of magnitude higher at fish farms compared to unaffected areas (Brown et al., 1987; Hall et al., 1990; Holmer, 1991).

Sedimentation from net pens decreases sediment oxygen levels by increasing the demand for oxygen, and by decreasing both diffusion and water flow into the interstitial spaces of the sediment. As increasing amounts of fine sediment accumulate, the depth to which oxygen penetrates is reduced and the underlying sediment layers become devoid of oxygen (anoxic) and unable to support animal life. The only organisms found in such sediments will be those that have access to the surface waters for respiration via burrows or siphons, and anaerobic bacteria, which derive energy from sources other than oxygen.

Depending on the rates of organic loading, community structure near net pens may become dominated by pollution tolerant species or fauna may disappear entirely. Impact studies show variable results with some showing a clear correlation between the deposition of fish wastes and community changes (Brown et al., 1987). Pearson and Rosenberg (1978) present a comprehensive review of the impacts of organic enrichment from a variety of natural and man-made sources on bottom sediments and the associated benthic community. The authors show that benthic communities tend to respond along a gradient of organic loading with effects most pronounced near the source and decrease progressively with increasing distance.

In undisturbed sediments a stable, diverse benthic community exists comprised of relatively large epibenthic (surface dwelling) organisms, smaller burrowing organisms (< 0.5 mm) comprising the macroinfauna and the meiofauna, smaller (< 0.064 mm) that occupy the interstitial spaces between sediment particles. As organic matter is introduced into an undisturbed environment, it provides an additional source of nutrition for the benthic organisms. This additional organic matter benefits the existing filter- and deposit- feeders, and encourages colonization by additional species. Thus, both species diversity and biomass (total weight) of the benthic organisms increases, and the benthic community is enhanced. The authors refer to this as the "transition zone."

Earll et al. (1984) observed benthic conditions below 25 net-pen facilities in Scotland. He noted that the redox potentials were reduced to a distance of 20 to 30 m from the pens and that Beggiatoa first appeared 10 to 15 m from the pen perimeter. Outside this zone, the sediment surface appeared normal and was light brown in color with a thin covering of diatoms. Predator species such as crab, flatfish, nudibranchs, and anenomes were abundant. Scallops, starfish, and sea cucumbers were also observed. Stewart (1984) noted that organic loading, carbon:nitrogen ratios, and redox potentials were essentially normal beyond 40 m of a pen site. He concluded that the transition zone extended 37 to 100 m from the pens.

High species abundance and diversity, representing both pre-existing species and newly colonized species, were found in a zone 15 to 120 m from pens by Brown et al. (1987). Gowen et al. (1988) observed that total organic carbon, redox potentials and dissolved oxygen levels were normal beyond 15 m of the pens, and that opportunistic species dominated the zone between 15 and 120 m, with the inner boundary of the transition zone being 20 to 25 m from the pen boundary.

In studies conducted by Weston and Gowen (1988) it was estimated that normal benthic communities extended to within 150 to 450 m of the pens. Mobile predators are also abundant in this area, including flat fish (Pease 1984) and crab (Earll et. al., 1984; Cross, 1988). Weston and Gowen (1988) concluded that changes in the biological community extended beyond the zone where chemical changes were detectable. Weston (1990) studied benthic infauna response to organic enrichment at a large Puget sound fish farm. Species richness, biomass and size of organisms decreased near the cages. Total abundance of individuals increased when nematodes (pollution tolerant species) were included. Suspension and deposit feeders found at 450 m either disappeared or were greatly reduced near cages.

Pearson and Rosenberg (1978) observed that as the level of organic input continues to increase, the sediments become progressively dominated by various opportunistic deposit feeders which are able to flourish under these conditions. The most notable deposit feeder is the small, common polychaeta worm *Capitella capitata,* indicative of organic enrichment. Under these conditions, the abundance of these opportunistic species can reach very high densities, to the exclusion of other species. Elimination of the larger, deeper borrowing animals further reduces the ability of oxygen to penetrate the sediments.

Gowen et al. (1988), and Brown et al. (1987) observed that the area between 3 and 15 m was almost exclusively dominated by opportunistic polychaete worms, especially *Capitella capitata.* The total number of species in this zone was about 20 percent of that in undisturbed sediments. The number of individuals, however, was 2 to 3 times normal with total biomass slightly below normal. All of the organisms were polychaete worms, with *Capitella capitata* representing 80 percent of the total organisms. Weston and Gowen (1988) observed increased concentrations of carbon, nitrogen, and reduced redox potentials between 15 and 60 m down current (east) from net pens in the Puget Sound. The abundance of organisms was approximately 4 times greater than background at the pen perimeter and declined to background levels at about 45 m, with *Capitella capitata* the dominant species. Biomass was reduced to about 45 m and increased moderately between 90 and 150 m. Normal conditions were reached between 150 and 450 m from the pens. Pease (1984) reported that geoduck (bivalve mollusk) abundance increased in this area away from the pens. No geoducks were found in the area occupied by *Bogota*. However, in a more recently developed site in British Columbia, geoducks were observed in within the more distant area occupied by *Beggiotoa* (Cross 1988).

At very high rates of organic sedimentation, few species can survive. At this point, the anoxic layer reaches the sediment surface, depriving the animals of oxygen and exposing them to toxic H2S. In these sediments, the surface is black and devoid of any animals (azoic). Gowen et al. (1988) estimated that input of organic matter at rates greater than about 8 g carbon/m /day resulted in production of methane and azoic conditions. At low concentrations, H_2S can reduce fish health through gill damage and at higher concentrations be toxic to fish in the pens above the sediments. Such affects have only been reported in stagnant areas with little water circulation.

Azoic zones have been reported under most net pens, though their presence depends on the size (amounts of wastes produced) of the fish farm (Weston and Gowen 1988) and water circulation beneath and around cages (Weston 1986; Institute of Aquaculture 1988). The absence of *Beggiotoa* under the pens observed by Earll et al. (1984) was attributed to its need for both oxygen from surface water and H_2S from the anoxic sediments. No live animals were observed in this zone; however, occasional dead starfish, nudibranchs and sea cucumbers were observed on the surface. Gas bubbles (methane) were evident in the sediment and redox potentials were severely depressed. Stewart (1984) observed these conditions to extend to about 3 m from the pen perimeter. observed a zone of dark, black sediments under most net pens observed. Similar observations are reported by Gowen et al., (1988) extending 3 m from the pens. In this zone, total organic carbon levels are about twice background levels and redox potentials were consistently less than -100 mV, despite seasonal variations. Dissolved oxygen in the overlying water was reduced and gas bubbles were observed. Hall and Holy (1986) measured chemical changes below a small net pen complex. Both total organic carbon and nitrogen concentrations were increased ten-fold above background levels, and benthic oxygen consumption was increased 12 to 15 times. Deposition under these pens was 50 to 200 g/m2/day total solids, about 20 times higher than background.

The effects of organic enrichment of the sediments begins quickly after installation and operation of the net pens. Weston and Gowen (1988) observed only limited changes in the community at the Squaxin Island site after 18 months of operation. Ritz et al. (1989) saw a decline in macroinfauna signifying moderately disturbed conditions (biomass>abundance) beneath salmonid cages in Tasmania within seven weeks of fish stocking. Infauna community conditions (biomass<abundance) returned to normal within seven weeks after harvest. Further measurable change at 14 weeks post-harvest. Species richness increased by a factor of 2.5 after fish were harvested. Mazzola et al. (1999) examined changes in meiofauna community structure at a Mediterranean fish farm. Sediments reached reducing conditions within 6 weeks of commencement of culture operations. Meiofauna species richness and abundance decreased (on average 70 percent) within three months.

Recovery of affected benthic communities may take a period of months or years, however, the benthic sediment chemistry appears to recover to normal levels relatively rapidly. In Puget Sound, Pamatmat et al. (1973) observed normal benthic oxygen consumption 2 months after pen removal. Dixon (1986) noted that bottom sediments appeared normal at two pen sites in the Shetland Island, 12 months after removal of the pens. Biological recovery may take much longer depending on the successional colonization of the area by different species and normal recruitment cycles (Pearson and Rosenberg, 1978). Species abundance will recover more quickly than biomass due to the growth rates of the larger animals. Rosenberg (1976) observed that the recovery of the area surrounding a pulp mill discharged required 3 to 8 years to recover.

An extensive review of more recent studies (since 2000) of fish farming impacts to benthic communities can be found in Price and Morris (2013).

9.5 Antibiotics

Three antibiotics are currently registered by the U.S. Food and Drug Administration (FDA) for use in treating fishes farmed for human consumption. Austin (1985) discussed the effects of antimicrobial compounds that are used in fish farming and that may escape into the environment. He noted that data are not available on the quantities of antimicrobial compounds entering the environment from fish farming. However, his research provides estimates of probable concentrations of antibiotics leaving freshwater fish farms. The estimated dilution of Oxytetracycline (OTC), based on maximum allowable levels of administration, was 1 part in 50,000,000. This dilution was regarded as a worst-case estimate, based on no retention of the administered drug in the fish. Thus, Austin (1985) concludes that the concentrations of drugs reaching the environment are very small.

Austin (1985) noted that use of antibiotics in fish farms could lead to an increase in antibiotic resistance among bacteria in the farm effluent. Other authors have reported the phenomenon of antibiotic resistance of bacteria near fish farms in which the medications are applied (Aoki, 1975, 1988; Aoki et al., 1971, 1972b, 1974, 1977, 1980, 1984, 1985, 1986a, 1987a; Aoki and Takahashi, 1986; Takashima, et al 1985; Bullock et al., 1974; Toranzo et al., 1983). Bacteria can gain antibiotic resistance through the selection of bacteria which contain resistance factors, or plasmids, some of which may be transferable from one fish pathogenic bacterium to another under certain conditions (Akashi and Aoki, 1986b; Aoki and Kitao, 1985; Aoki and Takahashi, 1987; Aoki et al., 1972a, 1986b, 1987b, 1981; Mitoma et al., 1984; Toranzo et al., 1984). It is also known that the plasmids, or resistance factors, can confer resistance to more than one antibiotic when transferred from one bacterium to another (Aoki et al., 1987a). The presence of plasmids has been documented in both fish pathogenic bacteria (see above citations) and in native aquatic bacteria (Burton et al., 1982).

An FDA study to evaluate the use of OTC for aquatic applications analyzed the environmental impact of the antibiotic on disease control in lobsters held in impoundments Katz (1984). Based on seawater dilution and lack of long-term selective pressure favoring the persistence of OTC resistant organisms, Katz (1984) concluded that "there should be no build-up of antibiotic resistant population of microorganisms from the use of OTC in treating gaffkemia in lobsters." In the same report, Katz concluded that "the potential of R-factor (resistance-factor) transfer between organisms should be minimal", due to dilution, low levels of nutrients, low temperatures, and high salinity of seawater.

The technical literature cited above indicates the several factors. They are occurrence of antibiotic resistant bacteria in association with aquaculture depends on the diversity, frequency, and dosage of antibiotic administration, and environmental conditions of culture including temperature, dilution of the antibiotics, and the containment of the fish and associated bacteria.

The reports of antibiotic resistance from Japan are from very intensive aquaculture sites characterized by warm temperatures, high densities of fish grown in confined ponds, and the use of a variety of antibiotics not registered for use in the United States. As well, the dosage and duration of antibiotic treatment in Japan appears to exceed both legal and general practices in the United States. Thus, while these studies document antibiotic resistance in fish pathogenic bacteria due to the administration of antibiotics, they should not be interpreted to indicate that similar antibiotic resistance will occur under very different environmental conditions and fish husbandry practices. Importantly, studies (Austin, 1985; Aoki et al., 1984) have noted that the increased level of antibiotic resistance associated with antibiotic use around fish farms was soon reduced after antibiotic use stopped. This phenomenon has been observed in human medicine (Forfar et al., 1966) where dramatic declines in resistance levels of bacteria occur after antibiotic treatments are stopped.

The possibility of transfer of drug-resistance factors from a fish disease-causing bacteria to a potential human disease-causing bacteria*, V. parahaemolyticus,* was investigated in Japan (Hayashi et al., 1982). Using test tube conditions and temperatures of about 86°F to 96°F, these authors were able to transfer drug resistance to *V. parahaemolyticus*. These authors also noted that in Japan, where antibiotics have been extensively used in aquaculture, drug-resistant strains of the *V. parahaemolyticus* have never been found in the environment.

Toranzo et al (1984) reported the transfer of drug resistance from several bacteria isolated from rainbow trout to the bacterium, *Escherichia coli*. The transfer to resistance was performed under laboratory conditions at 25° C (77° F). The studies demonstrated the potential for transfer under controlled laboratory conditions and these authors concluded that "Responsible use of drugs in aquaculture will aid in minimizing the development and spread of R+ factor-carrying microorganisms that may confer drug resistance…”.

The accumulation of antibiotic residues in shellfish near fish farms has received little study. In the Puget Sound area (Tibbs et al., 1988) found that mussels, oysters, and clams suspended within a matrix of net pens in which coho salmon were being given food supplemented with OTC had no detectable levels of the antibiotic in their tissues. That study examined the phenomenon of antibiotic accumulation in shellfish under worst-case conditions with regard to the distance between the fish pen and shellfish (the shellfish were placed within the matrix of fish pens). Weston (1986) noted the large dilution factor that would occur when antibiotics are used in a net pen. He made conservative calculations and computed a diluted level of 3 parts per billion of OTC in a parcel of water passed through a fish pen receiving medicated feed. Given this dilution factor and the water-soluble nature of antibiotics like OTC, Weston (1986) concluded that there was little potential for bioaccumulation of antibiotics used in fish farming.

Jacobsen and Bergline (1988) reported the persistence of OTC in sediments from fish farms in Norway. These authors also conducted laboratory tests and concluded that the half-life (time required for a given concentration to decay to 50 percent of the starting concentration) for OTC in marine sediments was about ten weeks, but would likely depend on sediment type and other factors. They examined sediments from underneath four farms, but did not report the duration or quantities of OTC applied at each location. OTC was found in sediments from three of the four farms at levels from 0.1 to 4.0 mg/kg (ppm) of dry matter. This level would potentially be high enough to be inhibitory to marine bacteria (1-2 ppm is considered inhibitory) including vibrios. However, since the concentration is reported relative to dry weight, it overestimates the actual concentration in hydrated sediment. The study does demonstrate that measurable OTC can accumulate below fish farms. Conservatively, the study can be interpreted to show the highest concentrations were just above inhibitory levels on a dry-weight basis. The authors also noted that the oxidation state of the sediments would affect the half-life of OTC. An Environmental Assessment of OTC by the FDA (USFDA, 1983) concluded that "the use of OTC is beneficial to control diseases in aquatic environment and does not pose adverse effects on this compartment. However, steps should be developed to avoid the emergence of drug-resistant organisms."

Accumulation of antibiotics in marine sediments is also a function of the dilution factor (which determines the level of antibiotic reaching the sediment), biotransformation of the compound in the sediment, oxidation state of the sediment, and water solubility of the antibiotic. Levels of OTC such as those calculated by Weston (1986) to reach sediments are not likely to have inhibitory effects on non-pathogenic bacteria, which are little affected at levels below 1 ppm (Carlucci and Pramer, 1960). In their study of the microbial quality of water in intensive fish rearing, Austin and Allen-Austin (1985) note that while it is difficult to make generalizations, their study indicated that two freshwater fisheries they monitored did not produce "a major imbalance in the aquatic bacterial communities."

Although some technical details require further study, the issues surrounding antibiotic use in fish farming have received some detailed study. Studies demonstrate that antibiotics will be released into the environment when used as a medication for farmed fish. Antibiotics have not been detected in shellfish held near salmon net pens. One Norwegian study found concentrations of one antibiotic may have been close to inhibitory levels in three of four farms. The concentrations of antibiotics outside of the immediate proximity of the fish pens are regarded by most authors as being too low to have adverse effects.

The presence of plasmids, a mechanism by which bacteria transfer resistance, is documented in pathogenic and native aquatic bacteria. Antibiotic resistance has been recorded in bacteria around fish farms. Most of the technical literature describing antibiotic resistance in fish pathogenic bacteria is based on studies of aquaculture practices and environmental conditions not comparable with salmon net-pen farming in the Puget Sound region. These conditions include high temperatures, high densities of fish, close proximity of multiple farms, and use of a variety of antibiotics not used in fish farming in the United States. Conditions in the studies reporting antibiotic resistance favor the development of resistance. In comparison, salmon net-pen farming in the Puget Sound region would not favor the development of antibiotic resistance. In addition, the federal regulations that apply to the use of antibiotics in fish farming in the United States appear to be much more stringent than those that apply in Japan and Europe, where most of the technical literature has originated. Antibiotic resistance tends to disappear when antibiotic administration is stopped. Shellfish held within a net-pen complex did not accumulate detectable levels of OTC. This observation and the calculated dilution of antibiotics away from the fish pens further suggest that any quantities of antibiotics accumulated in shellfish, or other benthic or planktonic marine invertebrates not near the pens would be substantially below levels of concern.

The lack of antibiotic resistance in a potential human disease-causing bacteria such as V. parahaemolyticus in Japan, despite the extensive use of antibiotics in aquaculture there, indicates the transfer of drug resistance from fish to human pathogenic bacteria is unlikely. It appears such transfer is a laboratory phenomenon, which requires highly controlled conditions and is not representative of phenomena that occur in the environment. The Toranzo et al (1984) study further demonstrates the potential for drug resistance transfer under controlled conditions (77°F).

The applicant has indicated that FDA-approved antibiotics or other therapeutants will not likely be used (within any feed or dosing the rearing water) during the proposed project.[19] The need for drugs is minimized by the strong currents expected at the proposed action area, the low fish culture density, the cage material being used, and the constant movement of the cage. In the event that drugs are used, the NPDES permit requires that the use of any medicinal products including therapeutics, antibiotics, drugs, and other treatments are to be reported to the EPA. The report must include types and amounts of medicinal product used and the period of time it was used.

9.6 Waste Deposition Analysis

The proposed project generates and discharges various amounts of solid and dissolved wastes depending on the fish biomass contained and amount of feed added daily. Solid waste consists primarily of unconsumed feed and fecal material. Other minor sources of solid wastes include dead fish, fish parts (i.e. scales, mucous, etc.) and material dislodged during net cleaning operations. Dissolved wastes include fish metabolic wastes, plus therapeutic agents (e.g. antibiotics), if used, antifoulants, if applicable. The focus of this analysis is the discharge of the primary solid wastes, feed and fecal material and dissolved metabolic wastes.

This facility as proposed consists of a single 17 m diameter floating cage estimated to hold approximately 80,000 lbs of fish at harvest. It is estimated that feeding rates would approximately 745 lbs per day at the maximum expected fish biomass. Factors influencing the transport and fate of materials discharged from net-pen facilities include oceanographic characteristics of the receiving water, physical characteristics of the net-pen, water depth below the net-pen, configuration and orientation of the net-pen system in relation to predominant currents, type of food used, fish feeding rates and stock size. Oceanographic considerations include tides, wind, stratification, and current velocities and direction.

The NCCOS conducted environmental modelling analysis of the proposed project to help determine the fate and effects of solid wastes discharged from the net-pen at maximum production rates. Numerical models were constructed based upon anticipated farming parameters including configuration (net pen volume and mooring configuration), fish production (species, biomass, size) and feed input (feed rate, formulation, protein content). It should be noted that the models used the maximum fish production amounts for the entirety of the simulation period. Several model scenarios were constructed, the first based on the actual estimated production of a single cohort to harvest. The second scenario examined the solids discharge based on a doubling of the estimated actual production to provide a “worst case” for potential impacts. The third model scenario assumed a maximum biomass for the entire 5-year term of the NPDES permit.

9.6.1 Solid Waste Discharge

A solids deposition model was performed using data from the production model, as well as environmental and oceanographic data on the proposed offshore location (see NCCOS technical reports in Appendix A and B). DEPOMOD and NewDEPOMOD, a particle tracking model for predicting the flux of particulate waste material (with resuspension) and associated benthic impact, was developed for net-pen fish farms. Net depositional flux of organic carbon was predicted in g m^2/yr on a two-dimensional grid overlaid on the farm footprint. The grid size of 4 km^2 was selected such that it would encompass the whole depositional footprint.

[19] The applicant is not expected to use any drugs; however, in the unlikely circumstance that therapeutant treatment is needed, three drugs were provided to the EPA as potential candidates (hydrogen peroxide, oxytetracycline dihydrate, and florfenicol).

The results of the first depositional model show that for the estimated production values, net organic carbon accumulation would be at 3.0 $g/m^2/yr$ or less for 99.7 percent of the test grid. The second depositional model performed at twice the estimated production, net organic carbon accumulation would be 5.0 $g/m^2/yr$ or less for 99.0 percent of the grid.

The model also estimated a biotic index, Infaunal Tropic Index (ITI), that is used as an indicator of organic enrichment based on expected changes in benthic macroinvertebrate community feeding responses to increases in deposited organic matter. The three model simulations resulted in ITI predictions ranging from 58.67 to 58.96. The predicted ITI close to 60 suggests that the proposed Velella project will not likely have a discernable impact on the benthic infaunal community around the site. The third modeling scenario (full production for the 5-year term) showed that "Velella project will present challenges for monitoring and detecting environmental impacts on sediment chemistry or benthic communities because of the circulation around the project location and the small mass flows of materials from the net pen installation."

9.6.2 Dissolved Wastes

The NCCOS technical reports estimated that 2,743 kg of ammonia nitrogen would be produced using the maximum biomass for the entire 280-day fish production cycle. The report suggested that daily ammonia production at levels twice as high as estimated will be undetectable within 30 meters of the cage at typical current flows regimes in the vicinity of the proposed site.

The NCCOS technical report did not provide dilution estimates for the dissolved waste discharge downstream of the cage. Modelling input parameters within the NCCOS report were used to calculate the flow-averaged ammonia concentration at the downstream edge of the cage for comparison with published water quality criteria for ammonia in saltwater (EPA, 1989). The ambient water quality criteria for ammonia in saltwater state that "saltwater aquatic organisms should not be affected unacceptably if the four-day average concentration of un-ionized ammonia does not exceed 0.035 mg/l more than once every three years on the average and if the one-hour average concentration does not exceed 0.233 mg/L more than once every three years on the average."

A total ammonia loading of 2,743 kg, based an initial estimated 280-day fish production cycle (Table 3 within the NCCOS technical report) was averaged to 9.8 kg/ammonia/day and 113.0 milligrams per second (mg/s). The flow-averaged ammonia concentration is estimated at 0.0072 mg/l (based on an ammonia production of 9.8 kg/day loading rate).[20]

Since the NCCOS technical report, changes in estimated production parameters resulted in total ammonia loading estimates for a 365-day production cycle of 3,978 kg/day. The average daily ammonia load was calculated at 10.9 kg/d and 126.0 mg/s. The flow-averaged ammonia concentration was estimated at 0.008 mg/l (based on an ammonia production of 10.9 kg/day loading rate). Estimates of the flow-averaged ammonia concentrations at the cage edge at maximum fish production are significantly below the published ammonia aquatic life criteria values for saltwater organisms.

[20] The current velocity used for flow calculations is 13.26 cm/s, which is the total mean from Table 4 within the NCCOS technical report. A lateral two-dimensional cage surface area is 1,190,000 cm^2. The lateral flow through the cage was estimated 15,779,400 cm^3/s.

10.0 Evaluation of the Ocean Discharge Criteria

This section summarizes EPA's review of the ten factors that the EPA must consider in determining, pursuant to 40 CFR § 125.122(a), whether a discharge will cause unreasonable degradation of the marine environment, to ensure that the proposed NPDES permit complies with CWA § 403. This section discusses how conditions and limitations included in the final permit for the proposed project ensure compliance with these ODC, and the determination, under CWA § 403, that the NPDES permit will not cause unreasonable degradation of the marine environment with all NPDES permit limitations, conditions, and monitoring requirements in effect.

10.1 Evaluation of the Ten ODC Factors

10.1.1 Factor 1 - Quantities, Composition, and Potential for Bioaccumulation or Persistence of Pollutants

The quantities and composition of the discharged material were presented in Section 4 and the potential for bioaccumulation or persistence was addressed in Section 9. Due to the relatively small fish biomass production estimated for this demonstration project and limited discharges other than fish food and fecal matter, the volume and constituents of the discharged material are not considered sufficient to pose a significant environmental threat through bioaccumulation or persistence. However, to confirm the EPA's decision and as a precaution against any changes in operational practices that could change the EPA's assumptions, the NPDES Permit requires environmental monitoring and implementation of an environmental monitoring plan to meet the requirements of the CWA § 402 and CWA § 403.

10.1.2 Factor 2 - Potential for Biological, Physical, or Chemical Transport

Section 3 and 4 of this document discusses the oceanographic process characteristic of the continental shelf off the west coast of Florida responsible for the physical transport of fish wastes in the environment. Section 8 discusses the results of predicted impacts to the water column and waste deposition on the seafloor surrounding the proposed facility.

Due to the small scale of the proposed project and because the discharged wastes are largely comprised of organic and inorganic particulates and dissolved metabolic wastes, there is little potential for biological or chemical transport. Ocean currents are expected to flush the cages sufficiently to carry wastes away from cages and dilute and disperse dissolved and solid wastes over a large area. For any solid matter settling on the seafloor, bioturbation should serve to mix sediments vertically at low to moderate benthic loading rates and resuspension of sediments should further enhance the dispersion of uneaten food and fecal matter. High loading rates that would be expected to impair benthic communities and reduce the effect of bioturbation are not expected to occur. The physical transport of these waste streams is considered to be the most significant source for dispersion of the wastes and monitoring and regulation is based on the results of those investigations.

10.1.3 Factor 3 - Composition and Vulnerability of Biological Communities

The third factor used to determine no unreasonable degradation of the marine environment is an assessment of the presence of unique species or communities of species, endangered species, or species critical to the structure or function of the ecosystem. Section 4 describes the biological communities of the eastern Gulf including the presence of endangered species and Section 8 discusses the factors that make these communities or species vulnerable to the permitted activities.

High organic loading from fish farms have been shown to alter the physical structure of benthic sediment and to cause anoxic conditions which reduce diversity and abundance of infauna, meiofauna and epibenthic organisms. The area around the proposed facility is mainly comprised of soft sand sediments and their characteristic benthic communities. Results from deposition modeling (Section 8) show the potential for benthic impacts over an area in excess of 1 km^2. The potential for impacts due to toxic effects from a demonstration size fish farm discharge, however, is minimal.

10.1.4 Factor 4 - Importance of the Receiving Water to the Surrounding Biological Community

The importance of the receiving waters to the species and communities of the eastern Gulf is discussed in Section 4 and Section 5 in conjunction with the discussion of the species and biological communities. The receiving water is considered when determining the discharge rate restrictions. The dissolved nutrient estimates and deposition modeling considered concentrations of organic particulates that may have impacts on aquatic life. Permit limitations on minor discharges ensure that levels of these effluents are below levels that could have impacts on local biological communities. EPA finds that operating discharges from the proposed facility will have little adverse impacts on species migrating to coastal or inland waters for spawning or breeding.

10.1.5 Factor 5 - Existence of Special Aquatic Sites

The existence of special aquatic sites and proximity to the proposed project are discussed in Section 7. EPA has determined that the proposed area is located sufficiently far from special aquatic sites off the west Florida coast that any impacts resulting from the proposed facility will likely be limited to the surrounding area, within 300-500 meters from the perimeter of the cage array, and will therefore not impact any special aquatic sites.

10.1.6 Factor 6 - Potential Impacts on Human Health

Section 9 details the Federal and state human health criteria and standards for pollutants of concern. These criteria and standards are for marine waters based on fish consumption. These analyses compare projected pollutant concentrations with these criteria and standards, and indicate that there will be an insignificant depositional and water quality impact. In addition, the permit prohibits the discharge or use of antifouling agents or chemical fish treatments other than antibiotics allowed by the FDA animals raised for human consumption. Based on consideration of this factor, EPA finds that the proposed facility is not likely to have impacts on human health.

10.1.7 Factor 7 - Recreational or Commercial Fisheries

The commercial and recreational fisheries occurring in the eastern Gulf, mainly Alabama, Florida, and Mississippi, are assessed in Section 6. Based on the following, EPA finds that the discharges from the project will not adversely affect water quality or the health of these fisheries:

1. The modeling performed for the proposed project found that there would be minimal to insignificant impact on water quality and seafloor benthic communities.
2. EPA determined that the conditions and limitations in the permit for the proposed project are adequate to ensure that the recreational and commercial fisheries will not be adversely impacted. In addition to environmental monitoring, the NPDES permit will include a requirement that all fish stocked must obtain an Official Certificate of Veterinary Inspection prior to being stocked, and implement BMPs related to fish health management.
3. EPA evaluated that potential social, economic, and environmental impacts to commercial and recreational fisheries caused by the proposed project within the Environmental Assessment to comply with the National Environmental Policy Act (NEPA).
4. The EPA determined, in consultation with NMFS, that there the minimal short-term impacts associated with the discharge will not result in substantial adverse effects on Essential Fish Habitat (EFH), habitats of particular concern, or managed species in any life history stage, either immediate or cumulative, in the proposed project area (see EFH consultation record for more information).

10.1.8 Factor 8 - Coastal Zone Management Plans

Section 7 provides an evaluation of the coastal zone management plan for the State of Florida. On January 3, 2019, the permit applicant submitted a CZMA consistency determination to the Florida State Clearinghouse with the Florida Department of Environmental Protection. On January 15, 2019, the Florida Department of Agriculture and Consumer Services (FDACS) documented that the coastal consistency determination submitted by the applicant was consistent with all FDACS statutory responsibilities for aquaculture. On February 18, 2019, the Florida Fish and Wildlife Conservation Commission (FWC) found that the applicant's coastal consistency determination was consistent with FCMP. Therefore, the EPA has determined that the action covered by this permit is consistent with the CZMA and its implementing regulations.

10.1.9 Factor 9 - Other Factors Relating to Effects of the Discharge

Effluent Guidelines and Standards have been developed for the Concentrated Aquatic Animal Production (CAAP) Point Source Category for facilities producing 100,000 pounds or more of aquatic animals per year in floating net pens or submerged cage systems (40 CFR Part 451 Subpart B). The New Source Performance Standards effluent limitation guidelines for the CAAP industry were applied to the proposed project in the NPDES permit. The effluent limitations and standards for these facilities are non-numeric effluent limitations expressed as practices designed to control the discharge of pollutants from these types of operations. the NPDES permit will include effluent limitations expressed as best management practices (BMPs) for feed managment, waste collection and disposal, harvest discharge, carcass removal, materials storage, maintenance, record keeping, and training. Therefore, impacts to water quality will be reduced by a range of non-numeric effluent limitations through the implementation of project-specific BMPs and operational measures.

Factor 9 of the marine unreasonable degredation criteria are "such other factors relation to the effects of the discharge as may appropriate. Factor 9 was considered, along with the other 9 factors, in developing permit conditions to ensure that unreasonable degradation to the marine environment will not occur as a result of the discharges from the proposed facility. As provided in 40 CFR § 125.123(a),[21] the EPA has included permit conditions that have been determined to be necessary to ensure that unreasonable degradation of the marine environment will not occur by including necessary conditions specified in 40 CFR § 125.123(d), including the following conditions:

1. Implementation of environmental monitoring and an environmental monitoring plan will be required in the NPDES permit to meet the requirements 40 CFR § 125.123(d)(2).[22] The applicant will be required to monitor and sample certain water quality, sediment, and benthic parameters at a background (up-current) location and near the cage.
2. In accordance with 40 CFR § 125.123(d)(3),[23] the NPDES permit must include two conditions related to fish health management and the indirect discharge of pathogens:
    a. a requirement that all stocking of live aquatic organisms, regardless of life stage, must be accompanied by an Official Certificate of Veterinary Inspection signed by a licensed and accredited veterinarian attesting to the health of the organisms to be stocked; and
    b. the BMP plan shall include conditions to control or minimize the transfer of pathogens to wild

[21] 40 CFR § 125.123(a) states that "If the director on the basis of available information including that supplied by the applicant pursuant to § 125.124 determines prior to permit issuance that the discharge will not cause unreasonable degradation of the marine environment after application of any necessary conditions specified in §125.123(d), he may issue an NPDES permit containing such conditions."

[22] 40 CFR § 125.123(d)(2) states that EPA is allowed to "specify a monitoring program, which is sufficient to assess the impact of the discharge on water, sediment, and biological quality including, where appropriate, analysis of the bioaccumulative and/or persistent impact on aquatic life of the discharge."

[23] 40 CFR § 125.123(d)(3): "Contain any other conditions, such as performance of liquid or suspended particulate phase bioaccumulation tests, seasonal restrictions on discharge, process modifications, dispersion of pollutants, or schedule of compliance for existing discharges, which are determined to be necessary because of local environmental conditions, and"

fish.

3. In accordance with CWA § 403 of the, 40 CFR § 125.123(a), and 125.123(d)(3), the NPDES permit will contain a condition that "The discharge from the facility shall not cause unreasonable degradation of the marine environment underneath the facility and in the surrounding area" under 40 CFR § 125.123(d)(3).

10.1.10 Factor 10 - Marine Water Quality Criteria

The Federal and state marine water quality criteria and standards are discussed in Section 8. The proposed facility will be located in federal waters where no federal or state criteria apply; however, the discharges from the proposed project are not expected to exceed the recommended federal water quality criteria for marine waters that were considered in this ODC Evaluation.

10.2 Conclusion

The consideration of the ten factors discussed in this ODC Evaluation were based on the available information from published literature regarding impacts that have occurred near net pen fish farms from around the world, and information in the Administrative Record for the NPDES permit action regarding the proposed facility and the potential impacts of discharges from the proposed facility. Sufficient information currently exists regarding open water marine fish farming activities and expected impacts from such activities, coupled with information regarding the proposed discharge, to allow the EPA to adequately predict likely environmental outcomes for the Proposed project.

The EPA also determined that the NPDES permit must contain necessary conditions allowed by 40 CFR § 125.123(d). First, the NPDES permit will contain a comprehensive environmental monitoring plan that will confirm EPA's determination and ensure no significant environmental impacts will occur from the proposed project. Second, the NPDES permit must include a requirement that all stocking of live aquatic organisms, must obtain an Official Certificate of Veterinary Inspection prior to being stocked, and implement BMPs related to fish health management. Finally, the NPDES permit will contain a condition that the discharge from the facility shall not cause unreasonable degradation of the marine environment. EPA finds that these conditions, along with other the other conditions in the NPDES permit (i.e. BMP plan, Facility Damage Prevention and Control Plan, etc.), will ensure that the discharges from the facility do not cause unreasonable degradation of the marine environment.

The EPA finds that "no-unreasonable degradation" will likely occur as a result of the discharges from this project based on the available scientific information concerning open ocean fish farming, the results predicted by deposition and dilution modeling, the effluent limit guidelines for the CAAP industry that are being applied to this facility, and the conditions included within the NPDES permit as allowed by the ODC implementing regulations.

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Appendix A

CASS Technical Report

Environmental Modelling to Support NPDES Permitting for Velella Epsilon Offshore Demonstration Project in the Southeastern Gulf of Mexico

CASS Technical Report

Environmental Modelling to Support NPDES Permitting for Velella Epsilon Offshore Demonstration Project in the Southeastern Gulf of Mexico

Lead Scientists: Kenneth Riley, Ph.D. and James Morris, Ph.D.
Environmental Engineer: Barry King, PE
Submitted to Jess Beck (NMFS) and Kip Tyler (EPA), July 19, 2018

This analysis uses an environmental model to simulate effluent to inform the NMFS Exempted Fishing Permit (EFP) and EPA National Pollutant Discharge Elimination System (NPDES) Permit for the Velella Epsilon Offshore Demonstration Project. Kampachi Farms, LLC (applicant) proposes to develop a temporary, small-scale demonstration net pen operation to produce two cohorts of Almaco Jack (*Seriola rivoliana*) at a fixed mooring located on the West Florida Shelf, approximately 45 miles offshore of Sarasota, Florida (Figure 1; Table 1). Scientists from the NOAA Coastal Aquaculture Siting and Sustainability (CASS) program worked with the EPA project manager and the applicant to develop estimates of effluents and sediment related impacts for the offshore demonstration fish farm.

A numerical production model for two cohorts of Almaco Jack was constructed based upon anticipated farming parameters including configuration (net pen volume and mooring configuration), fish production (species, biomass, size) and feed input (feed rate, formulation, protein content). Using industry standard equations, daily estimates of biomass, feed rates, total ammonia nitrogen production, and solids production (*see Microsoft Excel Spreadsheet – Velella Epsilon Production Model*) were developed under a production scenario to estimate the maximum biomass of 20,000 fish that would be grown to 1.8 kg in approximately 280 days. The total biomass produced with one cohort and no mortality was determined to be 36,280 kg. The density in the cage at harvest would be 28 kg/m^3. Fish will be fed a commercially available growout diet with 43% protein content. Daily feed rations range from 12 kg at stocking to a maximum total daily feed ration equivalent to 399 kg at harvest. Maximum daily excretion of total ammonia nitrogen is estimated at 16 kg and solids production is 140 kg. A total of 66,449

The **Coastal Aquaculture Siting and Sustainability (CASS)** program supports works to provide science-based decision support tools to local, state, and federal coastal managers supporting sustainable aquaculture development. The CASS program is located with the Marine Spatial Ecology Division of the National Centers for Coastal Ocean Science, National Ocean Service, NOAA. To learn more about CASS and how we are growing sustainable marine aquaculture practices at: https://coastalscience.noaa.gov/research/marine-spatial-ecology/aquaculture/ or contact Dr. Ken Riley at Ken.Riley@noaa.gov.

kg of feed will be used for production of each cohort of fish to achieve a feed conversion ratio (FCR) of 1.8. Summary statistics were developed for each cohort and the entire project (Table 2).

Table 1. Boundary locations for the Velella Epsilon Offshore Aquaculture Project.

Location	Latitude	Longitude
Northwest corner	27.072360 N	-83.234709 W
Northeast corner	27.072360 N	-83.216743 W
Southwest corner	27.056275 N	-83.216743 W
Southeast corner	27.056275 N	-83.234709 W

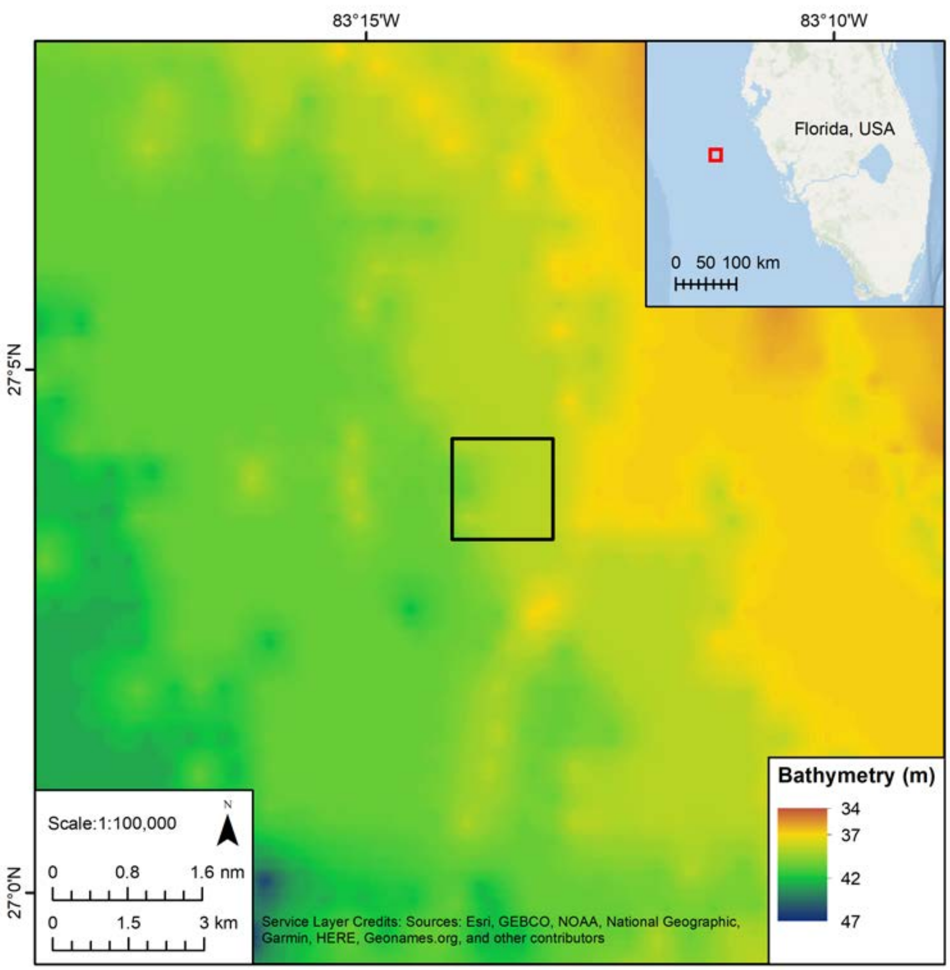

Figure 1. Bathymetric map of proposed Velella Epsilon Offshore Aquaculture Project.

Table 2. Summary statistics for the Velella Epsilon Offshore Aquaculture Project.

Farming parameter	Value
Growout duration	280 days per cohort
Total number	20,000 fish per cohort
Individual size at harvest	1.8 kg
Maximum biomass	36,280 kg
Cage density at harvest	28 kg/m^3
Maximum daily feed rate	399 kg
Total feed used	66,449 kg
Feed conversion ratio	1.8

In order to estimate sediment related impacts, a depositional model (DEPOMOD; Cromey et al 2002) was parameterized with data from the production model and environmental and oceanographic data on the proposed offshore location. DEPOMOD is the most established and widely used depositional model for estimating sediment related impact from net pen operations. DEPOMOD is a particle tracking model for predicting the flux of particulate waste material (with resuspension) and associated benthic impact of fish farms. The model has been proven in a wide range of environments and is considered through extensive peer-review to be robust and credible (Keeley et al 2013). Although this modelling platform was initially developed for salmon farming in cool-temperate waters (Scotland and Canada), it has since been applied and validated with warm-temperate and tropical net pen production systems (Magill et al. 2006; Chamberlain and Stucchi 2007; Cromey et al. 2009; Cromey et al. 2012). Coastal managers responsible for permitting aquaculture worldwide have been using this modelling platform because it produces consistent results that are field validated and comparable (Chamberlain and Stucchi 2007; Keeley et al 2013). It is routinely used in Scotland and Canada to set biomass (and thereby feed use) limits and discharge thresholds of in-feed chemotherapeutants (SEPA 2005). Further, the model output has been used to develop comprehensive and meaningful monitoring programs that ensure environmentally sustainable limits are not exceeded (ASC 2012).

Traditionally a baseline environmental survey is used to inform water quality and depositional models with site specific analysis of currents, tidal flows, sediment profiles, and benthic infaunal profiles (species richness and abundance). In the absence of a survey, data were collected from oceanographic and environmental observing systems in the vicinity of the project area. Current data were obtained from NOAA Buoy Station 42022 along the 50-m isobath and located 45 miles northwest of the project location (27.505 N, 83.741 W). Currents were recorded continuously from July 2015 through April 2018. Currents were measured at 1-meter intervals from 4.0 meters to 42.0 meters below the surface (Table 3). Bathymetric data were obtained from the

NOAA Coastal Relief Model. Bathymetry was resampled to 10 x 10 meter grid cells using a bilinear interpolation to all for use within the deposition model.

Table 3. Water column related impacts for the Velella Epsilon Offshore Aquaculture Project. Values represent summation of daily values over a 280-day production cycle.

Parameter	Value (kg)
Total solids production	23,257
Total ammonia nitrogen	2,743
Total oxygen consumption	16,612
Total carbon dioxide production	19,187

The depositional model was executed for two different production simulations that assume maximum standing biomass and maximum feed rate, which is characteristic when the fish are at pre-harvest size. The first simulation represented the maximum standing biomass for the Velella Epsilon Offshore Aquaculture Project. The model was run for 365 days assuming a net pen with a constant daily standing biomass at 36,275 kg (28 kg/m^3) and a daily feed rate of 1.1 percent of biomass or equivalent to 399 kg of feed. The second simulation doubled production to assess sediment related impacts at higher levels of biomass and feed rates. The second simulation at a higher level of production was intended to aid EPA in development of an environmental monitoring program. Under the second simulation, the model was run for 365 days assuming two net pens each with a combined constant daily standing biomass at 72,550 kg (28 kg/m3 per net pen) and a daily feed rate of 1.1 percent of biomass or equivalent to 798 kg of feed.

Waste feed and fish fecal settling rates are important determinants of distance that these particles will travel in the current flow. The model does not allow the settling velocity of particles to change through the growing cycle. The values used for feed and feces represented those that would be encountered during the period of highest standing biomass, largest feed pellet size, and highest waste output. Each simulation assumed maximum standing biomass each day of the simulation with a fecal settling velocity at 3.2 cm/s. Many marine fish have fecal settling velocities ranging from 0.5 to 2.0 cm/s, while salmonids tend to have higher settling velocities ranging from 2.5 to 4.5 cm/s. Fecal settling velocities applicable to salmon production were used because they are well studied, validated, and allow for maximum benthic impact assessment. Standard feed waste was estimated at 3% and the food settling velocity was 9.5 cm/s. Pelleted fish feed is the single largest cost of fish farming, and because of this expense, farms use best feeding practices to ensure minimal loss. Feed digestibility and water content were set at 85% and 9%, respectively, which are standards based on technical data provided by feed manufacturers. All other model parameters were consistent with existing net pen farm waste modelling methodologies (Cromey et al. 2002a,b) and regulatory farm modelling standards (SEPA 2005).

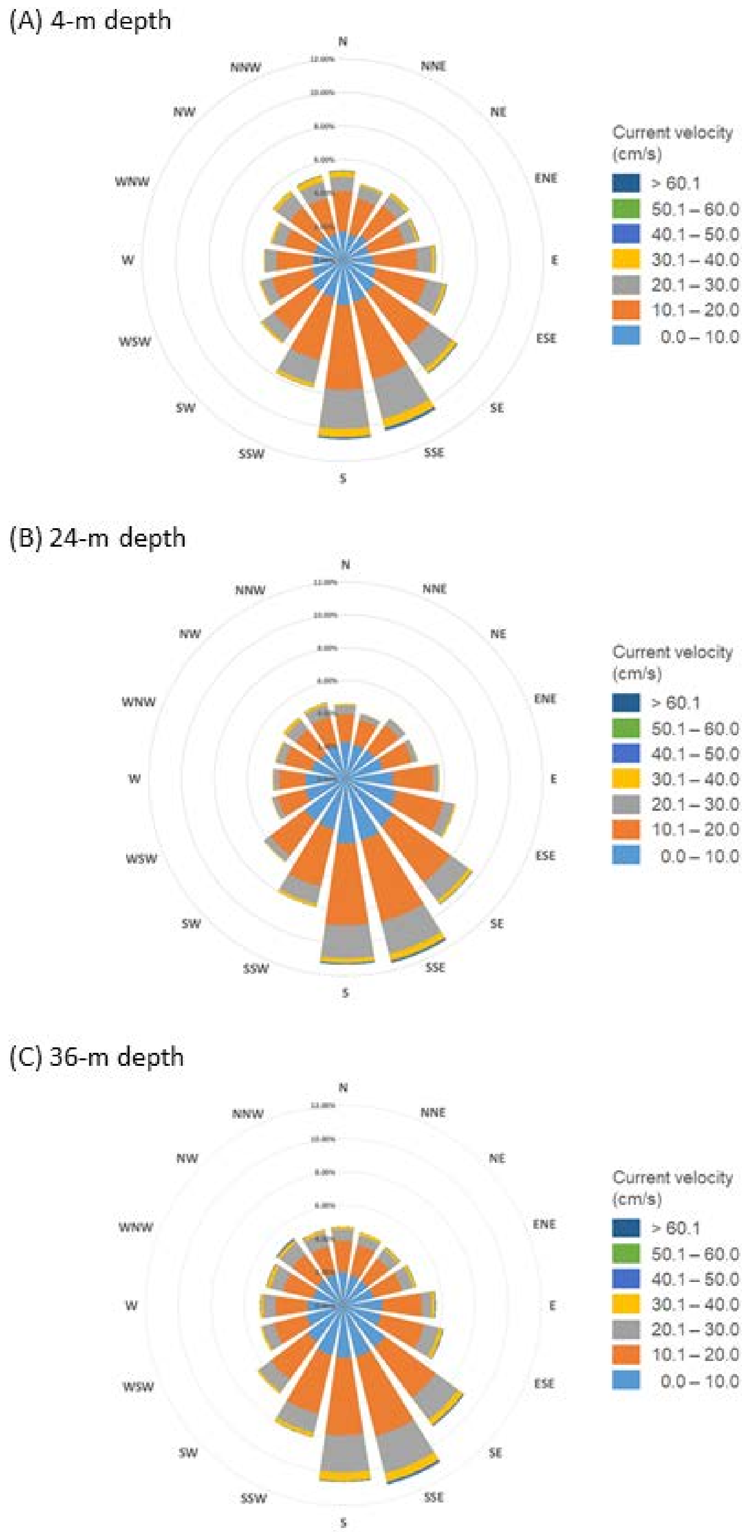

Figure 2. Distribution of current velocities (cm/s) and direction for NOAA Buoy Station 42022 located along the 50-m isobath approximately 45 miles northwest of project location. Currents are reported for water column depths of 4 m, 24 m, and 36 m.

Table 4. Current velocities (cm/s) for NOAA Buoy Station 42022 located along the 50-m isobath approximately 45 miles northwest of project location. Average current velocities are reported with standard deviation.

Depth (m)	Average current (cm/s)	Maximum current (cm/s)
4	14.6 ± 8.1	83.9
10	12.8 ± 8.0	80.3
20	12.2 ± 7.3	67.6
30	13.8 ± 8.2	70.8
40	12.9 ± 7.6	68.7

Table 5. Model settings applied for depositional simulations of an offshore fish farm in the Gulf of Mexico.

Input variable	Setting
Feed wastage	3%
Water content of feed pellet	9%
Digestibility	85%
Settling velocity of feed pellet	0.095 m/s
Settling velocity of fecal pellet	0.032 m/s

Offshore fish farms can be managed in terms of maximum allowable impacts to water quality and sediment that are based on quantifiable indicators. This project will be difficult to monitor and detect environmental change because of the relatively low level of production associated with a demonstration farm and the nature of the net pen configuration deployed and moving about on a single point mooring.

Overall, this analysis found that the proposed demonstration fish farm is not likely to cause significant adverse impacts on water quality, sediment, or the benthic infaunal community. Water quality modelling demonstrated that at the maximum farm production capacity of 36,280 kg only insignificant effects would occur in the water column. We believe that the excreted ammonia levels of 16 kg per day will be rapidly diluted to immeasurable values near (within 30 meters) of the net pen under typical flow regimes of 12.8 ± 8.0 cm s^{-1}. Dilution models could be used to estimate nearfield and farfield dilution as used in conventional ocean outfall systems.

However, based on our experience with offshore aquaculture installations and development of modeling and monitoring programs, we believe that ammonia levels will be difficult to detect beyond the zone of initial dilution.

The model does not allow the net pen or mooring configuration to move in space or time, therefore, the model was executed at a fixed location (27.064318, -83.225726) in the center of the project location (i.e., farm footprint). Net depositional flux was predicted in g m^{-2} yr^{-1} on a two-dimensional grid overlaid on the farm footprint. The grid size was selected such that it would encompass the whole depositional footprint. The distribution of deposited materials beneath the cage is a function of local bathymetry and hydrographic regime. In low current speed environments, only limited distribution of the solids footprint occurs. As current speeds increase, greater dispersion of solids occurs during settling resulting in a more distributed footprint. Greater water depth at a site results in increased settling times and result in a more distributed footprint. Solids distribution is even greater where bottom current speeds are high causing sediment erosion and particle resuspension and redistribution.

The predicted carbon deposition and magnitude of biodeposition for the single and dual cage scenarios were estimated over a 2.04 km by 2.04 km evaluation grid. The grid is partitioned into cells numbering 82 east-west by 82 north-south and identified as 1-82 in both directions. The units of the axes in both Figures 3 and 4 are these cell counts. The dimension of a single cell therefore is 2,040m/82=24.87 m. The depositional model predicted and integrated at each one-hour step, the total carbon that ended up in each cell in the model grid, of which there are 82 x 82 = 6,724 cells. At the end of an execution run the accumulated mass of carbon within each cell is reported. Predicted annual benthic carbon deposition are presented in Figures 3 and 4. Frequency histograms of the carbon deposition per cell were created to help with interpretation of results. The depositional data derived from the frequency histograms are presented in Table 6 and 7.

Table 6 shows the distribution of carbon that results from a single net pen operated for one year at maximum standing biomass. Of the 6,724 computational cells, 1,386 had no carbon from the farm. Over 88% of the cells received less than or equal to 1 gram of carbon. Only 2 cells on the farm measured more than 4 grams of carbon over the year-long simulation.

Table 7 shows the distribution of carbon that results from a two net pens operated for one year at maximum standing biomass. Similar to the depositional model with one cage, over 75% of the cells received less than or equal to 1 gram of carbon. One cell was calculated to receive more than 11 grams, but it is a minuscule mass of carbon to be assimilated by a square meter of ocean bottom.

Table 6. Frequency of carbon deposition within 6,724 cells, each measuring 619 m^2, over a 4.16-km^2 grid system. Values represent an annual sum of carbon deposition resulting from an offshore fish farm with a constant standing stock biomass of 36,275 kg.

Carbon deposition ($g/m^2/yr$)	Occurrence (N)	Frequency (%)
0	1,386	20.6
0.1 – 1.0	4,561	67.8
1.1 – 2.0	620	9.2
2.1 – 3.0	141	2.1
3.1 – 4.0	14	0.2
4.1 – 5.0	2	0.03

Table 7. Frequency of carbon deposition within 6,724 cells, each measuring 619 m^2, over a 4.16-km^2 grid system. Values represent an annual sum of carbon deposition resulting from an offshore fish farm with a constant standing stock biomass of 72,550 kg.

Carbon deposition ($g/m^2/yr$)	Occurrence (N)	Frequency (%)
0	999	14.9
0.1 – 1.0	4,086	60.8
1.1 – 2.0	903	13.4
2.1 – 3.0	390	5.8
3.1 – 4.0	200	3.0
4.1 – 5.0	75	1.1
5.1 – 6.0	40	0.6
6.1 – 7.0	20	0.3
7.1 – 7.0	7	0.1
8.1 – 9.0	3	0.04
9.1 – 10.0	0	0.0
10.1 – 11.0	0	0.0
11.1 – 12.0	1	0.01

Because of physical oceanographic nature of the site including depth and currents (>10 cm/sec), dissolved wastes will be widely dispersed and assimilated by the planktonic community (Rensel et al. 2017). The results of the depositional model show that benthic impacts and accumulation of particulate wastes would not be detectable or distinguishable from background levels through measurement of organic carbon, even when the standing stock biomass is doubled. The final component or step in the modeling process is to predict some measure of change in the benthic community as a result of increased accumulation of waste material. Deposition of nutrients may result a minor increase in infaunal invertebrate population or no measureable effect whatsoever.

As part of the model assessment, benthic community impact was predicted by an empirical relationship between depositional flux (deposition and resuspension) and the Infaunal Trophic Index (ITI). The ITI is a biotic index that has been used to quantitatively model changes in the feeding mode of benthic communities and community response to organic pollution gradients (Word 1978, 1980; Maurer et al. 1999). ITI scores are calculated based on predicted solids accumulation on the seabed (g m^{-2} yr^{-1}). ITI scores range from 0 to 100 g m^{-2} yr^{-1} and are banded in terms of impact as:

- 60 < ITI < 100 – benthic community normal
- 30 < ITI < 60 – benthic community changed
- ITI < 30 – benthic community degraded.

Correlations between predicted solids accumulation and observed ITI and total infaunal abundance have been established using data from numerous farm sites around the world. Among the findings of these studies, a completely unperturbed benthic community at equilibrium is considered to have an ITI of 60 and an ITI rating of 30 is the boundary where the redox potential of the upper sediment goes from positive to negative and sulfide production begins. A standard approach in Europe and Canada is to use an ITI of 30 as a lower limit for acceptable impacts. In the present study with the Velella Project, the two model simulations resulted in ITI predictions ranging from 58.67 to 58.81. The predicted ITI close to 60 suggests that the Velella Project, as proposed, will not likely have a discernable impact on the sediment or benthic infaunal community around the site.

In summary, the resulting model predictions covered a range of outputs representing both submitted farming parameters and a worst-case scenario (doubled standing stock biomass) for the Velella Epsilon Project. We conclude that there are minimal to no risks to water column or benthic ecology functions in the subject area from the operation of the net pen as described in Kampachi Farms, LLC applications for EFP and NPDES permits.

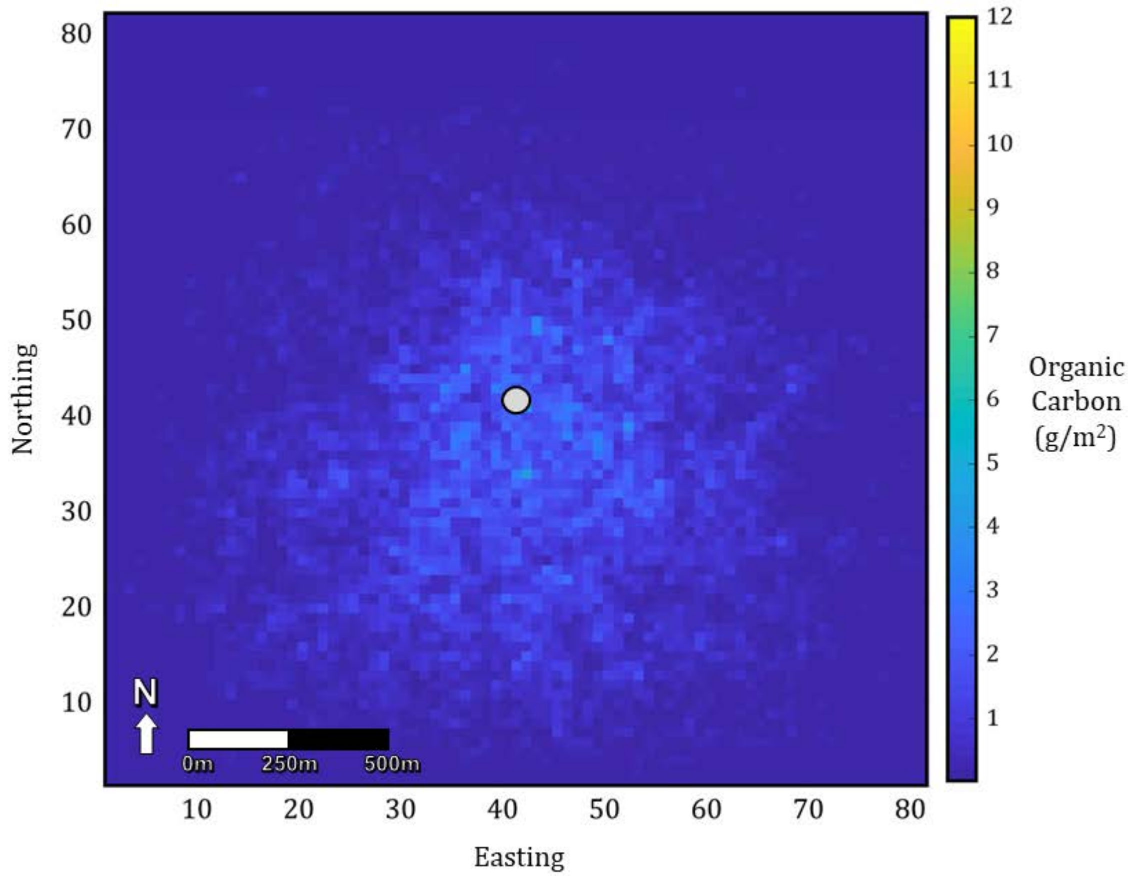

Figure 3. Predicted annual benthic carbon deposition field beneath one net pen with a standing stock biomass of 36,280 kg of Almaco Jack (*Seriola rivoliana*). Gray circle indicates center position of the net pen. Axes indicate simulation cell numbers and deposition mass is in grams.

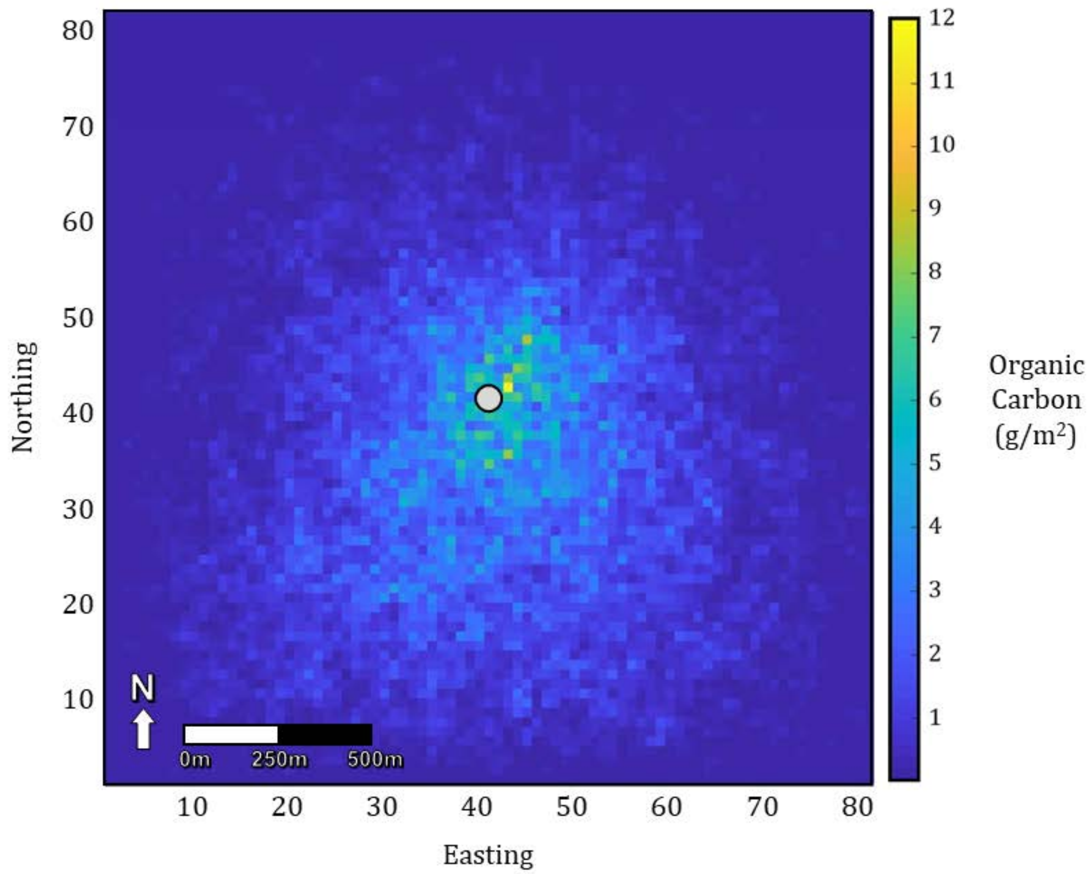

Figure 4. Predicted annual benthic carbon deposition field beneath two net pens with a standing stock biomass of 72,560 kg of Almaco Jack (*Seriola rivoliana*). Gray circle indicates center position of the net pen. Axes indicate simulation cell numbers and deposition mass is in grams. The center of the pens is located at (27.056275 N, -83.216743 W). Predicted carbon loading was derived from the 12-month time series relationship based on depositional flux with resuspension.

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Appendix B

CASS Technical Report
Addendum: Environmental Modelling to Support NPDES Permitting for Velella Epsilon Offshore Demonstration Project in the Southeastern Gulf of Mexico

CASS Technical Report

Addendum: Environmental Modelling to Support NPDES Permitting for Velella Epsilon Offshore Demonstration Project in the Southeastern Gulf of Mexico

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Environmental Engineer: Barry King, PE
Submitted to Kip Tyler (EPA), September 23, 2020

This report is submitted as an addendum to the report "Environmental Modelling to Support NPDES Permitting for Velella Epsilon Offshore Demonstration Project in the Southeastern Gulf of Mexico" of August 2018. The Environmental Protection Agency (EPA) is preparing to issue an NPDES permit for the Velella Epsilon Offshore Demonstration Project. The applicant, Kampachi Farms, LLC (now Ocean Era, Inc.), proposes to develop a temporary, small-scale demonstration net pen operation to produce a single cohort of Almaco Jack (*Seriola rivoliana*) at a fixed mooring located on the West Florida Shelf, approximately 45 miles offshore of Sarasota, Florida. With this addendum, scientists from the NOAA Coastal Aquaculture Siting and Sustainability (CASS) program continued to work with the EPA NPDES permitting program to develop estimates of farm discharge deposition on the seabed and surrounding benthic community. Specifically, the farm simulation was executed for five years at the maximum stocking density, with the predicted feed and fish waste daily contributions. The most recent version of DEPOMOD modelling software (i.e., NewDEPOMOD) was used to calculate the distribution and deposition of solid materials at the project location.

Current data were obtained from NOAA Buoy Station 42022 along the West Florida Shelf at the 50-m isobath and located 45 miles northwest of the project location (27.505 N, 83.741 W). The buoy is owned and data are collected by the University of South Florida Coastal Ocean Monitoring and Prediction System with support from the U.S. Integrated Ocean Observing System. Lacking five continuous years of water column flow data at the site, a single year of current data from the original simulation was used to produce the assumed current profile at the project location. Given that single year current data was used for this model, year-to-year variability in oceanographic patterns that are associated with changing climate and weather patterns, water temperature, and storm tracks (e.g., hurricanes) are not evaluated.

As previously reported, bathymetric data were obtained from the NOAA Coastal Relief Model. Bathymetry was resampled to 25 x 25 meter grid cells using a bilinear interpolation to all, for use within the deposition model. The characterization of the site and composition of benthic surfaces were informed by U.S. Geological Survey offshore surficial sediment data (usSEABED) that describes seabed characteristics, including textural, geochemical, and compositional information for the Gulf of Mexico. The benthic surfaces for the project location were also informed by acoustic survey and sub-bottom profile data included with the applicant's Baseline Environmental Survey (BES). Sediment samples, including core or grab samples, were not collected or analyzed as part of the BES. Without knowing explicitly the hydraulic roughness of the benthic surface at the project location, the model was run (as previous) with the assumption of a smooth benthic surface characteristic of unconsolidated sediments (coarse to fine grain sand bottom) such as those common on the West Florida Shelf. Modelling with a smooth benthic surface and reduced roughness tends to lower the bed shear stress and increase resuspension.

The model does not allow the net pen or mooring configuration to move in space or time, therefore, the model was executed at a fixed location (27.064318, -83.225726) in the center of the project location (i.e., farm footprint). The model domain also remained as reported. The model domain was set to encompass the whole initial depositional footprint under average current velocities estimated at 20 cm/s and with particles settling at rates faster than 0.75 cm/s. The dimensions for the model domain are standards required by the Scottish Environmental Protection Agency for marine aquaculture operations. The domain also captures reasonable efficiency in processing large data sets or long time-series data (*i.e.*, model requires 24-36 hours to process). The predicted carbon deposition and magnitude of biodeposition were estimated over a 2.04 km by 2.04 km evaluation grid. The grid is partitioned into square cells with sides measuring 24.87 m and cells numbering 82 east-west by 82 north-south with cells identified as 1-82 in both directions. The modelling software reports the average solids and carbon within each cell as grams per square meter at the moment it is queried, typically at the end of the simulation period.

This model execution did not allow the settling velocity of particles to change through the growing cycle. The values used for feed and feces represented those that would be encountered during the period of highest standing biomass, largest feed pellet size, and highest waste output from the net pen operation. Each simulation assumed maximum standing biomass each day of the simulation with fecal settling and food settling velocities applicable to salmon production at 3.5 and 9.5 cm/s, respectively. The values for fecal settling velocity may have implications for dispersion. For this study, a conservative settling velocity (3.5 cm/s) was used to assess the maximum extent of fecal deposition on benthic surfaces. Knowledge of the physical properties of fish feces under net pen conditions is rudimentary. Most reported literature addresses the fecal stability, density, and settling velocity (3.5 cm/s) of farmed salmon (Reed et al. 2009). Data on fecal settling velocity for Amberjack (*Seriola* spp.) are scarce. Amberjack feces are shapeless and unstable in the water column (*e.g.*, lacking cohesiveness). The species has a reported fecal settling velocity of about 1.6 cm/s owing to its smaller size and density (Fernandes and Tanner 2008).

The model was run for 1,825 days assuming a net pen with a constant daily standing biomass at 36,288 kg (22.85 kg/m3) and a daily feed rate of 1.1 percent of biomass or equivalent to 399 kg of feed. Standard feed waste was estimated at 3%. The model simulates release of fecal and feed particles from a net pen at hourly increments. Multiple particles are released representing different mass percentages and different settling velocities defined in the set-up files. The particles are all tracked throughout the domain at each time step over the duration of the simulation. Particles that are transported out of the domain boundary at 1,020 m away at the closest, are lost and removed from the calculations. Only masses of material that remain in the domain at the moment a surface is queried and recorded are reported. At high current velocity sites, such as this project location where the average flow is 13 cm/s and peaking at 67 cm/s at 4 meters above the seabed (Figure 1), the bulk of settleable solids from the aquaculture operation are dispersed outside of the simulation domain. It is expected that these solids would continue to be oxygenated and transported along benthic surfaces downstream where currents allow for deposition and resuspension. This particulate organic carbon would be readily available and consumed by bacteria and benthic infauna.

SOFTWARE UPDATES

NewDEPOMOD (version 1.3, released July 2020) and previous versions of DEPOMOD are computer models that have been developed by the Scottish Association of Marine Science to inform siting, permitting, and regulation of marine fish farms. The model predicts the impact of farm deposition on the seabed in order to optimize the operation of aquaculture sites to match the environmental capacity. The Scottish Environmental Protection Agency has used the software for over a decade in direct support of their aquaculture permitting standards.

NewDEPOMOD incorporates a range of features in its newest release including:

- improved predictive abilities for offshore aquaculture projects including the capacity to use three-dimensional hydrodynamic flow field data;
- an updated and characterized resuspension process using data from an extensive set of field measurements of erosion, resuspension and transport at farm sites;
- a new model framework for sediment deposition which allows the model to include varying bathymetry; and
- a model that produces conservative estimates of the holding capacity of a proposed site that can be tuned using data collected once a farm enters production to improve predictions, also useful for planning expansion of an existing farm.

ESTIMATING DEPOSITION AND MASS FLOW TO THE BENTHOS

Mass flows of solids onto the seabed were estimated from the mass of cultured fish on the farm and the specific rate, which they are fed (Table 1). We developed a model for a 1,296-m^3 net pen[1] with a stocking density of 28 kg/m^3, which will yield a biomass of 36,288 kg. An estimated 399.17 kg of feed will be applied per day at a feeding rate of 1.1 percent of body weight. During permitting, the applicants changed the net pen design to a larger volume, however the biomass within remained the same at 36,288 kg which is the keystone value for the waste dispersion simulation.

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[1] After completion of modelling, it was noted by the EPA that minor changes occurred with submission of the Ocean Era permit application. The net pen configuration changed as did the size of fish at harvest. The discrepancy in net pen volume (1,296 m^3 vs 1,588 m^3) and fish size (1.8 kg vs. 2.0 kg), and the implications on model results are negligible.

With a feed moisture content of 9% and an estimated 3% food waste rate, the feed dry mass lost from the net pen is: [399.17 kg feed * (100%-9% kg dry feed / kg feed) * 3% kg dry feed lost/kg dry feed] = 10.89 kg dry feed lost to the environment each day, or 0.454 kg per hour.

Since the feed is measured as 49% carbon, the flux is: 10.89 kg dry feed wastage * 0.49 kg carbon/ kg dry feed = 5.34 kg carbon per day from feed.

Similarly, for the fecal mass produced with the assumed 9% feed moisture and 85% utilization: [(399.17 kg feed – 3% lost (11.97 kg)) * 15% fecal mass/mass of solid feed ingested * 91% kg solid feed / kg feed] = 52.85 kg of fecal solids per day, or 2.2022 kg per hour.

Fecal matter is measured as 30% carbon and yields: 52.85 kg of fecal solids * 0.30 kg carbon / kg of fecal solids = 15.85 kg carbon per day

Combining the flux masses for solids and carbon an estimated 63.74 kg of solids and 21.19 kg of carbon are released into the environment each day from the demonstration project.

Table 1. Summary statistics for the Velella Epsilon Offshore Aquaculture Demonstration Project.

Farming parameter	Value
Initial Total number	20,000 fish
Individual size at harvest	1.8 kg
Maximum biomass during growout	36,288 kg
Net pen density at harvest	22.85 kg/m^3
Maximum daily feed rate	399 kg
Total feed used	66,449 kg
Feed conversion ratio	1.8

Table 2 reports the mass flows of solids and carbon from the Velella Epsilon Offshore Aquaculture Demonstration Project within the simulation domain. The bulk of released solids and their carbon are lost from the domain, carried into the far-field by currents. Comparing values of solids in Table 2, the simulation predicts that 3.63% of the solids remain within the simulation domain after five years. There are periods in the water flow cycles when solids accumulation is variable in the domain, as illustrated in Figure 2. The masses on the final day approximate the average concentrations.

Table 2. Mass flows of solids and carbon from the Velella Epsilon Offshore Aquaculture Demonstration Project within the simulation domain at the end of 5 years.

Model Parameters and Simulation Results	Value
Mass of feed applied (5 years)	728,481.60 kg
Mass of feed wastage (5 years)	19,887.57 kg
Mass of feed wastage carbon (5 years)	9,744.89 kg
Mass of fecal materials (5 years)	96,454.61 kg
Mass of fecal carbon (5 years)	28,936.38 kg
Total mass dry solids released / day	63.75 kg
Total mass dry solids released / year	23,268.43 kg
Total mass dry solids released / 5 years	116,342.17 kg
Total mass carbon released / day	21.20 kg
Total mass carbon released / year	7,736.25 kg
Total mass carbon released / 5 years	38,681.27 kg
Solids balance (Total solids within domain after 5 years)	4,224.87 kg
% solids retained inside domain	3.63 %
% solids exported outside domain	96.37 %
Carbon balance (Total carbon within domain after 5 years)	1,406.13 kg
% carbon retained inside domain	3.64 %
% carbon exported outside domain	96.36 %

At the project location, water velocities are typical for currents along the West Florida Shelf. Figure 1 illustrates the water velocity at the Velella site at a depth of 36.7 meters or approximately 4.0 meters above the seafloor. Currents at this project location will likely re-suspend feed wastes and fecal materials transporting these solids across the seafloor. The simulation software calculates the movement of the released solids using the particle characteristics, the nature of the seafloor, and the velocity of the water body in the proximity of the seafloor.

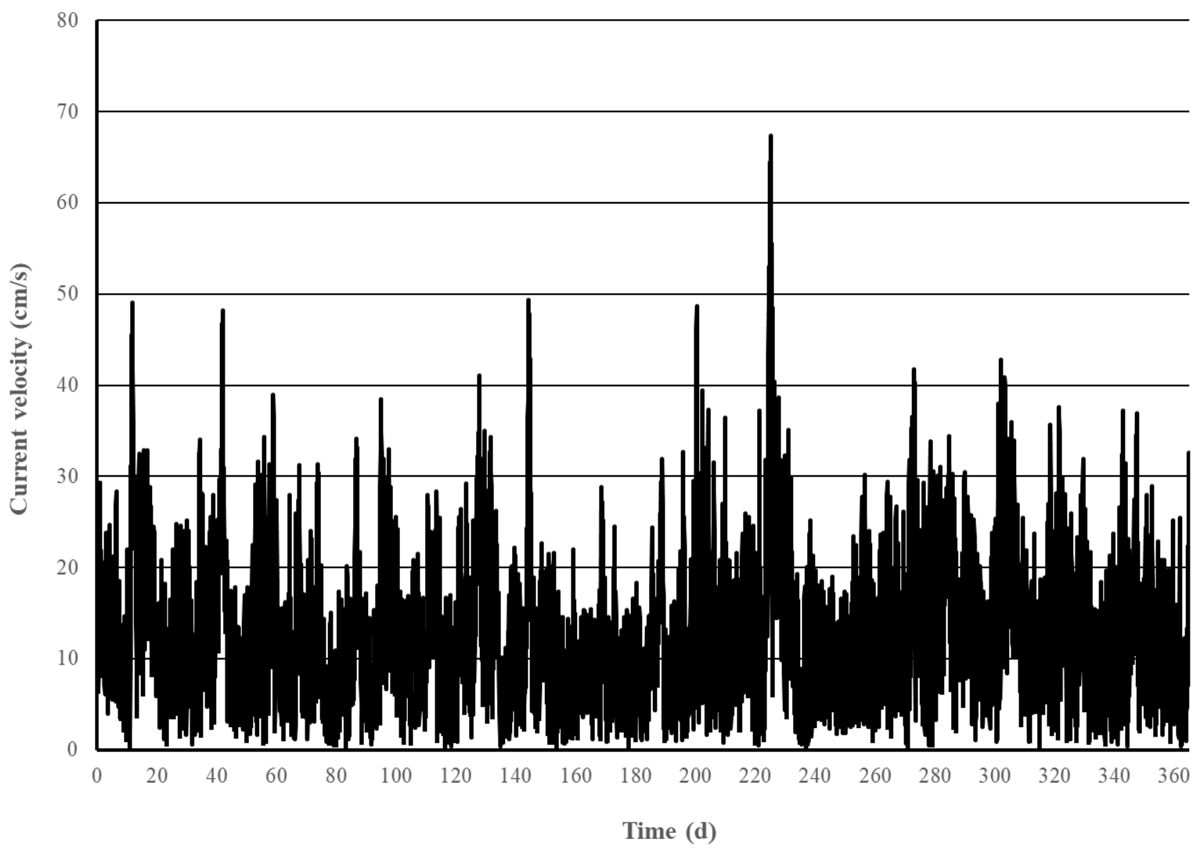

Figure 1. Water currents and flow velocity measured at 4 m above the seafloor.

Figure 2 illustrates the fate of the remaining solids within the domain over the five-year simulation, calculated from the total mass of released solids, minus the total mass of solids that are exported out of the simulation domain. The figure shows that over the five-year simulation solids on the seafloor within the domain reach an equilibrium, at an average total mass of 4,013 kg. The leading edge of the plot illustrates the point material accumulates on the seabed where it will eventually resuspend leading to more material being transported away from the depositional site as currents reach the shear force threshold. During the first days of operation little material was available for resuspension, all the while, new material was being added at a constant 63.75 kg per day.

NewDEPOMOD reports distribution of solids as surface plots of either solids or carbon, it does not distinguish between the sources of the carbon, either feed or fecal, and are combined. In Figure 3, the distribution of carbon is plotted for the final hour of the five-year simulation. Within the software, each surface plot generates its own scale to coincide with the colors on the map. The reader should use caution when comparing plots.

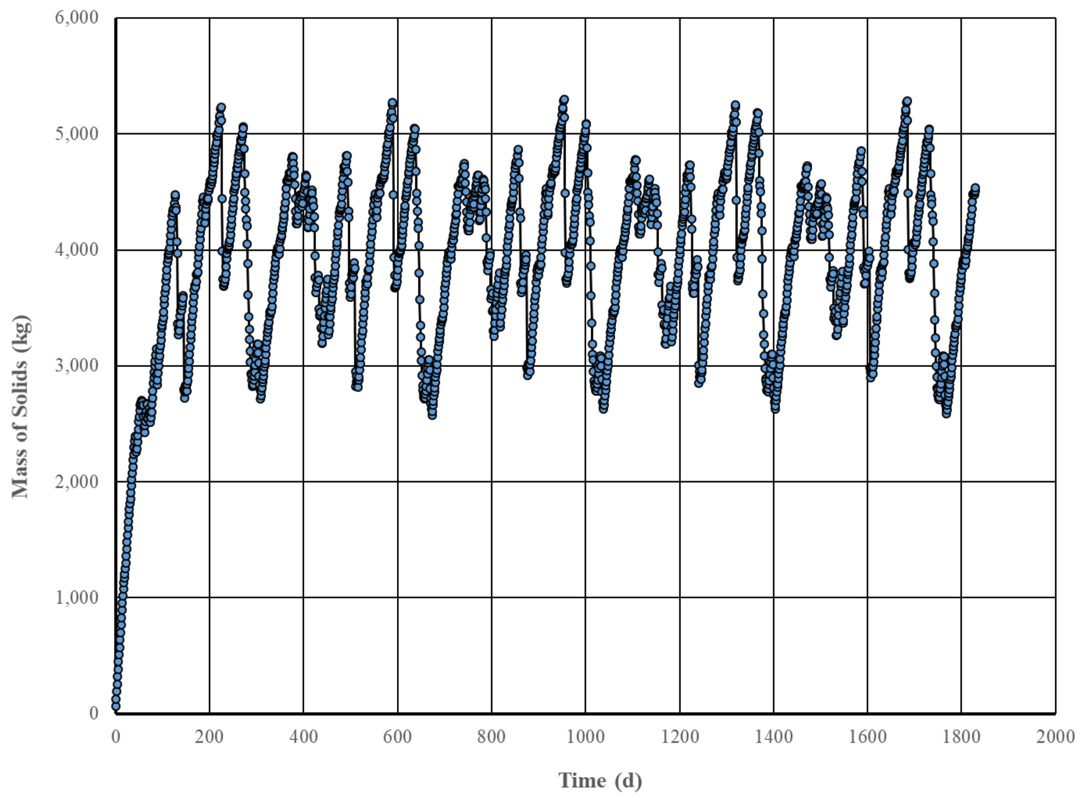

Figure 2. Predicted solids deposition beneath one net pen with a standing stock biomass of 36,288 kg of Almaco Jack (*Seriola rivoliana*) after five-year farm simulation.

Figure 3 shows the carbon distribution over the 2,040 x 2,040 meter Velella simulation domain on day number 1,830. The highest concentration of aquaculture sourced carbon on the site is 4.35 g/m^2. Most noticeable in this deposition prediction map is the wide distribution of carbon over 4 km^2 with small accumulations and no areas of excessive concentrations. Frequency histograms of the carbon deposition per cell were created to help with interpretation of results. The depositional data derived from the frequency histograms are presented in Table 3.

This wide dispersion and low concentration of carbon created the average Infaunal Trophic Index (ITI) score for this final overall benthic surface of 58.96 out of 60. As previously reported, a predicted ITI of close to 60 suggests that the Velella project will not likely have a discernable impact on benthic communities around the project location. Similar to other studies reporting ITI as a measure of benthic impacts from net pen operations, we do not expect significant impact on sediment redox potential or sulfide production. For example, Hargrave (2010) and Keeley et al. (2013) extensively documented correlations among the carbon deposition rate, redox potential, hydrogen sulfide concentration, interstitial dissolved oxygen, and ITI. We believe that the Velella project will present challenges for monitoring and detecting environmental impacts on sediment chemistry or benthic communities because of the circulation around the project location and the small mass flows of materials from the net pen installation. As the simulation illustrates, the high energy environment at the site and the mass flow of materials equilibrates at a resident total mass of waste products at approximately 4,000 kg with local masses never exceeding more than 43.4 g solids per square meter for a single sample point over the 5 year simulation.

CONCLUSION

There are minimal to no risks to sediment chemistry or benthic ecology functions in the project area from the operation of the net pen as described in the Ocean Era, LLC application for an NPDES permit.

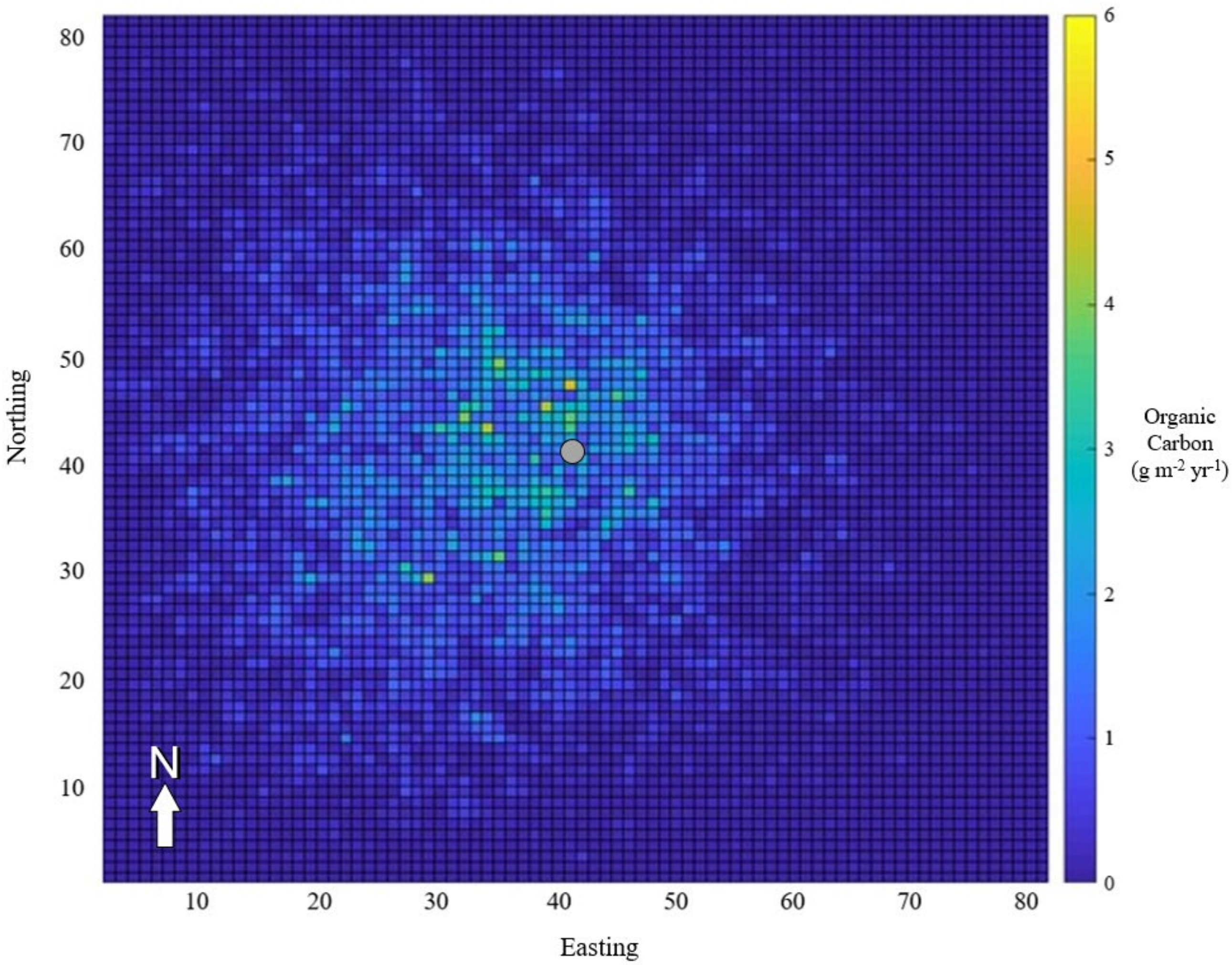

Figure 3. Predicted benthic carbon deposition field beneath one net pen with a standing stock biomass of 36,288 kg of Almaco Jack (*Seriola rivoliana*) after five years. Grey circle indicates center position of the net pen. Axes indicate simulation cell numbers and carbon deposition mass is in grams.

Table 3. Frequency of carbon deposition within 6,724 cells, each measuring 619 m^2, over a 4.16-km^2 grid system. Values represent an annual sum of carbon deposition resulting from an offshore fish farm with a constant standing stock biomass of 36,288 kg.

Carbon deposition ($g/m^2/yr$)	Occurrence (N)	Frequency (%)
0	1,508	22.43
0.1 – 1.0	4,526	67.32
1.1 – 2.0	559	0.08
2.1 – 3.0	111	1.65
3.1 – 4.0	16	< 0.01
4.1 – 5.0	4	< 0.01

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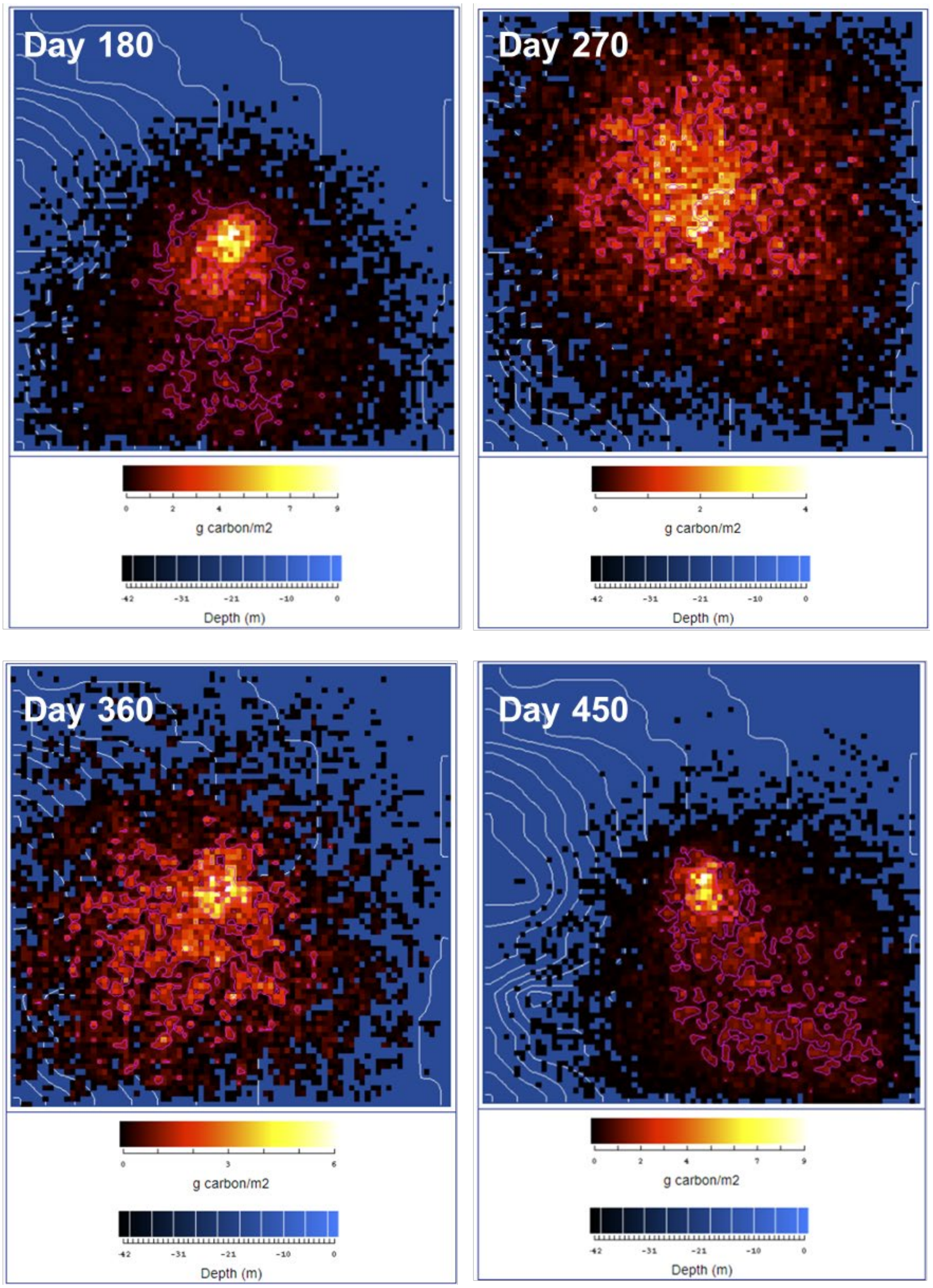
Appendix: Time-series simulation of predicted benthic carbon deposition beneath one net pen with a standing stock biomass of 36,288 kg of Almaco Jack (*Seriola rivoliana*). The reader should use caution comparing plots. The software generates a new legend for each plot in the time series. The scale and color ramp varies with each surface plot.



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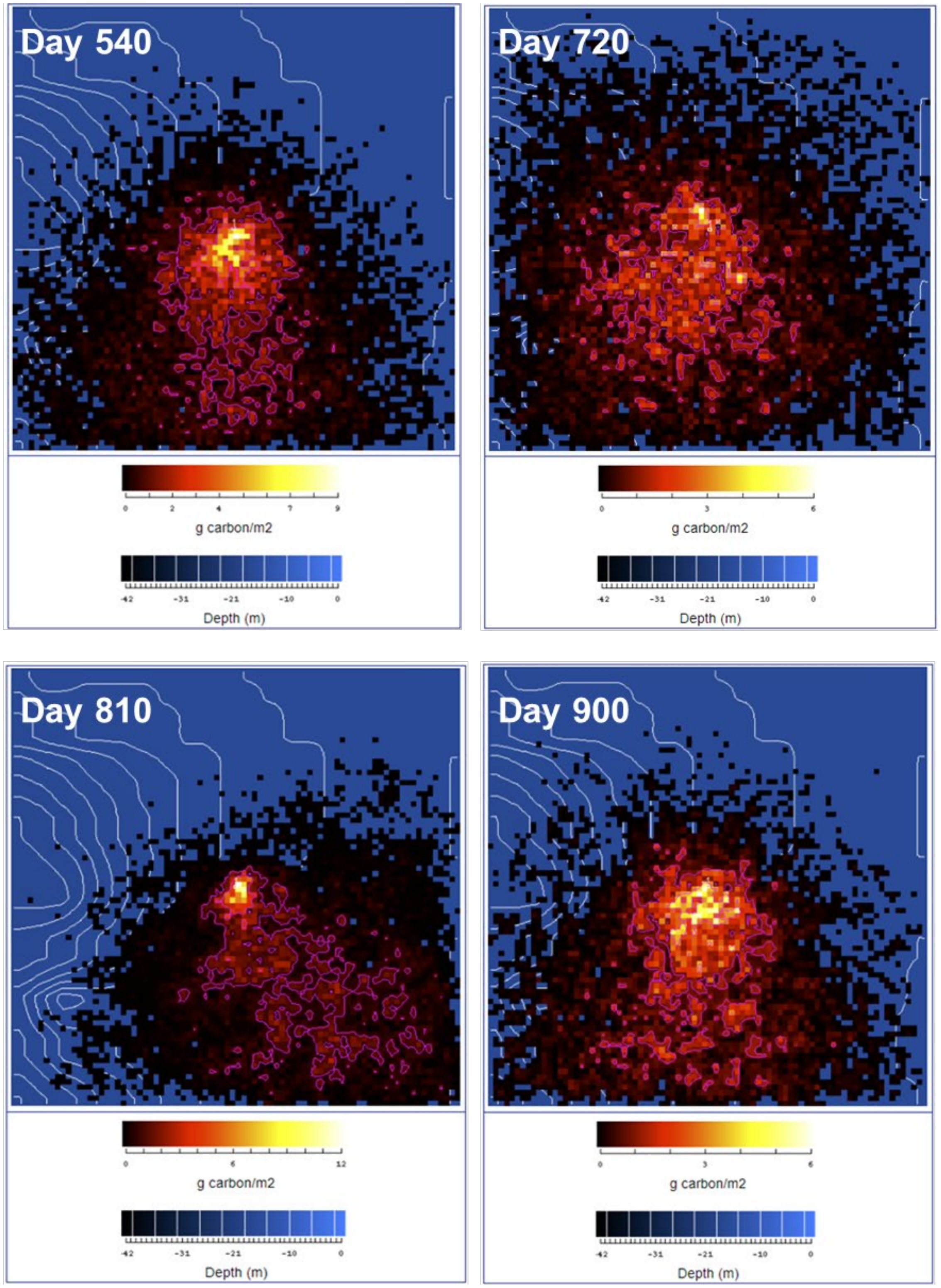

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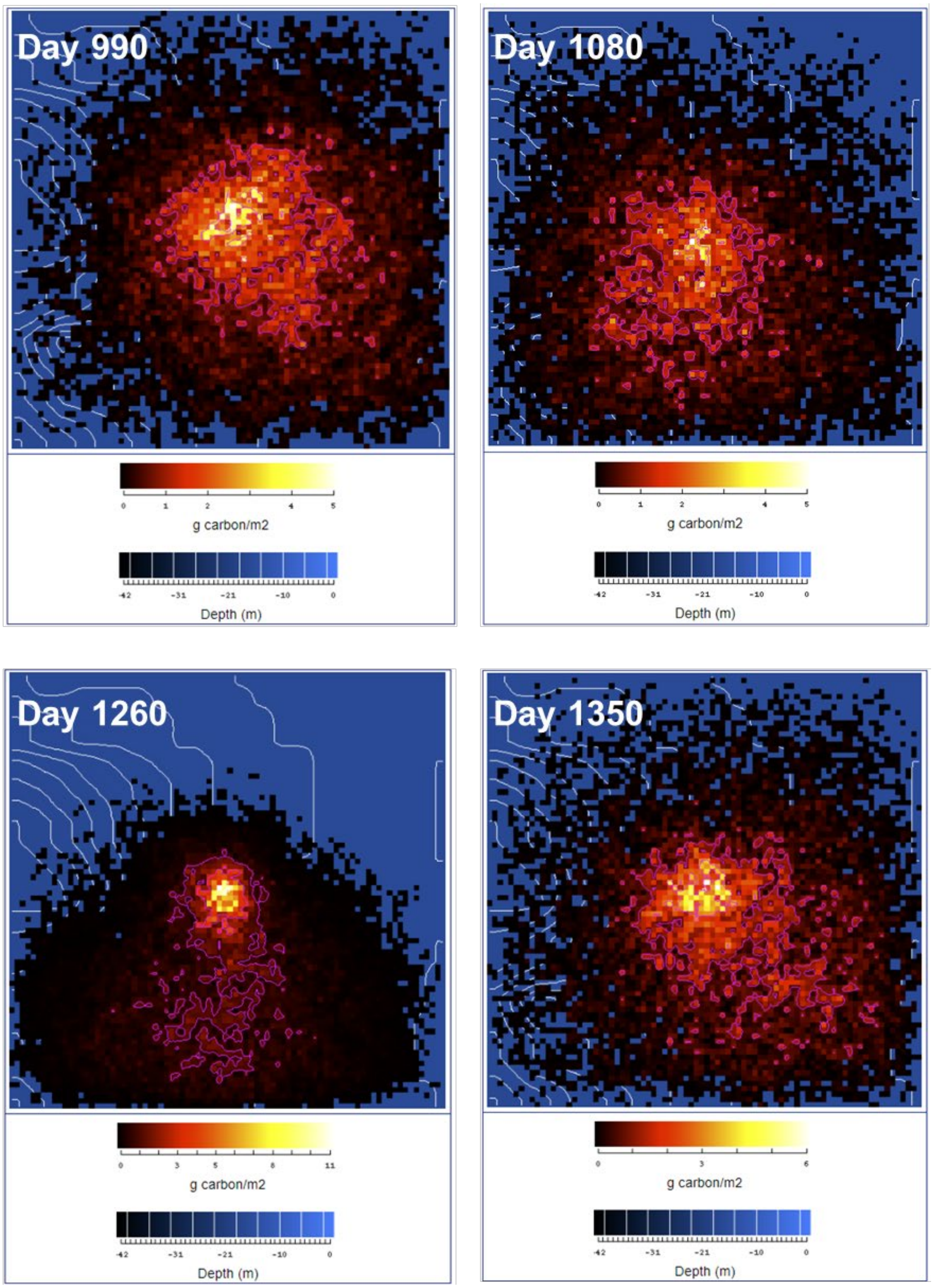

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