OCS Study
BOEM 2020-022

Continuing and Expanding a Deepwater Biological Observation System in the Northern Gulf of Mexico

U.S. Department of the Interior
Bureau of Ocean Energy Management
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ABOUT THE COVER

ROV image of a great barracuda swimming with almaco jacks beneath a platform in the Northern Gulf of Mexico.

ACKNOWLEDGMENTS

The authors are grateful for the cooperation of Shell, BP, Petrobras America, Anadarko and Oceaneering. Dr. Ruth Perry (Shell) was instrumental in enabling access to Shell observations and inspection data. Mr. Joe Gelpi (Oceaneering) provided valuable assistance in securing observations from their ROV systems. Taxonomic identification was crucial and we appreciate the help of Dr. John Caruso, Dr. Kenneth Sulak, Dr. Michael Vecchione, Dr. Steve Haddock, Dr. Erik Cordes, Dr. Mary Wicksten, Dr. Dave Pawson, Dr. Morgan Kilgour, and Dr. Jose Castro.

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List of Abbreviations and Acronyms

Short Form	Long Form
AC	Alaminos Canyon
ADCP	acoustic doppler current profiler
BOEM	Bureau of Ocean Energy Management
BOP	blow-out preventer
CTD	conductivity, temperature, depth recoder
DC	De Soto Canyon
DSC	digital stills camera
DOI	US Department of the Interior
ESP	Environmental Studies Program
ESPIS	Environmental Studies Program Information System
GB	Flower Garden Banks
GC	Green Canyon
KC	Keathley Canyon
MC	Mississippi Canyon
MODU	mobile offshore drilling unit
NOAA	National Oceanic and Atmospheric Administration
ROV	remotely-operated vehicle
SERPENT	Scientific ROV Partnership using Existing iNdustrial Technology
SS	Ship Shoal
WR	Walker Ridge

Introduction

SERPENT (Scientific [remotely-operated vehicle] ROV Partnership using Existing iNdustrial Technology) is a global scientific collaboration between the oil and gas industry and academia. It affords scientific access to industrial vessels and the remotely-operated vehicles (ROVs) that are deployed in support of petroleum exploration and production. SERPENT operates in the Northeast Atlantic, off West Africa, Australia, and in the Gulf of Mexico (Gulf SERPENT). Gulf SERPENT was initiated in 2005 with a grant from NOAA's Office of Ocean Exploration. BP was the first industrial partner and the success of that project led to funding from the Bureau of Ocean Energy Management (BOEM) in 2007 until 2016.

The concept behind Gulf SERPENT is simple: use industrial ROV operational standby time for scientific observations. Most deepwater vessels are equipped with one or two ROV systems capable of operating to 3000 or 4000 m depth. These ROVs serve as the eyes and hands of the vessel in the deep sea. Many deepwater vessels are drillships or mobile offshore drilling units (MODU) tasked with drilling exploratory wells in search of hydrocarbons at sites where seismic data suggest the presence of oil or gas. These exploration vessels are connected to the subsea well by a narrow pipe called a riser. The riser may extend for several thousand meters and contains the drill, conductors for drilling fluids, and power and/or telemetry feeds. At the seabed the riser is connected to the blowout preventer (BOP), a smaller device designed to prevent any hydrocarbons from leaving the subsea well in the event of an emergency. The ROVs are tasked with inspecting the integrity of the riser and BOP at intervals of one to three days and to monitor the condition of the BOP as well as to deploy/recover/inspect other subsea instrumentation (e.g., ADCPs, pipelines). The ROVs are tasked with various subsea work but on average, they are operational and on standby about 30–40% of the time. This is time when they can potentially be devoted to science.

Drilling a well takes approximately three months. This affords a much more complete picture of conditions in the ocean than would be provided by a scientific research cruise of a few weeks' duration. Moreover, the narrow riser and the small BOP mean that the drilling operation has a very low impact on the abundances and behaviors of marine organisms. Animals drifting through the water column have little to no advance warning of the presence of the riser. Animals on the seabed experience anthropogenic signals in the form of drilling cuttings and drilling muds only in a narrow zone extending within a narrow zone around the BOP. Thus, deepwater drilling operations provide excellent opportunities to document the biodiversity and vertical distributions of deep-sea marine life for an extended period.

Once oil or gas has been discovered, the well is completed and capped. Then, if economical, a more permanent structure is deployed at the site and wells are connected by a production riser to this moored structure (often called a platform or a spar). Hydrocarbons are then extracted from the well by a series of production risers, subjected to some initial processing, and then routed to shore-based refineries through subsea pipelines. These platforms or spars are usually also equipped with an ROV, which inspects the integrity of the production risers and the subsea infrastructure. These production facilities are usually in place for decadal time periods. Again, the ROVs are sometimes available to collect observations of both water column and seafloor marine life. If an ROV is not based at a production facility, periodic visits by vessels equipped with ROVs are undertaken to inspect the condition and integrity of the subsea equipment and risers. These periodic inspection videos are archived and represent a unique time-series of biological observations in the deep Gulf of Mexico.

Using industrial ROVs for scientific data collection requires special training because the pilots are not typically trained in collecting scientifically useful data with the vehicles. Before 2010, Gulf SERPENT conducted hands-on training at deepwater exploration and production sites. After acquiring all necessary deepwater safety and security certifications, a Gulf SERPENT representative would fly by helicopter out to each rig and spend several days (often accompanied by a qualified student or postdoctoral assistant) to familiarize offshore management with the project and to train the ROV pilots in the specifics of our water column and seafloor surveys. We would also recommend modifications of lighting and vehicle power, and video recording settings to optimize the quality of the observations. Once these training site visits were completed, the ROV pilots collected regular video observations, which were burned to DVD, SD cards, or hard drives, which were then sent to Louisiana State University (LSU) for analysis. Return visits to the vessels were conducted when possible and were based on factors such as when the ROV was likely to be available for extended periods, availability of space on board, substantial changes in the composition of the ROV crew, or occurrence of data quality issues.

In the aftermath of the 2010 *Deepwater Horizon* spill, it has become more difficult, though not impossible (depending on the company) to conduct training by direct offshore site visits. As an alternative, we have developed Microsoft® PowerPoint® and/or Adobe PDF® training packages that can be sent to the ROV teams. Data are still sent back by hard drives and feedback on data quality can be provided to improve the quality of the data. This process isn't as optimal as before but it still works effectively. This latter approach continues to use two survey strategies and two other observation approaches. Water Column Surveys consist of horizontal transects separated by ~150 m, flown into the prevailing current at constant velocity, depth, and speed for defined times or distances. On the return transect the ROV is free to collect close-up videos of organisms to enable better taxonomic discrimination. These surveys yield estimates of numbers of different taxa per unit time or distance. Seafloor surveys use a radial transect design centered on the BOP (Fig. 1). The ROV flies a series of 12 linear transects on primary compass headings (N, E, S, W) for a distance that depends on the length of the tether (electro-optical cable connecting the ROV to its vertical umbilical). On each compass heading, the ROV flies three parallel transects offset by a few meters to avoid overlap. The outbound transects are flown at an altitude of ~ 1 m while the vehicle moves at a constant speed with the camera aimed obliquely down at ~30°. On the return transect the vehicle can deviate to get high-resolution close-ups of marine life. If the ROV is equipped with laser-scalers then the field of view can be quantified and numbers of each taxa per m^2. Otherwise, numbers per unit distance can be calculated and then averaged over all transects to estimate the site mean abundance. Opportunistic encounters occur when during the course of normal industrial taskings, an interesting organism appears. If time and safety permit, the ROV records as much video as possible. Some of our most interesting encounters have resulted from these chance observations. Finally, most ROV pilots keep past encounters with unusual marine life on personal computers. We are often able to secure copies of these videos, which often include metadata. Where possible, and with the cooperation of industry, we are able to add these data to our database.

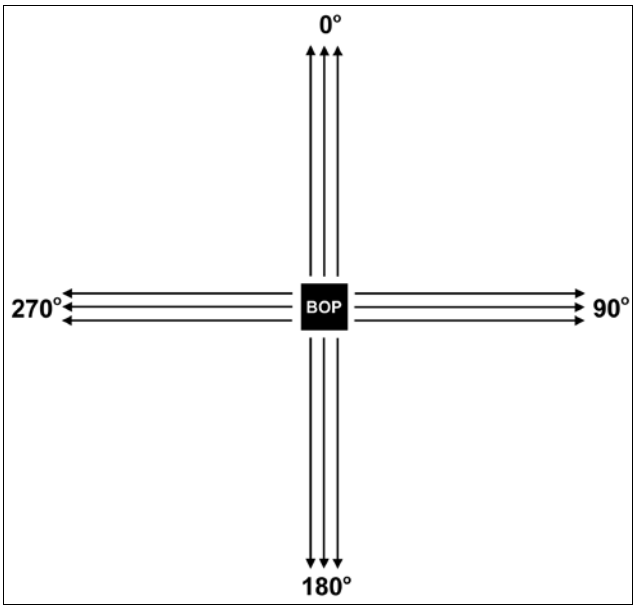


Figure 1. An example of a seafloor survey.
Three parallel transects are flown outbound from the BOP in each cardinal compass direction at constant speed, altitude, and heading. During the return, the ROV is free to deviate to obtain close-up images of representative marine life.

During the period covered in this report, we also made substantial use of inspection videos provided by Shell. These observations, recently collected and archived in full HD (1080p), provide an excellent opportunity to study the vertical distribution patterns of invertebrates and some fishes in relation to hard structure that extends throughout the water column.

Objectives

The objectives of Gulf SERPENT were to use video observations–collected by ROVs operating in the oceanic waters of the Gulf of Mexico–to assemble a picture of:

(1) what organisms were present;
(2) where did they occur in terms of season, time of day, and depth; and
(3) to document behavior and inter- and intra-species associations.

This report covers Gulf SERPENT activities from September 2013 through December 2018 conducted under the cooperative agreement M13AC00010 titled “Gulf SERPENT: Continuing and Expanding a Deepwater Biological Observation System in the Northern Gulf of Mexico.” Also included are some observations from 2012 that were collected after this initial Gulf SERPENT report (Benfield and Kupchik 2017) (Cooperative Agreement No. M07AC12468) was published.

2. Operations

2.1 Shell Oil

Shell was one of the first Gulf SERPENT partners. Shell began operations in 2009 and continues to the present day. Observations from Shell (Fig. 2) were obtained from production facilities: Ursa (MC809A); Mars (MC807A); Olympus (MC806/MC807B); Auger (GB426); Ram Powell (VK956); and Perdido (AC857A). Shell exploration facilities that also contributed observations included: GC200; GC247; GC248; MD525; and MC762.

2.2 BP

BP was the first petroleum company to partner with Gulf SERPENT and they have provided data since 2006. After the *Deepwater Horizon* spill, fewer observations were obtained from BP facilities; however, they provided data from DC32; DC33; DC801; KC57; KC147; GC743; GC787; MC778; and MC822 (Fig. 2).

2.3 Petrobras America

Petrobras America partnered with Gulf SERPENT from 2012 to 2015 and contributed observations from the drillship *Titanium Explorer* and ENSCO *Deep Ocean Medocino* operating in WR206 and WR426 (Fig. 2). Petrobras America ended exploration operations in the Gulf of Mexico in 2016.

2.4 Anadarko Petroleum

Anadarko Petroleum is the newest Gulf SERPENT partner. Thus far they have provided a few observations from *Ocean Black Hornet* operating in KC875 (Fig. 2).

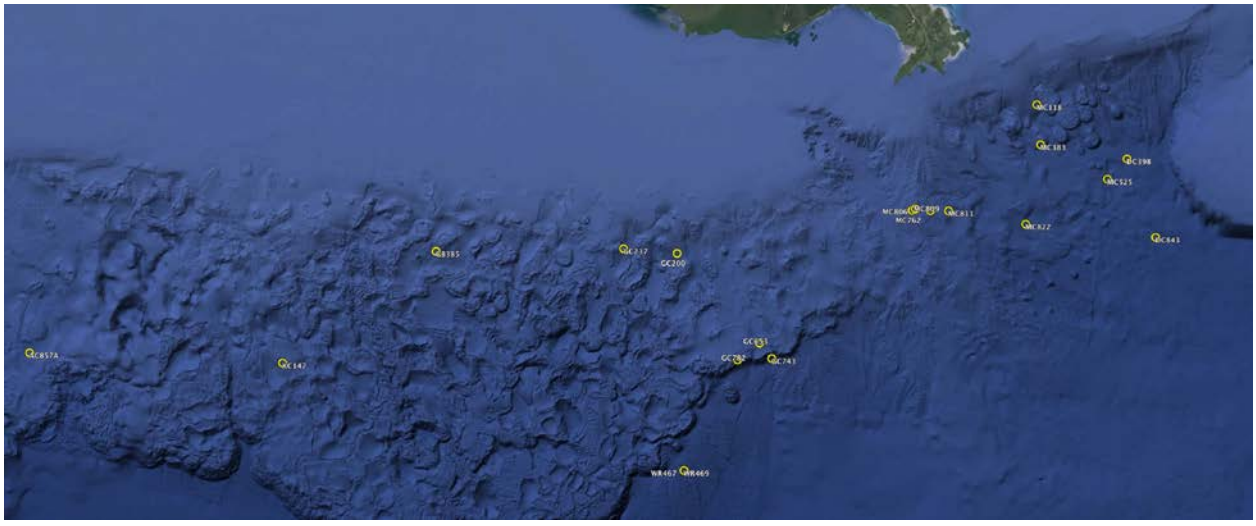


Figure 2. Gulf SERPENT observation locations from 2013 to 2018.

3. Biological Observations 2013–2016

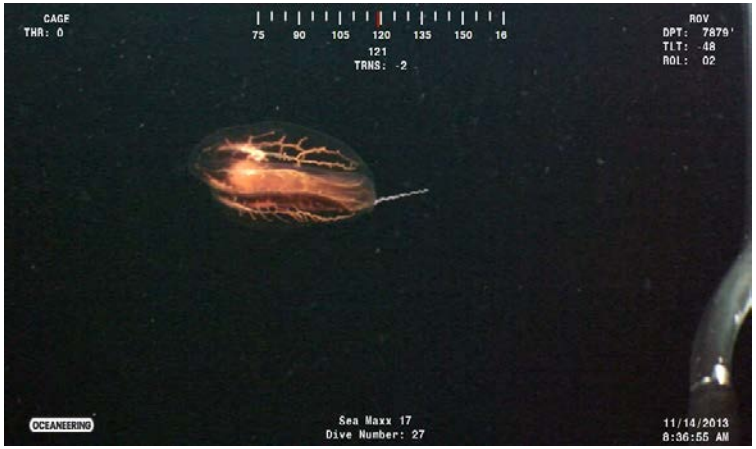
Gulf SERPENT relies on directed surveys of the water column and seabed, opportunistic encounters with marine life, and retrospective encounters that were in the possession of interested remotely-operated vehicle (ROV) personnel. The ROVs used by the oil and gas industry are sophisticated vehicles capable of operating to the full depth of the Gulf of Mexico. Unlike scientific ROVs, they generally lack instrumentation, such as laser scalers, a conductivity, temperature, and depth recorder (CTD), digital stills cameras (DSC), and collection and/or sampling systems. Without laser scalers, measurement of the sizes of organisms and the width of the field of view on the seabed cannot be undertaken. A CTD provides a continuous record of hydrographic parameters including at a minimum, temperature and salinity. The Oceaneering ROVs are equipped with a temperature sensor that can collect spot measurements; however, these data are not often recorded. The resolution of most DSCs is 18–24 megapixels. The frame grabs collected from high density (HD) video are approximately 2 MP. Consequently, the image quality and resolution of frame grabs is substantially lower than would be obtained from a dedicated DSC. The limitations on image resolution mean that taxonomic identifications are often much coarser than might be possible with high quality images from a DSC. The absence of sampling systems means that organisms can only be identified on the basis of information within the images. Despite these limitations, an industrial ROV in the hands of a skilled pilot can collect some remarkably useful images. During this project, data were collected from a variety of locations spanning the Northern Gulf of Mexico (Fig. 2). The observations that follow were collected by participating ROV teams between 2013–2016. Data collected at Petrobras sites in Walker Ridge are summarized in Chapter 3.

3.1 Alaminos Canyon

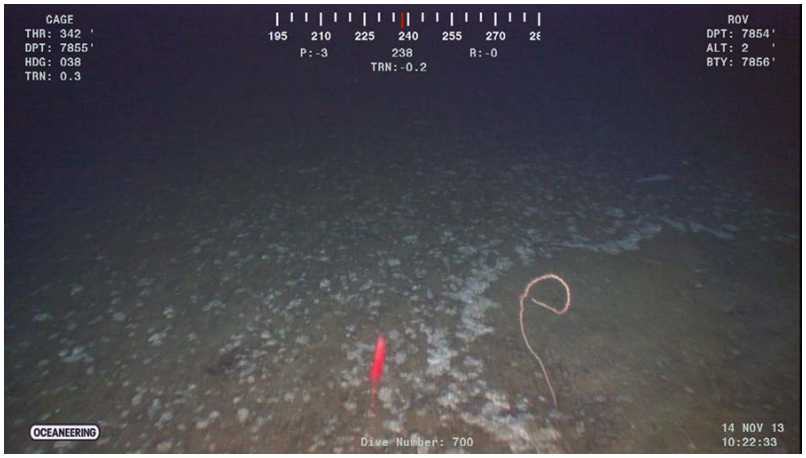
3.1.1 AC857A

Alaminos Canyon 857A is the location of Shell's Perdido Spar and is the westernmost site in Gulf SERPENT's network. The depth of the site (~2400 m) makes it an interesting study area and the dedicated ROV team of Oceaneering's MIL57 system have provided some very high quality observations. The site is notable for its abundance of holothurians. The bigfin squid *Magnapinna* sp. has been observed on numerous occasions at this site, usually just above the seabed. Highfin lizardfish *Bathysaurus mollis* were common.

Table 1. Biological Observations from AC857A

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 08:36:56	26.13 N 94.88 W	2402	Cydippid ctenophore *Aulacoctena* sp.	

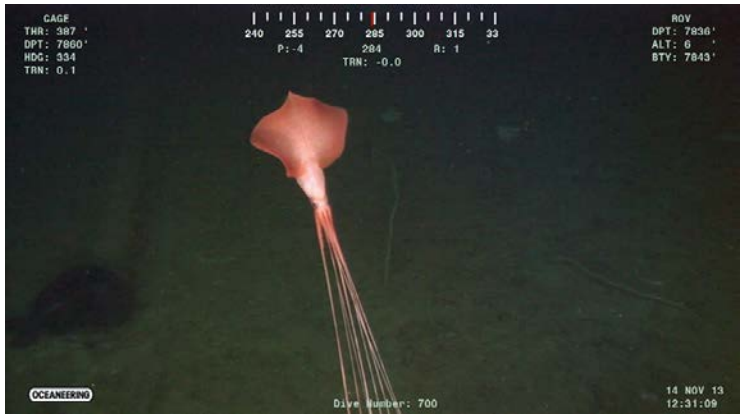
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 09:55:58	26.13 N 94.88 W	2391	Holothurian Enypniastes eximia	
11/14/13 09:59:06	26.13 N 94.88 W	2426	Holothurian Benthodytes typica	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 10:22:33	26.13 N 94.88 W	2395	Coldwater coral Unidentified	
11/14/13 10:25:12	26.13 N 94.88 W	2392	Highfin lizardfish Bathysauridae Bathysaurus mollis	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 10:42:26	26.13 N 94.88 W	2389	Hormathiid Anemone	
11/14/13 10:43:20	26.13 N 94.88 W	2389	Unidentified coral	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 10:43:51	26.13 N 94.88 W	2389	Unidentified coral	
11/14/13 10:44:30	26.13 N 94.88 W	2389	Unidentified squat lobster at base of sea pen.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 10:44:43	26.13 N 94.88 W	2389	Flytrap anemone *Actinoscyphia* sp. on sea pen	
11/14/13 12:28:56	26.13 N 94.88 W	2389	Fish Macrouridae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 12:31:09	26.13 N 94.88 W	2388	Bigfin squid Magnapinnidae Magnapinna sp.	
11/14/13 12:31:59	26.13 N 94.88 W	2388	Bigfin squid Magnapinnidae Magnapinna sp. (same individual as 12:31:09)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 12:35:20	26.13 N 94.88 W	2391	Highfin lizardfish Bathysauridae Bathysaurus mollis	
11/14/13 12:43:34	26.13 N 94.88 W	2388	Fish Alepocephalidae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 12:56:57	26.13 N 94.88 W	2394	Holothurian Enypniastes eximia	
11/14/13 12:59:47	26.13 N 94.88 W	2395	Highfin lizardfish Bathysauridae Bathysaurus mollis	

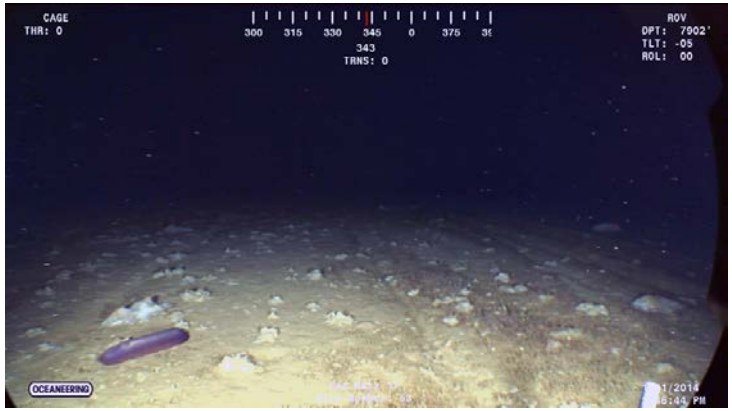
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/13 13:02:58	26.13 N 94.88 W	2388	Ophidiidae Bony-eared assfish Acanthonus armatus	
11/14/13 13:03:36	26.13 N 94.88 W	2387	Unidentified shrimp	

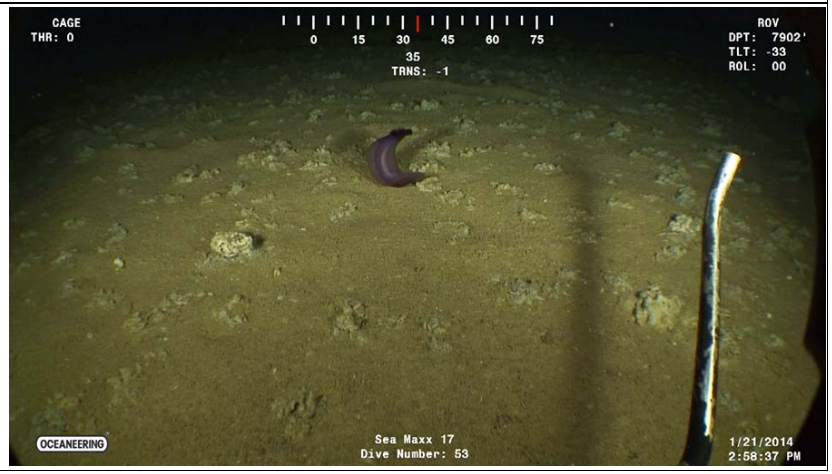
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/17/13 10:11:09	26.13 N 94.88 W	2385	Fish Inopiidae Bathypterois grallator	
11/17/13 10:12:40	26.13 N 94.88 W	2386	Fish Macrouridae Coryphaenoides mexicanus?	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/17/13 10:24:56	26.13 N 94.88 W	2388	Notacanthidae Polyacanthonotus challengeri	
12/11/13 15:46:51	26.13 N 94.88 W	460	Fish Sternoptychidae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/11/13 16:05:03	26.13 N 94.88 W	344	Medusa Unidentified	
12/13/13 10:27:29	26.13 N 94.88 W	2405	Brittle star *Bathypectinura heros*	

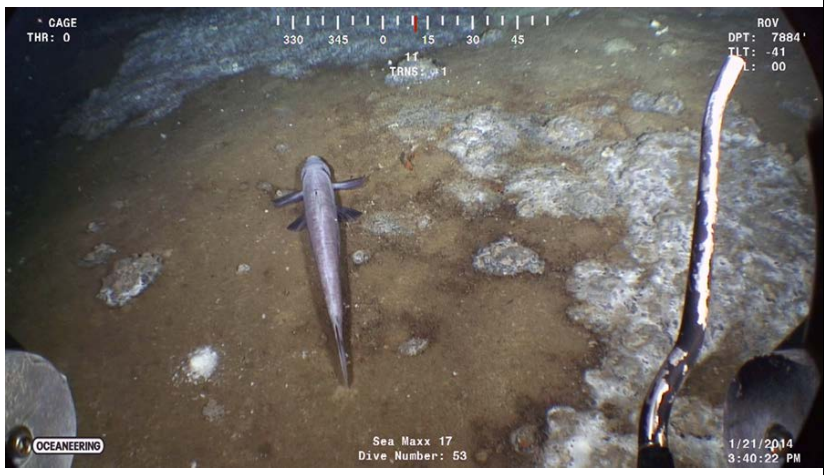
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/13/13 10:55:09	26.13 N 94.88 W	2313	Unidentified anemone	
12/28/13 08:24:28	26.13 N 94.88 W	1181	Scyphomedusa Periphyllopsis braueri	

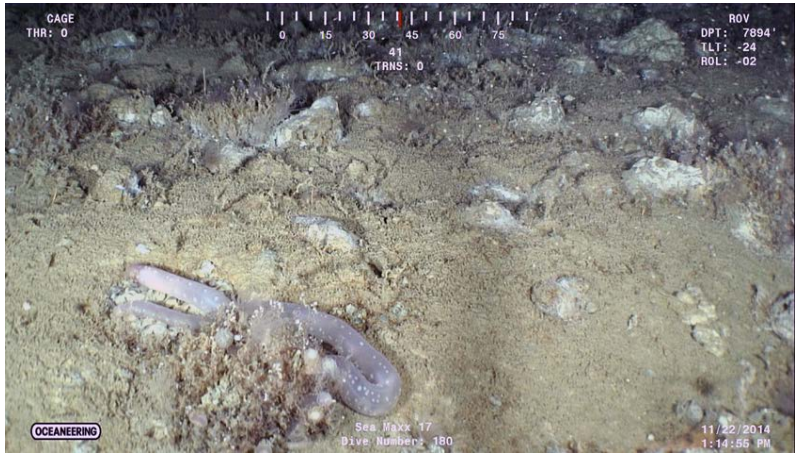
Date/ Time	Location	Depth (m)	Likely Identity	Image
01/21/14 02:46:44	26.13 N 94.88 W	2409	Holothurian Benthodytes typica	
01/21/14 02:56:52	26.13 N 94.88 W	2406	Holothurian Benthodytes typica	

Date/ Time	Location	Depth (m)	Likely Identity	Image
01/21/14 02:58:21	26.13 N 94.88 W	2408	Holothurian Benthodytes typica	
01/21/14 02:58:37	26.13 N 94.88 W	2409	Holothurian Benthodytes typica	

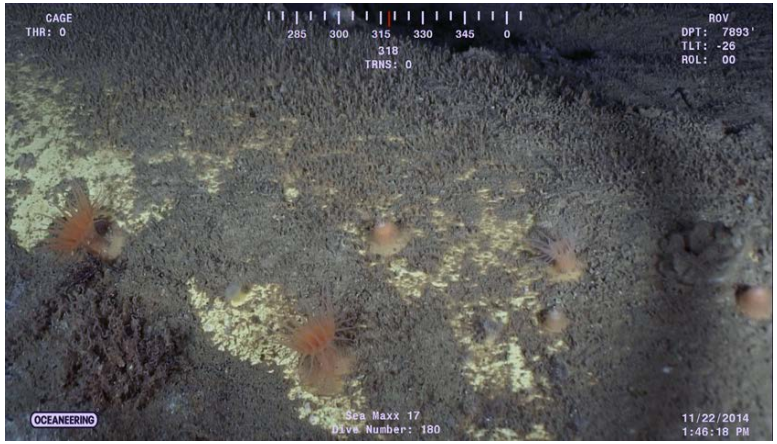
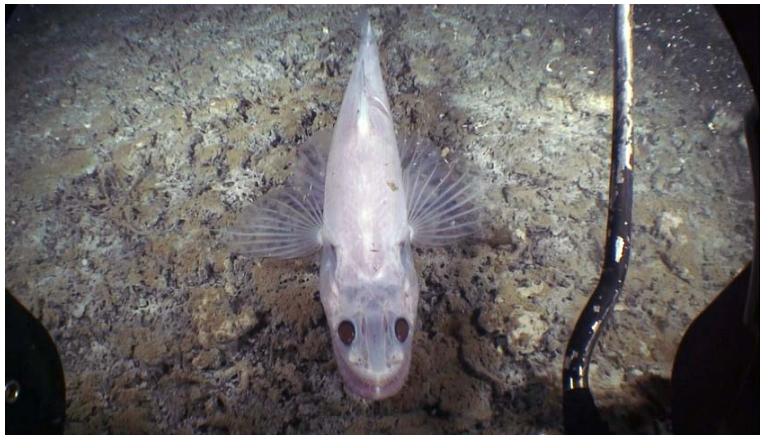
Date/ Time	Location	Depth (m)	Likely Identity	Image
01/21/14 03:04:39	26.13 N 94.88 W	2405	Unidentified squat lobster and shrimps *Nematocarcinus* sp.	
01/21/14 03:04:45	26.13 N 94.88 W	2405	Shrimps Nematocarcinus sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
01/21/14 03:07:50	26.13 N 94.88 W	2405	Holothurian Benthodytes typica	
01/21/14 03:18:15	26.13 N 94.88 W	2404	Unidentified squat lobsters	

Date/ Time	Location	Depth (m)	Likely Identity	Image
01/21/14 03:40:22	26.13 N 94.88 W	2403	Highfin lizardfish Bathysauridae Bathysaurus mollis	
11/22/14 10:12:11	26.13 N 94.88 W	2398	Fish Macrouridae Bathygadus sp. (B. arcuatus?)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/22/14 13:03:16	26.13 N 94.88 W	2405	Gastropod Unidentified	
11/22/14 13:14:55	26.13 N 94.88 W	2406	Holothurian Chiridotidae Chirodota sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/22/14 13:16:30	26.13 N 94.88 W	2406	Holothurian Chiridotidae Chirodota sp.	
11/22/14 13:28:26	26.13 N 94.88 W	2406	Hermit crab Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/22/14 13:46:18	26.13 N 94.88 W	2406	Anemones Unidentified	
03/07/15 14:40:00	26.13 N 94.88 W	2400	Highfin lizardfish Bathysauridae Bathysaurus mollis	

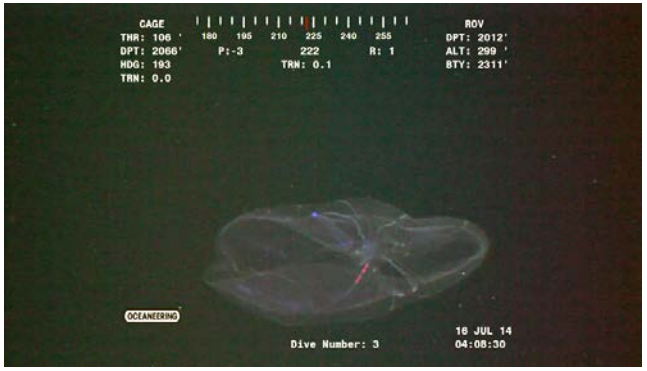
Date/ Time	Location	Depth (m)	Likely Identity	Image
03/07/15 14:40:02	26.13 N 94.88 W	2400	Highfin lizardfish Bathysauridae Bathysaurus mollis (same individual as 14:40:00)	
03/20/15 13:33:28	26.13 N 94.88 W	2393	Holothurian Benthodytes typica	

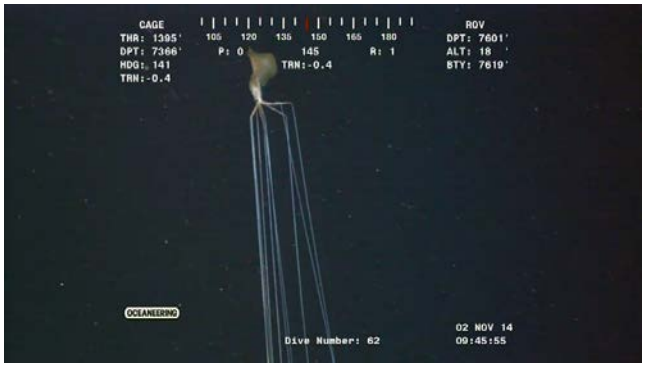
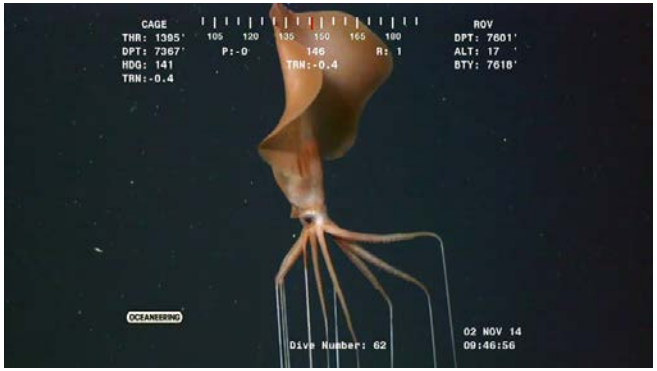
3.2 De Soto Canyon

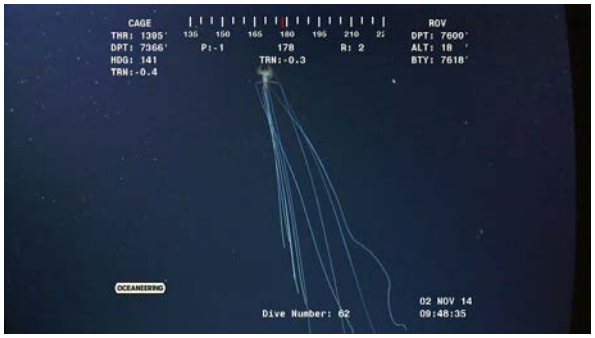
3.2.1 DC398

Observations at DC398 were collected by Oceaneering's Millennium 115 ROV. This is a deep site (~2300 m). Near bottom encounters from the summer and fall of 2014 revealed the presence of bigfin squid (*Magnapinna* sp.) and a large sleeper shark (*Somniosus* sp.).

Table 2. Biological Observations from DC398

Date/ Time	Location	Depth (m)	Likely Identity	Image
07/16/14 03:40:51	28.59 N 87.84 W	1220	Unidentified larvacean house	
07/16/14 04:08:30	28.59 N 87.84 W	613	Lobate ctenophore Thalassocalyce inconstans	

Date/ Time	Location	Depth (m)	Likely Identity	Image
08/14/14 15:33:22	28.59 N 87.84 W	2318	Sleeper shark Somniosus sp.	
11/02/14 09:45:55	28.59 N 87.84 W	2317	Bigfin squid Magnapinna sp.	
11/02/14 09:46:56	28.59 N 87.84 W	2317	Bigfin squid *Magnapinna* sp. (same individual as 09:45:55)	

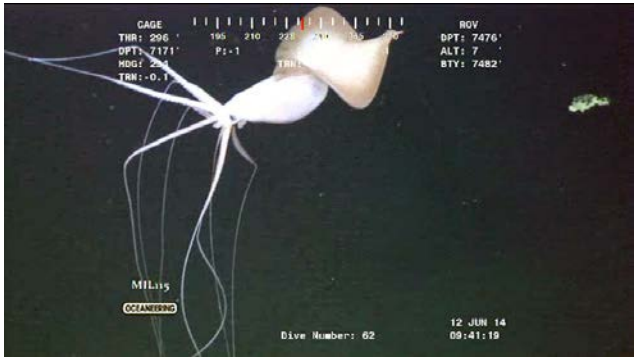
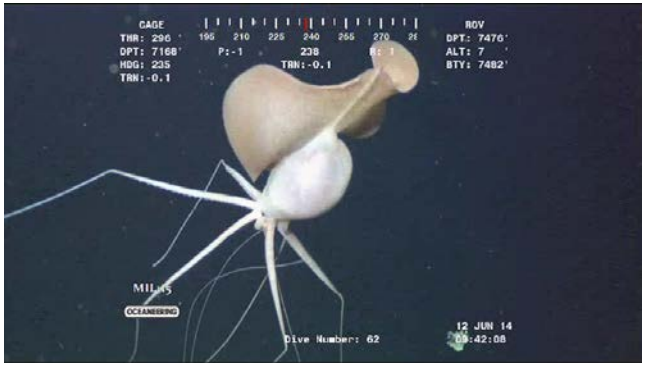
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/02/14 09:48:35	28.59 N 87.84 W	2316	Bigfin squid *Magnapinna* sp. (same individual as 09:45:55)	

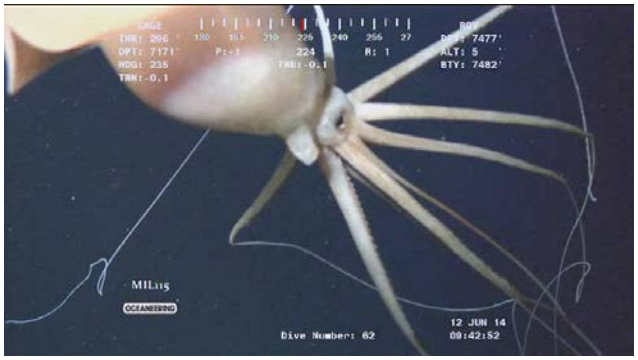
3.2.2 DC843

These observations were collected by Oceaneering's Millennium 115 system operating from Noble's *Globetrotter 1* drillship working under contract for Shell. This is an extremely deep site with a bottom depth in excess of 2275 m. A bigfin squid was observed near the seabed.

Table 3. Biological Observations from DC843

Date/ Time	Location	Depth (m)	Likely Identity	Image
01/13/14 11:48:49	Unavailable Reported as DC843	2596	Bony-eared assfish Acanthonus armatus	

Date/ Time	Location	Depth (m)	Likely Identity	Image
06/12/14 09:39:25	28.15 N 87.60 W	2278	Bigfin squid Magnapinna sp.	
06/12/14 09:41:19	28.15 N 87.60 W	2278	Bigfin squid *Magnapinna* sp. (same individual as 09:39:25)	
06/12/14 09:42:08	28.15 N 87.60 W	2278	Bigfin squid *Magnapinna* sp. (same individual as 09:39:25)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
06/12/14 09:42:52	28.15 N 87.60 W	2279	Bigfin squid *Magnapinna* sp. (same individual as 09:39:25)	

3.3 Garden Banks

3.3.1 GB385

One observation of a squid *Mastigoteuthis* sp. was provided by an Oceaneering ROV working aboard the multiservice vessel (MV) *Ocean Intervention IV* under contract for Shell. This observation is included because it occurred a few days before the onset of this project.

Table 4. Biological Observations from GB385

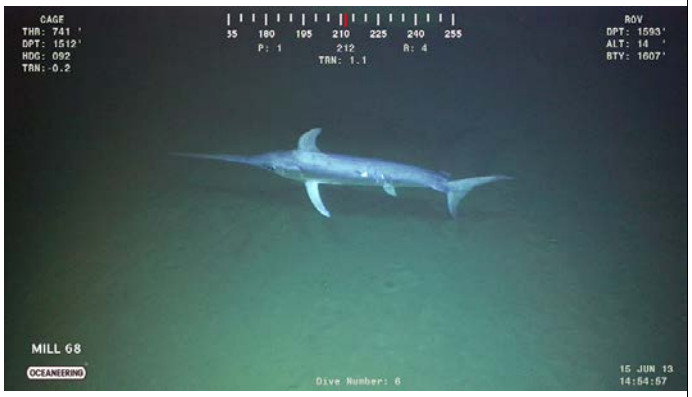
Date/ Time	Location	Depth (m)	Likely Identity	Image
08/29/13 07:10:21	27.60 N 92.30 W	799	Squid Mastigoteuthis sp.	

3.4 Green Canyon

3.4.1 GC200

One observation of swordfish *Xiphias gladius* in the mesopelagic zone was provided by an Oceaneering ROV working aboard the multiservice vessel (MV) *Ocean Intervention IV* under contract for Shell.

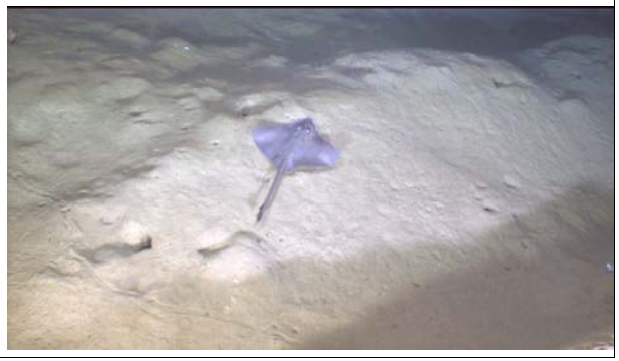
Table 5. Biological Observations from GC200

Date/ Time	Location	Depth (m)	Likely Identity	Image
06/15/13 14:54:57	27.76 N 90.74 W	490	Swordfish Xiphias gladius	

3.4.2 GC237

One observation of an unidentified ray was provided by an Oceaneering ROV working aboard the multiservice vessel (MV) *Ocean Intervention IV* under contract for Shell.

Table 6. Biological Observations from GC237

Date/ Time	Location	Depth (m)	Likely Identity	Image
03/23/14 11:36:00	27.75 N 91.09 W	732	Unidentified ray	

3.4.3 GC653

An Oceaneering ROV operating near the Shenzi TLP provided observations of a manta ray. The original video was from a 3D camera system and lacked an overlay.

Table 7. Biological Observations from GC653

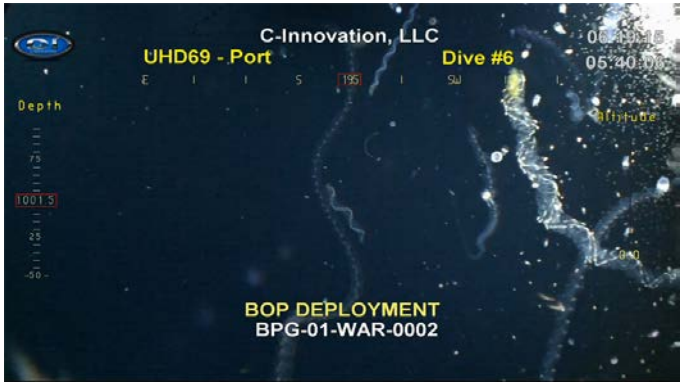
Date/ Time	Location	Depth (m)	Likely Identity	Image
05/04/14 07:53:01	27.30 N 90.14 W	61	Manta ray Manta birostris with remoras	
05/04/14 07:53:02	27.30 N 90.14 W	61	Manta ray Manta birostris with remoras (same individual as 07:53:01)	

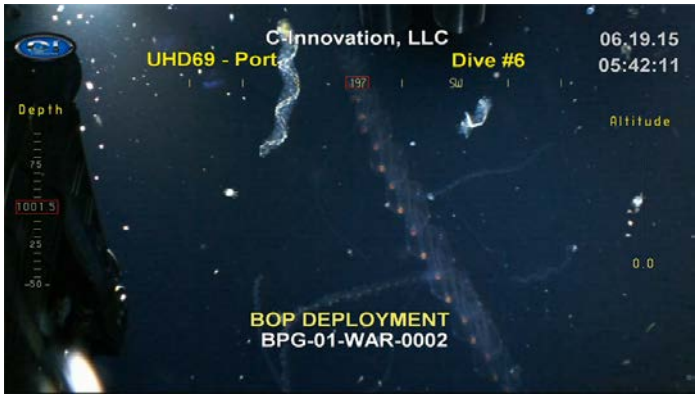
Date/ Time	Location	Depth (m)	Likely Identity	Image
05/04/14 07:53:03	27.30 N 90.14 W	61	Manta ray Manta birostris with remoras (same individual as 07:53:01)	

3.4.4 GC743

Green Canyon 743 observations were provided by an Oceaneering system Millennium 82 operating from the *Development Driller III* rig under contract to BP. Additional observations were collected by a C-Innovation ROV (UHD69). This soft-bottom site contained a diverse invertebrate and fish community. Invertebrates included holothurians (*Enypniastes eximia, Benthodytes typica, Benthothuria* sp.). At least three species of sea stars (Zoroaster fulgens, Nymphaster arenatus, and possibly *Plutonaster* sp.) were observed along with unidentified brittle stars. Sea pens were common. Shrimps included *Nematocarcinus* sp., *Cerataspis monstrosa,* and other unidentified taxa. The hermit crab *Sympagurus pictus* carrying an anemone *Adamsia obvolva* was common. This was one of only two locations where the flatback lobster *Polycheles* was recorded. Fishes were predominantly halosaurs, macrourids, the tripodfish *Bathypterois quadrifilis,* cutthroat eels *Synaphobranchus* sp., and the skate *Rajella purpuriventralis.*

Table 8. Biological Observations from GC743

Date/ Time	Location	Depth (m)	Likely Identity	Image
06/19/15 05:40:06	27.22 N 90.05 W	305	Salp chain *Helicosalpa virgula* (right)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
06/19/15 05:42:11	27.22 N 90.05 W	305	Salp chain Unidentified	
11/03/15 13:38:52	27.22 N 90.05 W	2097	Hermit crab *Sympagurus pictus* with anemone Adamsia obvolva	

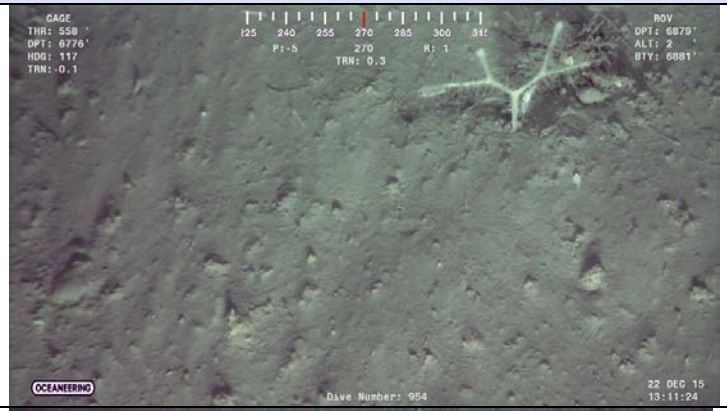
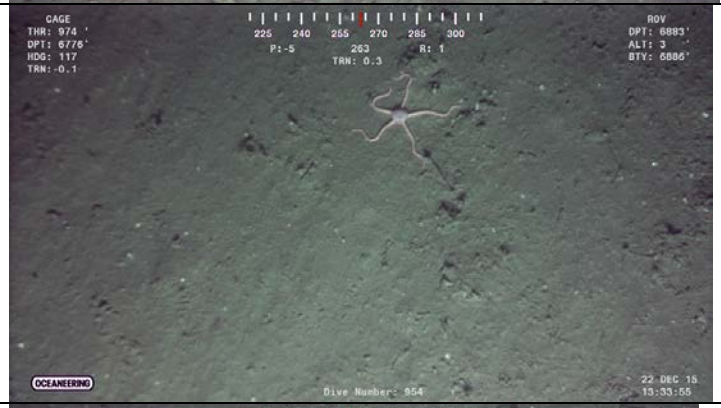
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/03/15 13:55:14	27.22 N 90.05 W	2091	Holothurian Benthodytes typica	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/03/15 13:55:14	27.22 N 90.05 W	2099	Fish Halosauridae Unidentified	
11/07/15 13:55:14	27.22 N 90.05 W	2080	Holothurian Enypniastes eximia	

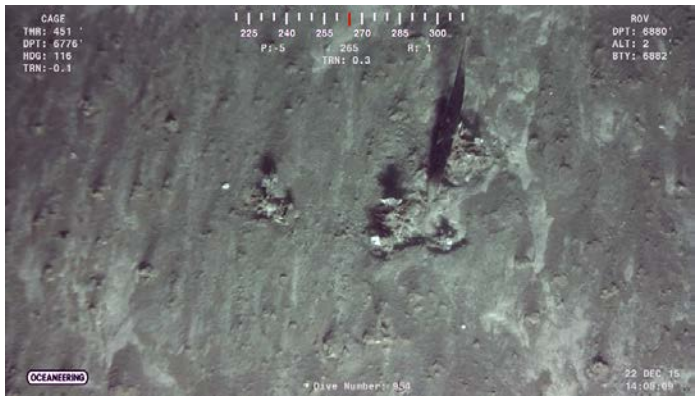
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/07/15 16:12:10	27.22 N 90.05 W	624	Fish Trichiuridae Possibly Aphanopus intermedius	
11/07/15 16:13:35	27.22 N 90.05 W	621	Dinner plate jellyfish Solmissus sp.	
12/22/15 12:35:47	27.22 N 90.05 W	2098	Hermit crab *Sympagurus pictus* with anemone *Adamsia obvolva*	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 12:35:47	27.22 N 90.05 W	2098	Unidentified anemone	
12/22/15 12:35:47	27.22 N 90.05 W	2098	Hormathiid anemone Unidentified	
12/22/15 12:48:56	27.22 N 90.05 W	2098	Fish Ipnopidae Bathypterois quadrifilis	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 12:49:35	27.22 N 90.05 W	2098	Stalked crinoid Bathycrinidae	
12/22/15 12:54:39	27.22 N 90.05 W	2098	Sea pen Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 13:11:24	27.22 N 90.05 W	2097	Sponge Unidentified	
12/22/15 13:33:55	27.22 N 90.05 W	2099	Brittle star Unidentified	
12/22/15 13:35:27	27.22 N 90.05 W	2099	Sea star Zoroaster fulgens	

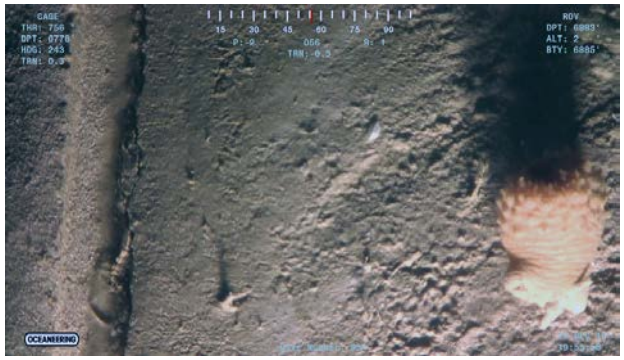
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 13:48:57	27.22 N 90.05 W	2099	Sea pen Unidentified	
12/22/15 13:52:24	27.22 N 90.05 W	2099	Holothurian Benthothuria sp.	
12/22/15 13:58:37	27.22 N 90.05 W	2098	Shrimp cerataspis monstrosa	

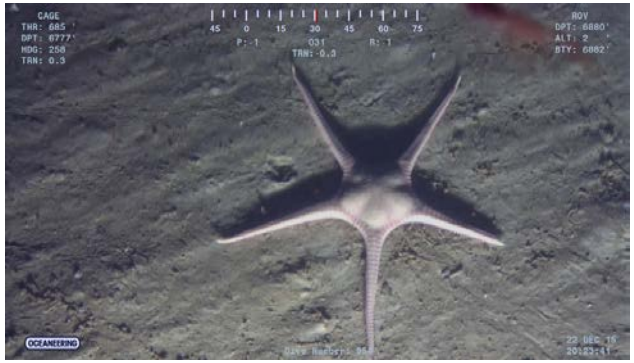
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 14:57:59	27.22 N 90.05 W	2098	Fish Synaphobranchidae Synaphobranchus sp.	
12/22/15 15:02:55	27.22 N 90.05 W	2097	Fish Halosauridae Unidentified	
12/22/15 15:05:09	27.22 N 90.05 W	2099	Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 15:07:29	27.22 N 90.05 W	2097	Sea star Astropectinidae *Plutonaster* sp.?	
12/22/15 18:17:45	27.22 N 90.05 W	2102	Fish Halosauridae Unidentified	
12/22/15 18:19:57	27.22 N 90.05 W	2099	Unidentified shrimp	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 18:38:39	27.22 N 90.05 W	2102	Fish Ipnopidae Bathypterois quadrifilis	
12/22/15 18:39:15	27.22 N 90.05 W	2102	Fish Ipnopidae Bathypterois quadrifilis	
12/22/15 18:42:22	27.22 N 90.05 W	2102	Skate *Rajella purpuriventralis*	

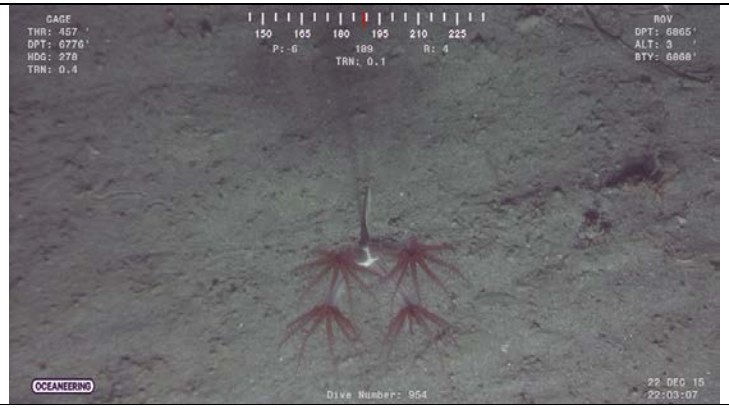
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 18:43:10	27.22 N 90.05 W	2102	Shrimp Cerataspis monstrosa (formerly Plesiopenaeus armatus)	
12/22/15 18:55:32	27.22 N 90.05 W	2101	Shrimp Nematocarcinus sp.	
12/22/15 19:48:56	27.22 N 90.05 W	2097	Holothurian Benthodytes typica	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 19:48:56	27.22 N 90.05 W	2099	Unidentified (holothurian?)	
12/22/15 20:02:08	27.22 N 90.05 W	2098	Fish Ipnopidae Bathypterois quadrifilis	
12/22/15 20:08:50	27.22 N 90.05 W	2097	Shrimp Nematocarcinus sp.	

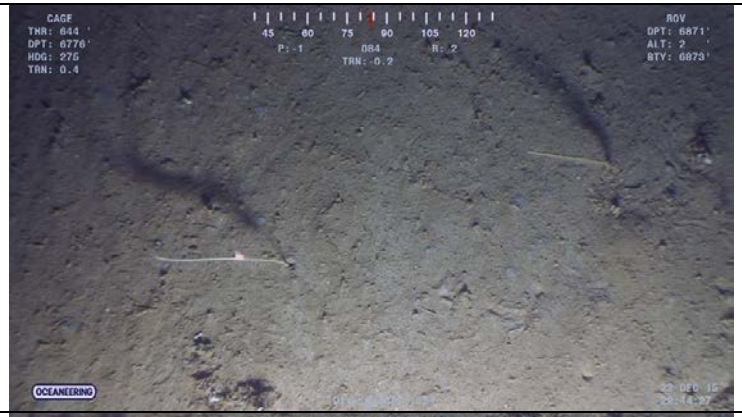
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 20:20:34	27.22 N 90.05 W	2099	Notacanthidae Polyacanthonotus challengeri	
12/22/15 20:23:41	27.22 N 90.05 W	2098	Sea star Nymphaster arenatus	
12/22/15 21:02:36	27.22 N 90.05 W	2091	Holothurian *Benthodytes abyssicola*	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 21:04:18	27.22 N 90.05 W	2094	Sea star Nymphaster arenatus	
12/22/15 21:11:51	27.22 N 90.05 W	2095	Sea pen Unidentified	
12/22/15 21:14:13	27.22 N 90.05 W	2095	Coral Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 21:27:14	27.22 N 90.05 W	2096	Stalked crinoid Bathycrinidae	
12/22/15 21:33:50	27.22 N 90.05 W	2097	Feather star Atelecrinidae	
12/22/15 21:34:23	27.22 N 90.05 W	2096	Shrimp Nematocarcinus sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 21:35:23	27.22 N 90.05 W	2096	Flatback lobster *Polycheles* sp. possibly *P. sculptus*	
12/22/15 22:02:47	27.22 N 90.05 W	2093	Sea pen *Umbellula* sp. Same individual as 22:02:39	
12/22/15 22:03:07	27.22 N 90.05 W	2093	Sea pen *Umbellula* sp. Same individual as 22:02:39	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 22:06:11	27.22 N 90.05 W	2094	Unidentified crab beneath pteropod shell.	
12/22/15 22:23:54	27.22 N 90.05 W	2096	Stalked crinoid Bathycrinidae	
12/22/15 22:29:45	27.22 N 90.05 W	2096	Unidentifed cerianthid anemone	

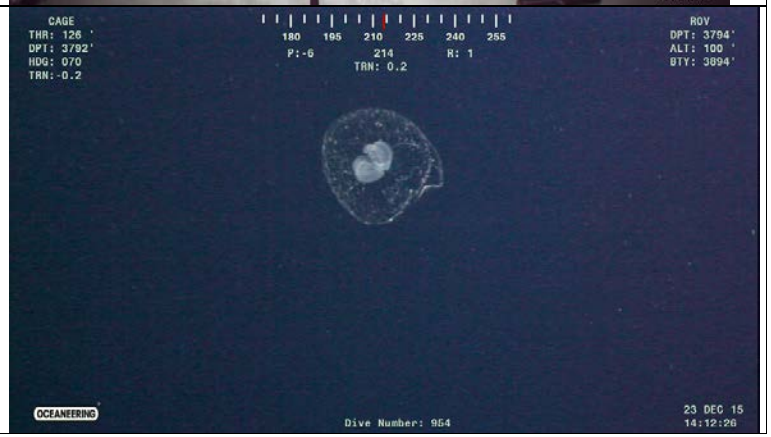
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 22:29:12	27.22 N 90.05 W	2096	Unidentified sea pen	
12/22/15 22:44:37	27.22 N 90.05 W	2095	Unidentified sea pen	
12/22/15 22:45:06	27.22 N 90.05 W	2095	Unidentified crinoid	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/22/15 22:50:12	27.22 N 90.05 W	2096	Macrouridae Coryphaenoides (mexicanus?)	
12/22/15 22:50:16	27.22 N 90.05 W	2096	Macrouridae *Coryphaenoides (mexicanus*?) Same individual as 22:50:12	
12/22/15 22:51:19	27.22 N 90.05 W	2096	Unidentified brittle star	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 08:31:42	27.22 N 90.05 W	2101	Sea pen *Umbellula* sp.	
12/23/15 08:41:10	27.22 N 90.05 W	2100	Unidentified sea pen	
12/23/15 09:04:05	27.22 N 90.05 W	2100	Hormathiid anemone Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 09:48:02	27.22 N 90.05 W	2099	Holothurian *Benthothuria* sp.	
12/23/15 10:18:02	27.22 N 90.05 W	2103	Sea star *Zoroaster fulgens*?	
12/23/15 10:23:18	27.22 N 90.05 W	2101	Shrimp Possibly *Aristeus antillensis*	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 10:25:35	27.22 N 90.05 W	2098	Eel Synaphobranchidae	
12/23/15 10:34:56	27.22 N 90.05 W	2099	Holothurian Benthodytes sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 10:37:32	27.22 N 90.05 W	2102	Skate Unidentified Rajella purpuriventralis?	
12/23/15 11:23:35	27.22 N 90.05 W	1156	Larvacean house Unidentified	

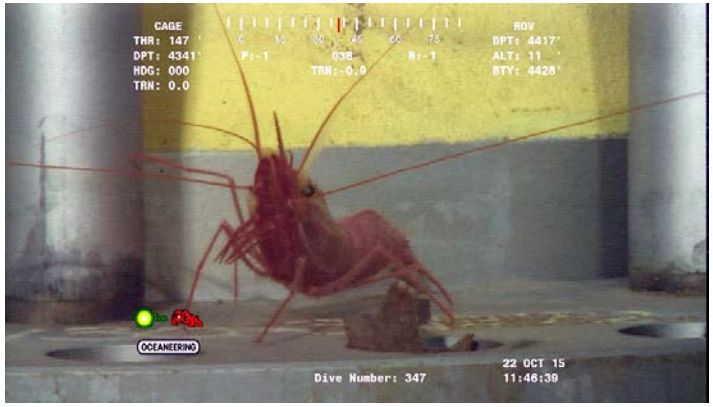
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 12:17:00	27.22 N 90.05 W	1921	Holothurian *Enypniastes eximia*	
12/23/15 13:12:01	27.22 N 90.05 W	1611	Lobate ctenophore *Bathocyroe fosteri*	

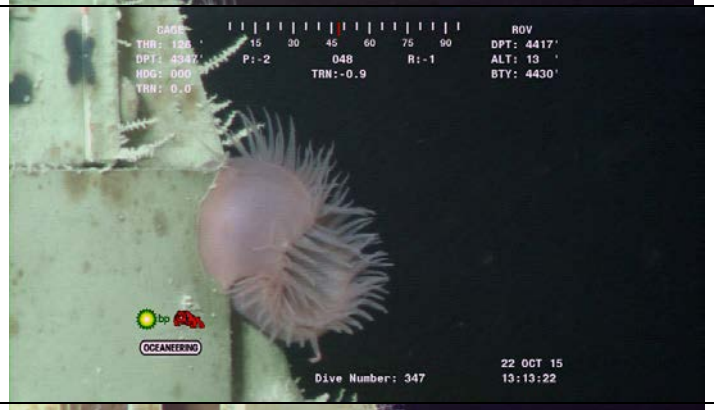
Date/ Time	Location	Depth (m)	Likely Identity	Image
12/23/15 14:26:25	27.22 N 90.05 W	1011	Midwater shrimp Unidentified	
12/23/15 14:47:01	27.22 N 90.05 W	855	Medusa Crossota millsae	
12/23/15 15:14:05	27.22 N 90.05 W	549	Calycophoran siphonophore Prayidae	

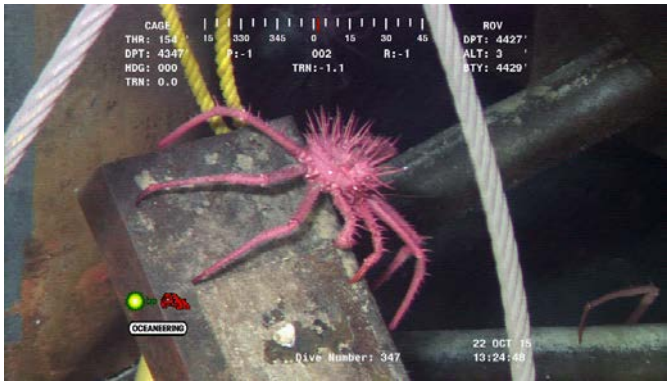
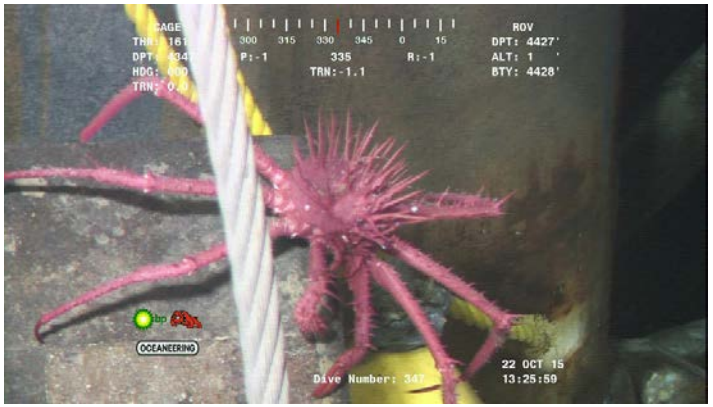
3.4.5 GC782

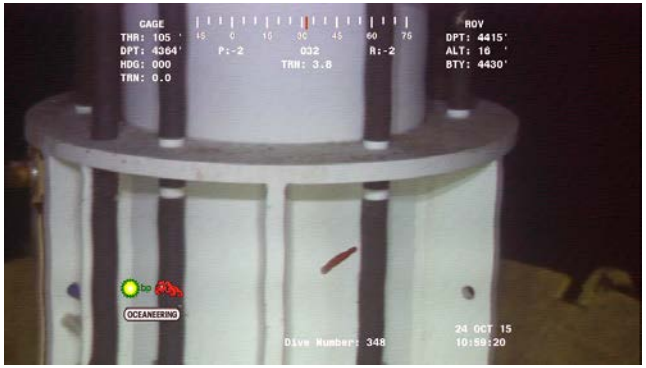
GC782 is the location of BP's Mad Dog Spar. This was a frequent contributor to Gulf SERPENT during the period 2008–2010, when a Saipem-America Innovator ROV was on board. That ROV has been upgraded to an Oceaneering system, which provided some observations from 2015. One of the most interesting things they recorded was a large aggregation of juvenile lithodid *Neolithodes agassizii* crabs at the base of the Spar. The aggregation was unusual because this species normally forages on soft sediments and is not known for its ability to climb up on structures, yet all these juveniles had scaled the base of the Spar.

Table 9. Biological Observations from GC782

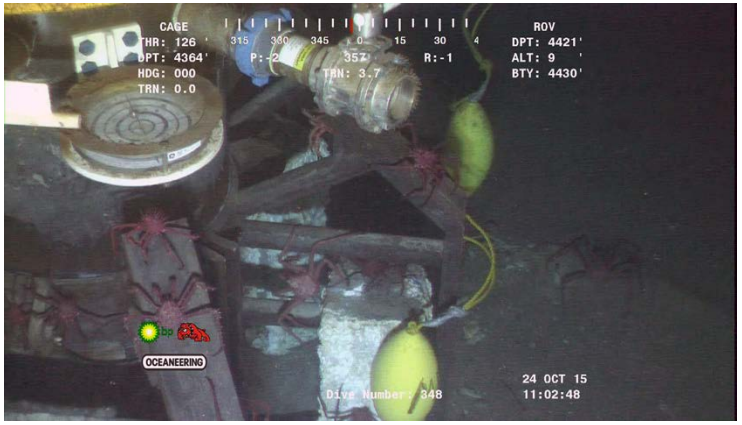
Date/ Time	Location	Depth (m)	Likely Identity	Image
10/22/15 11:46:39	27.19 N 90.27 W	1346	Shrimp Heterocarpus sp.	
10/22/15 13:11:48	27.19 N 90.27 W	1346	Flytrap anemone *Actinoscyphia* sp.	

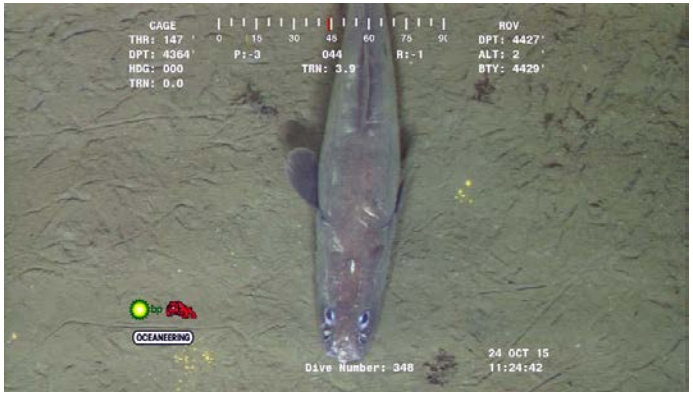
Date/ Time	Location	Depth (m)	Likely Identity	Image
10/22/15 13:13:08	27.19 N 90.27 W	1346	Flytrap anemone *Actinoscyphia* sp.	
10/22/15 13:13:22	27.19 N 90.27 W	1346	Flytrap anemone *Actinoscyphia* sp.	
10/22/15 13:17:36	27.19 N 90.27 W	1346	Hydroids Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/22/15 13:18:03	27.19 N 90.27 W	1346	Flytrap anemone *Actinoscyphia* sp.	
10/22/15 13:18:03	27.19 N 90.27 W	1349	Lithodid crab Neolithodes agassizii	
10/22/15 13:25:59	27.19 N 90.27 W	1349	Lithodid crab *Neolithodes agassizii* (same individual as 13:18:03)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/22/15 13:30:40	27.19 N 90.27 W	1350	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	
10/22/15 13:31:55	27.19 N 90.27 W	1350	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	
10/24/15 10:59:20	27.19 N 90.27 W	1346	Unidentified Chaetognath?	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/24/15 11:36:33	27.19 N 90.27 W	1346	Shrimp Glyphocrangon sp.	
10/24/15 11:01:38	27.19 N 90.27 W	1359	Lithodid crabs	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/24/15 11:02:20	27.19 N 90.27 W	1359	Lithodid crabs	
10/24/15 11:02:48	27.19 N 90.27 W	1359	Lithodid crabs	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/24/15 11:07:22	27.19 N 90.27 W	1349	Fish Macrouridae	
10/24/15 11:24:42	27.19 N 90.27 W	1350	Fish Ophidiidae Bassogigas gilli	

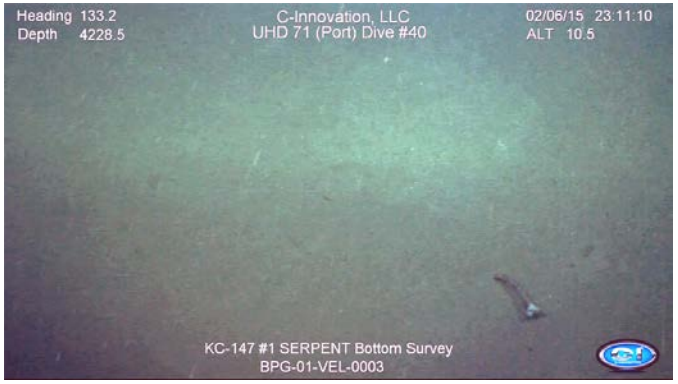
3.5 Keathley Canyon

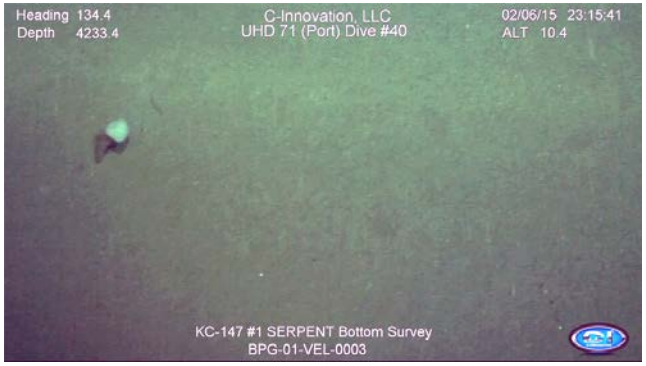
3.5.1 KC147

These observations were provided by ROVs (UHD70, UHD71) operated by C-Innovations working under contract for BP. Glass sponges were the dominant sessile invertebrates on the soft sediments. A variety of fishes including cusk eels, cutthroat eels, and macrourids occurred near the seabed. A notable feature of this site was the presence of a large asphalt seep containing a brine pool. Dead giant isopods *Bathynomus giganteus* carcasses were observed floating on the surface of the brine pool.

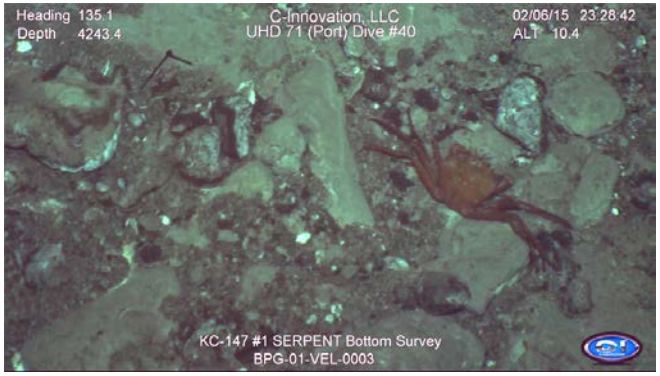
Table 10. Biological Observations from KC147

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/06/15 23:09:37	26.84 N 93.20 W	1292	Eel Nettastomatidae? Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/06/15 23:11:10	26.84 N 93.20 W	1292	Glass sponge Hexactinellidae Hyalonema sp.	
02/06/15 23:12:06	26.84 N 93.20 W	1292	Glass sponge Hexactinellidae Hyalonema sp.	

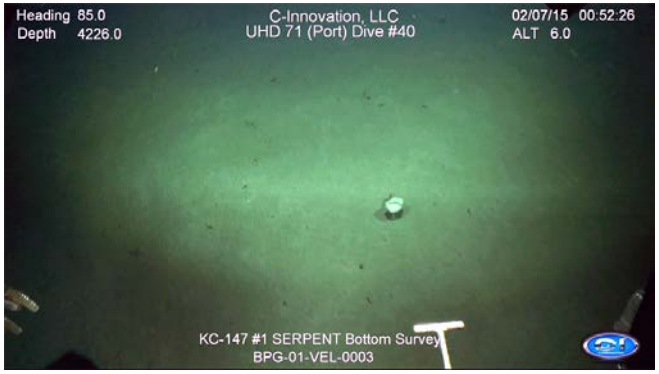
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/06/15 23:14:45	26.84 N 93.20 W	1293	Holothurian Benthodytes sp.	
02/06/15 23:15:41	26.84 N 93.20 W	1293	Glass sponge Hexactinellidae Hyalonema sp.	

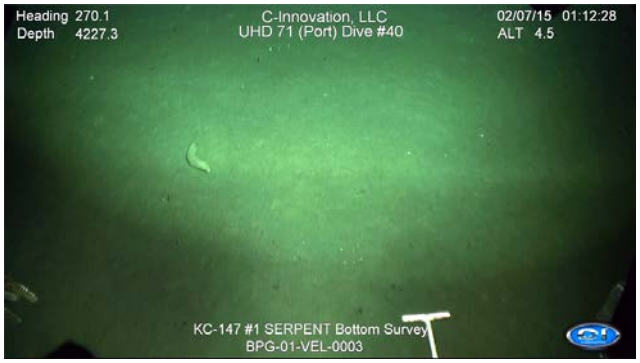
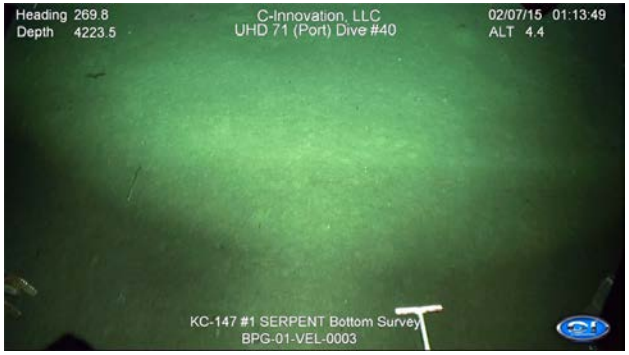
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/06/15 23:17:21	26.84 N 93.20 W	1294	Glass sponges Hexactinellidae Hyalonema sp.	
02/06/15 23:26:39	26.84 N 93.20 W	1297	Lithodid crab Neolithodes agassizii	

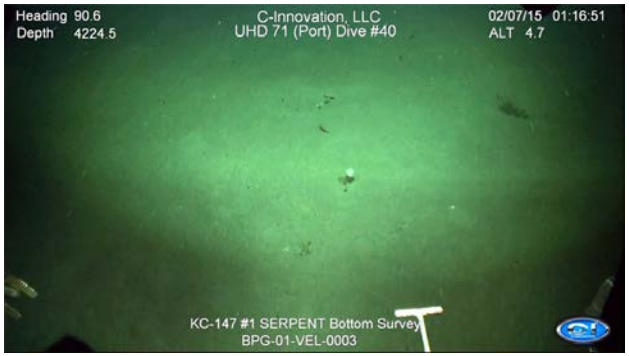
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/06/15 23:28:42	26.84 N 93.20 W	1297	Red crab Chaceon quinquidens	
02/07/15 00:14:27	26.84 N 93.20 W	1293	Fish Unidentified	

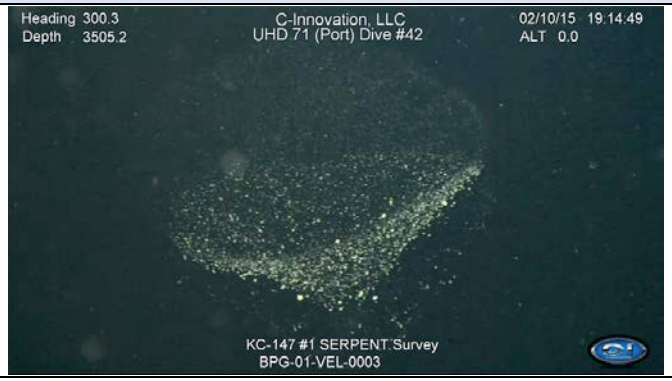
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/07/15 00:17:41	26.84 N 93.20 W	1291	Eel Synaphobranchidae? Unidentified	
02/07/15 00:38:40	26.84 N 93.20 W	1296	Eel Synaphobranchidae Synaphobranchus sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/07/15 00:39:41	26.84 N 93.20 W	1296	Sea pen Unidentified	
02/07/15 00:40:25	26.84 N 93.20 W	1295	Red crab Chaceon quinquedens	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/07/15 00:40:35	26.84 N 93.20 W	1294	Glass sponge Hexactinellidae Unidentified	
02/07/15 00:52:26	26.84 N 93.20 W	1290	Glass sponge Hexactinellidae Hyalonema sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/07/15 01:00:51	26.84 N 93.20 W	1297	Holothurian Enypniastes eximia	
02/07/15 01/12/28	26.84 N 93.20 W	1290	Holothurian Unidentified	
02/07/15 01/13/49	26.84 N 93.20 W	1289	Eel Synaphobranchidae? Unidentified	

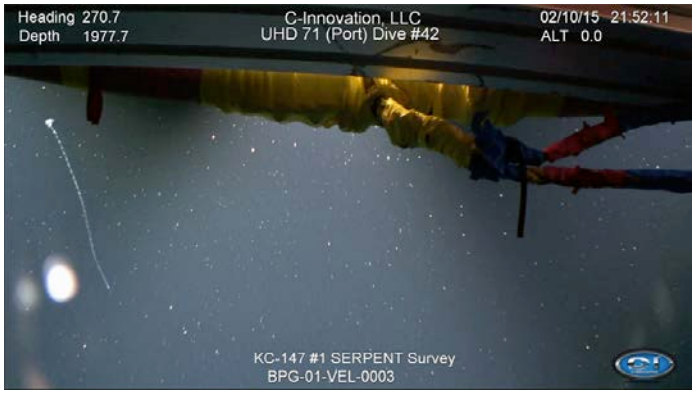
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/07/15 01/16/51	26.84 N 93.20 W	1286	Glass sponge Hexactinellidae Unidentified	
02/07/15 01/19/42	26.84 N 93.20 W	1295	Fish Ophiidae? Unidentified	
02/10/15 19/07/59	26.84 N 93.20 W	1068	Fish Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 19/14/49	26.84 N 93.20 W	1068	Large marine aggregate	
02/10/15 19/21/39	26.84 N 93.20 W	1068	Lobate ctenophore Bathocyroe fosteri	
02/10/15 20/30/00	26.84 N 93.20 W	914	Undescribed cydippid ctenophore	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 20/39/15	26.84 N 93.20 W	914	Unidentified	
02/10/15 21/12/54	26.84 N 93.20 W	765	Medusa Halitrephes valdiviae	
02/10/15 21/15/16	26.84 N 93.20 W	764	Fish Gonostomatidae Cyclothone sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 21/28/53	26.84 N 93.20 W	763	Midwater shrimp Unidentified	
02/10/15 21/29/51	26.84 N 93.20 W	763	Undescribed cydippid ctenophore	

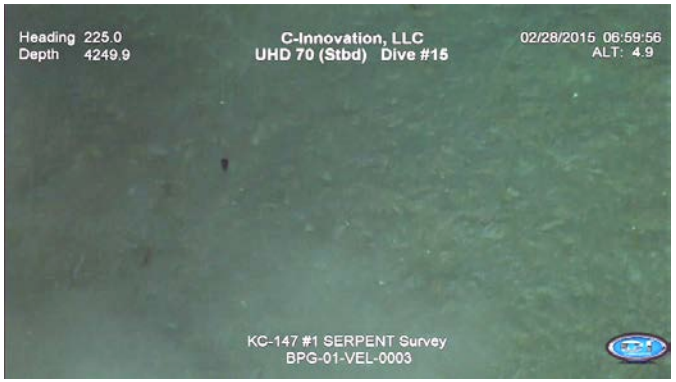
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 21/35/06	26.84 N 93.20 W	764	Physonect siphonophore Unidentified	
02/10/15 21/42/24	26.84 N 93.20 W	582	Chaetognath Unidentified	
02/10/15 21/52/03	26.84 N 93.20 W	603	Larvacean Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 21/52/11	26.84 N 93.20 W	603	Physonect siphonophore Unidentified	
02/10/15 21/55/27	26.84 N 93.20 W	611	Calycophoran siphonophore Praya sp.	

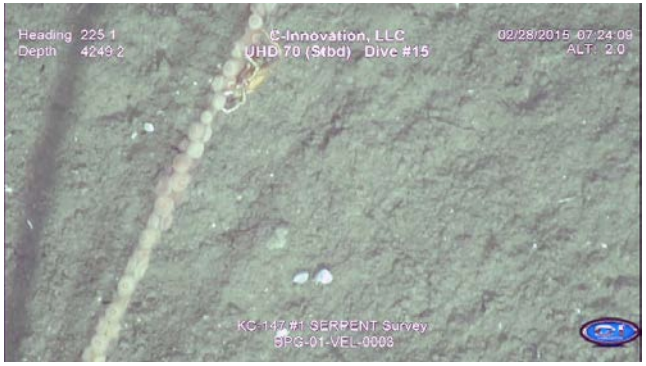
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 21/58/39	26.84 N 93.20 W	612	Hatchetfish Sternoptychidae Unidentified	
02/10/15 22/03/47	26.84 N 93.20 W	611	Medusa Rhopalonema sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 22/09/20	26.84 N 93.20 W	611	Dinner plate jellyfish Solmissus sp.	
02/10/15 22/13/06	26.84 N 93.20 W	610	Medusa Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/10/15 22/19/16	26.84 N 93.20 W	610	Tentacle Unidentified	
02/10/15 22/41/40	26.84 N 93.20 W	459	Salp chain Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/11/15 00/37/15	26.84 N 93.20 W	153	Shrimp Unidentified	
02/11/15 00/39/12	26.84 N 93.20 W	153	Amphipod Phronima sp.	
02/28/15 06:59:56	26.84 N 93.20 W	1297	Undescribed demersal cydippid ctenophore	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 07:06:25	26.84 N 93.20 W	1297	Glass sponge Hexactinellidae Hyalonema sp.	
02/28/15 07:08:01	26.84 N 93.20 W	1297	Shrimps Nematocarcinus sp.	
02/28/15 07:16:39	26.84 N 93.20 W	1296	Shrimp Glyphocrangon sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 07:18:32	26.84 N 93.20 W	1296	Brittle star Unidentified	
02/28/15 07:24:09	26.84 N 93.20 W	1296	Squat lobster Unidentified on soft coral	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 07:34:40	26.84 N 93.20 W	1291	Red crab Chaceon quinquedens	
02/28/15 07:42:48	26.84 N 93.20 W	1288	Giant isopod Bathynomus giganteus	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 07:46:05	26.84 N 93.20 W	1288	Holothurian Benthodytes sp.	
02/28/15 14:33:45	26.84 N 93.20 W	1297	Sea pen Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 14:34:43	26.84 N 93.20 W	1297	Eel Synaphobranchidae Synaphobranchus sp.	
02/28/15 14:39:42	26.84 N 93.20 W	1295	Eel Synaphobranchidae Synaphobranchus sp.	
02/28/15 15:05:07	26.84 N 93.20 W	1284	Lobate ctenophore Lampocteis cruentiventer	

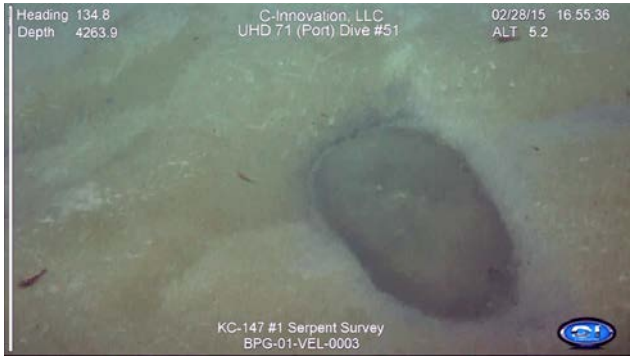
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 15:08:40	26.84 N 93.20 W	1294	Lithodid crab Neolithodes agassizii	
02/28/15 15:11:34	26.84 N 93.20 W	1296	Sea pen? Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 15:24:27	26.84 N 93.20 W	1291	Lobate ctenophore Bathocyroe fosteri	
02/28/15 15:24:41	26.84 N 93.20 W	1293	Glass sponge Hexactinellidae Hyalonema sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 15:49:30	26.84 N 93.20 W	1299	Holothurian Benthodytes sp.	
02/28/15 15:51:20	26.84 N 93.20 W	1300	Shrimp Glyphocrangon sp.	

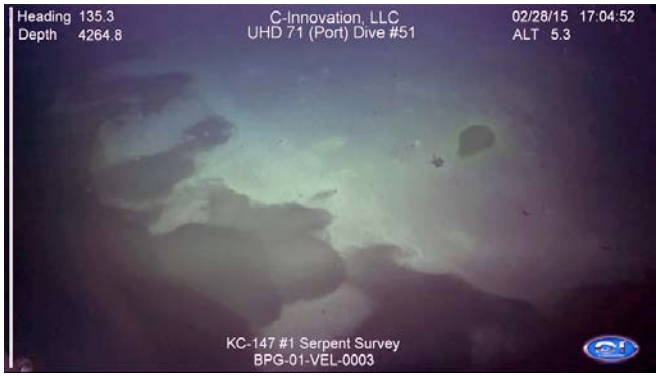
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 16:03:56	26.84 N 93.20 W	1300	Flatback lobster *Polycheles* sp. possibly *P. sculptus*	
02/28/15 16:05:18	26.84 N 93.20 W	1300	Fish Ophidiidae Bassogigas gilli	
02/28/15 16:09:50	26.84 N 93.20 W	1299	Fish Macrouridae Coryphaenoides sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 16:19:56	26.84 N 93.20 W	1299	Fish (upper left) Macrouridae Coryphaenoides sp.	
02/28/15 16:20:32	26.84 N 93.20 W	1299	Fish Ophidiidae Dicrolene introniger	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 16:26:06	26.84 N 93.20 W	1299	Eel Synaphobranchidae Synaphobranchus sp.	
02/28/15 16:55:36	26.84 N 93.20 W	1301	Shrimps *Nematocarcinus* sp. next to asphalt	
02/28/15 16:57:20	26.84 N 93.20 W	1301	Eel Synaphobranchidae Illyophis sp.?	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 16:57:36	26.84 N 93.20 W	1301	Asphalt seep with brine pool	
02/28/15 16:58:52	26.84 N 93.20 W	1301	Dead isopod *Bathynomus giganteus* floating on surface of brine pool	
02/28/15 16:59:54	26.84 N 93.20 W	1301	Dead isopod *Bathynomus giganteus* floating on surface of brine pool	

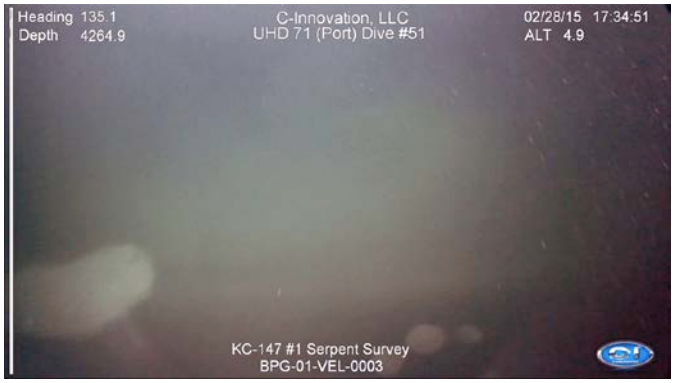
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:00:05	26.84 N 93.20 W	1301	Dead isopod *Bathynomus giganteus* floating on surface of brine pool	
02/28/15 17:03:02	26.84 N 93.20 W	1301	Dead isopod *Bathynomus giganteus* floating on surface of brine pool	

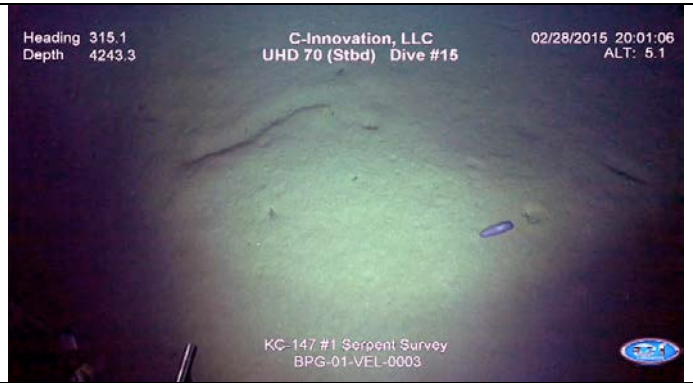
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:04:52	26.84 N 93.20 W	1302	Edge of asphalt seep	
02/28/15 17:07:12	26.84 N 93.20 W	1301	Lithodid crab Neolithodes agassizii	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:11:02	26.84 N 93.20 W	1301	Holothurian Benthodytes sp.	
02/28/15 17:17:06	26.84 N 93.20 W	1299	Eel Synaphobranchidae Unidentified	

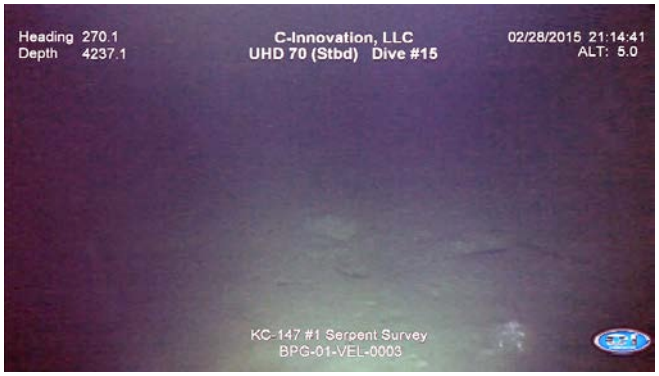
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:24:57	26.84 N 93.20 W	1298	Eel Synaphobranchidae Unidentified	
02/28/15 17:29:11	26.84 N 93.20 W	1300	Fish Ophidiidae Dicrolene introniger	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:32:06	26.84 N 93.20 W	1301	Squat lobsters Unidentified	
02/28/15 17:33:01	26.84 N 93.20 W	1301	Shrimp *Glyphocrangon* above unidentified squat lobster	

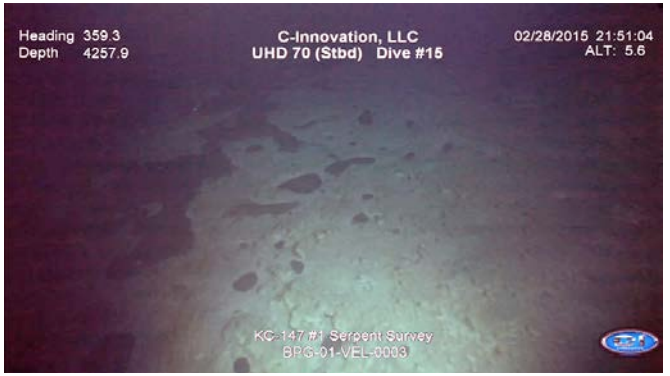
Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:34:51	26.84 N 93.20 W	1302	Brine pool	
02/28/15 17:35:57	26.84 N 93.20 W	1301	Brine pool	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 17:36:14	26.84 N 93.20 W	1301	Brine pool	
02/28/15 20:01:06	26.84 N 93.20 W	1295	Holothurian Benthodytes sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 20:29:22	26.84 N 93.20 W	1294	Eel Synaphobranchidae Synaphobranchus sp.	
02/28/15 20:30:49	26.84 N 93.20 W	1294	Fish Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 20:43:08	26.84 N 93.20 W	1295	Holothurian Benthodytes sp.	
02/28/15 21:14:41	26.84 N 93.20 W	1291	Lobate ctenophore Bathocyroe fosteri?	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 21:36:00	26.84 N 93.20 W	1300	Eel Synaphobranchidae Unidentified	
02/28/15 21:37:32	26.84 N 93.20 W	1295	Fish Macrouridae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 21:50:39	26.84 N 93.20 W	1299	Asphalt seeps	
02/28/15 21:51:04	26.84 N 93.20 W	1299	Asphalt seeps	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 21:51:41	26.84 N 93.20 W	1300	Shoreline of brine pool	
02/28/15 21:52:13	26.84 N 93.20 W	1300	Shoreline of brine pool	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/28/15 22:00:00	26.84 N 93.20 W	1300	Eel Synaphobranchidae Unidentified	
02/28/15 22:17:55	26.84 N 93.20 W	1281	Fish Ophidiidae? Bassogigas gilli	
02/28/15 22:17:55	26.84 N 93.20 W	1287	Fish Ophidiidae? Bassogigas gilli	

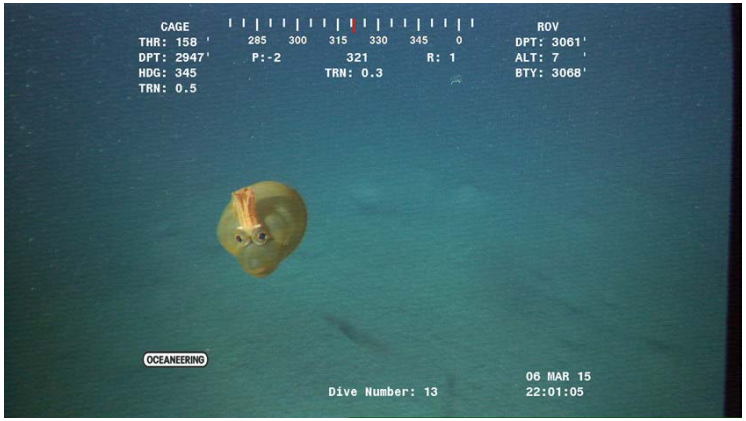
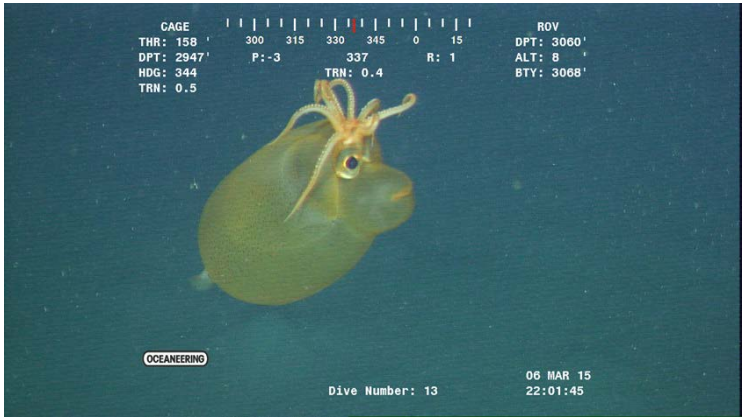
Date/ Time	Location	Depth (m)	Likely Identity	Image
03/09/15 18:07:37	26.84 N 93.20 W	1298	Lithodid crab Neolithodes agassizii	

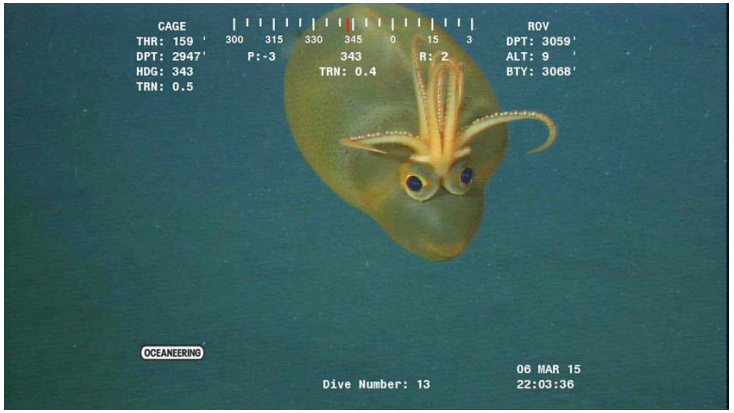
3.6 Mississippi Canyon

3.6.1 MC118

This single observation of the piglet squid *Helicocranchia* sp. was provided by an Oceaneering ROV (Millennium 160). No further information was available.

Table 11. Biological Observations from MC118

Date/ Time	Location	Depth (m)	Likely Identity	Image
03/06/15 22:01:05	28.85 N 88.48 W	933	Piglet squid Helicocranchia sp.	
03/06/15 22:01:45	28.85 N 88.48 W	933	Piglet squid *Helicocranchia* sp. (same individual as 22:01:05)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
03/06/15 22:03:36	28.85 N 88.48 W	933	Piglet squid *Helicocranchia* sp. (same individual as 22:01:05)	

3.6.2 MC383

A C-Innovation ROV (UHD48), operating from the Transocean *Development Driller III* working under contract for BP, provided a large number of observations during 2015. This soft-bottom site is located in the upper bathypelagic zone with a bottom depth of approximately 1435 m. Visibility near the seabed was often reduced by suspended sediment. This, combined with the altitude of the ROV, often reduced image quality. The site had a diverse invertebrate and fish community. Invertebrates included seastars *Nymphaster arenatus*, cerianthid anemones, shrimps *Nematocarcinus* sp. and *Glyphocrangon* sp. Red crabs *Chaceon quinquedens* were abundant and the lithodid crab *Neolithodes agassizii* was present. Fishes included several species of macrouridae, cutthroat eels *Synaphobranchus* sp., halosaurs, and cusk eels *Dicrolene introniger* and *Bassogigas gilli*.

Table 12. Biological Observations from MC383

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 15:31:10	28.62 N 88.43 W	1437	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	
11/13/15 15:32:43	28.62 N 88.43 W	1437	Fish Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 15:38:28	28.62 N 88.43 W	1437	Shrimp Nematocarcinus sp.	
11/13/15 15:42:02	28.62 N 88.43 W	1437	Shrimp Cerataspis monstrosa	
11/13/15 16:34:20	28.62 N 88.43 W	1466	Red crab Chaceon quinquedens	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 16:43:09	28.62 N 88.43 W	1466	Fish Macrouridae Coelorinchus?	
11/13/15 16:47:10	28.62 N 88.43 W	1466	Fish Ophidiidae Dicrolene introniger	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 17:05:48	28.62 N 88.43 W	1469	Fish Halosauridae Unidentified	
11/13/15 17:09:09	28.62 N 88.43 W	1470	Shrimp Nematocarcinus sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 17:09:42	28.62 N 88.43 W	1470	Fish Halosauridae Unidentified	
11/13/15 17:23:29	28.62 N 88.43 W	1449	Fish Ipnopidae Bathypterois quadrifilis	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 17:28:01	28.62 N 88.43 W	1449	Red crab Chaceon quinquedens	
11/13/15 17:42:21	28.62 N 88.43 W	1445	Fish Ophidiidae Bassogigas gilli	
11/13/15 19:00:53	28.62 N 88.43 W	1447	Fish Halosauridae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 19:06:04	28.62 N 88.43 W	1447	Sea star Nymphaster arenatus	
11/13/15 19:09:45	28.62 N 88.43 W	1447	Fish Ophidiidae? Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 19:28:50	28.62 N 88.43 W	1445	Red crab Chaceon quinquedens	
11/13/15 20:27:24	28.62 N 88.43 W	1434	Cerianthid anemone Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 20:30:36	28.62 N 88.43 W	1433	Fish Unidentified	
11/13/15 20:34:46	28.62 N 88.43 W	1434	Fish Halosauridae Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/13/15 20:57:29	28.62 N 88.43 W	1428	Fish Ipnopidae Bathypterois quadrifilis	
11/13/15 21:07:53	28.62 N 88.43 W	1436	Sea star Nymphaster arenatus	
11/13/15 22:24:43	28.62 N 88.43 W	1451	Fish Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 00:14:20	28.62 N 88.43 W	1446	Red crab Chaceon quinquedens	
11/14/15 00:19:25	28.62 N 88.43 W	1446	Fish Ophidiidae Bassogigas gilli	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 12:57:49	28.62 N 88.43 W	1448	Shrimp Cerataspis monstrosa?	
11/14/15 13:55:45	28.62 N 88.43 W	1449	Fish Stephanoberycidae? Unidentified	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 13:56:04	28.62 N 88.43 W	1448	Red crab Chaceon quinquedens	
11/14/15 14:02:21	28.62 N 88.43 W	1448	Shrimp Nematocarcinus sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 14:04:00	28.62 N 88.43 W	1449	Sea star Nymphaster arenatus	
11/14/15 13:33:31	28.62 N 88.43 W	1421	Red crab Chaceon quinquedens	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 13:35:20	28.62 N 88.43 W	1421	Sea star Unidentified	
11/14/15 13:36:00	28.62 N 88.43 W	1421	Shrimp Cerataspis monstrosa?	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 13:38:32	28.62 N 88.43 W	1421	Fish Macrouridae Unidentified	
11/14/15 13:39:37	28.62 N 88.43 W	1420	Fish Macrouridae Gadomus longifilis	
11/14/15 15:52:11	28.62 N 88.43 W	1418	Sea star Nymphaster arenatus	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 15:55:11	28.62 N 88.43 W	1418	Cerianthid anemone Unidentified	
11/14/15 16:01:02	28.62 N 88.43 W	1421	Sea star Unidentified	

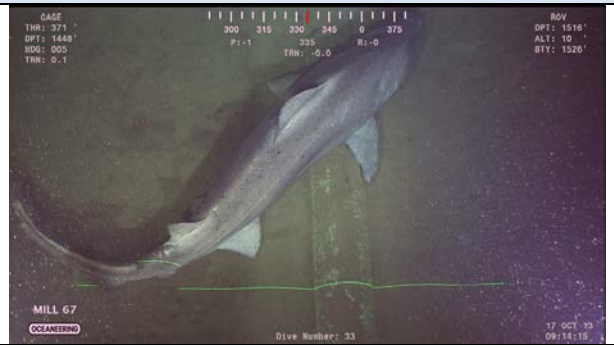
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 16:09:12	28.62 N 88.43 W	1432	Shrimp Glyphocrangon sp.	
11/14/15 16:18:10	28.62 N 88.43 W	1438	Lithodid crab Neolithodes agassizii	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/14/15 16:21:26	28.62 N 88.43 W	1443	Fish Unidentified	

3.6.3 MC451

A single observation of a seldom-seen deepwater shark, the ragged-tooth shark *Odontaspis ferox* was provided by an Oceaneering ROV from *Ocean Intervention IV*. The location of this observation was provided as MC451; however, latitude and longitude data were not available.

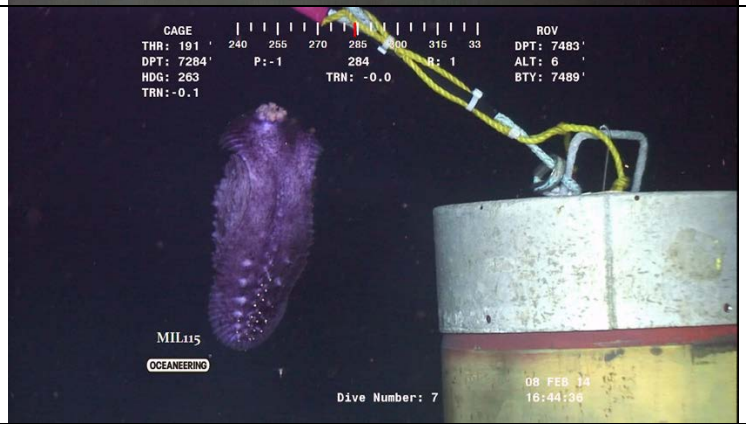
Table 13. Biological Observations from MC451

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/17/13 09:14:15	Unavailable	462	Ragged-tooth shark *Odontaspis ferox*	

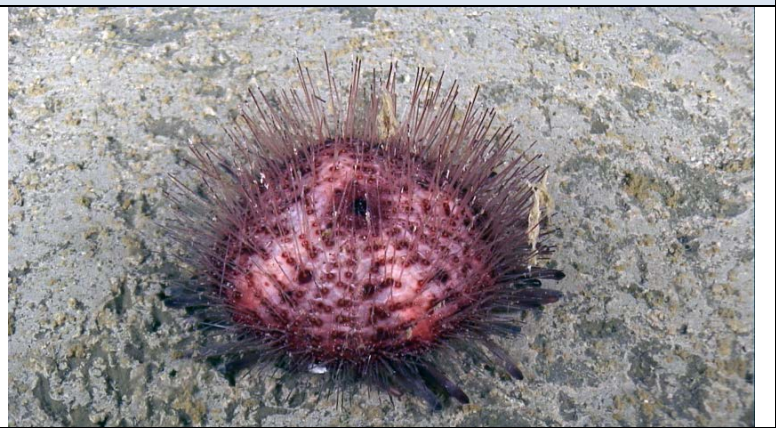
3.6.4 MC525

MC525 is a deep site with a bottom depth in excess of 2275 m. An Oceaneering ROV Millennium 115 provided observations of holothurians: *Benthodytes typica, Benthothuria funebris*, and *Enypniastes eximia* swimming above the seabed. The sea urchin *Phormosoma* sp. was observed here. Fishes typically observed only in deep locations included the bony-eared assfish *Acanthonus armatus* and a sleeper shark *Somniosus* sp.

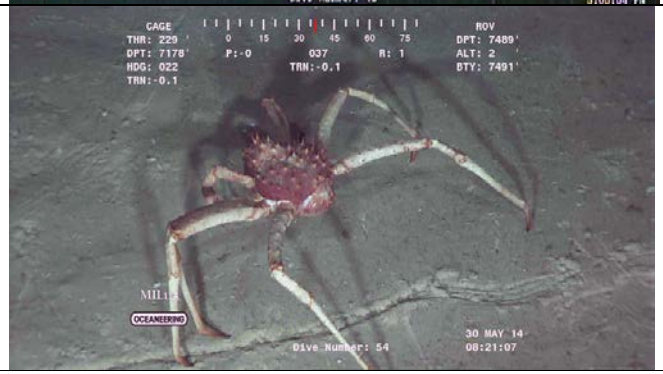
Table 14. Biological Observations from MC525

Date/ Time	Location	Depth (m)	Likely Identity	Image
01/28/14 15:51:31	28.46 N 87.96 W	2283	Holothurian Benthodytes typica	
02/08/14 16:44:36	28.46 N 87.96 W	2281	Holothurian Benthothuria funebris	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/11/14 04:09:52	28.46 N 87.96 W	2290	Sea urchin Phormosoma sp.	
02/11/14 07:03:20	28.46 N 87.96 W	2281	Holothurian Benthothuria funebris	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/16/14 00:48:00	28.46 N 87.96 W	2290	Sea urchin Phormosoma sp.	

Date/ Time	Location	Depth (m)	Likely Identity	Image
02/19/14 12:38:29	28.46 N 87.96 W	2278	Holothurian Enypniastes eximia juvenile	
02/24/14 13:20:25	28.46 N 87.96 W	2280	Witch eel Nettastomatidae Venefica procera	

Date/ Time	Location	Depth (m)	Likely Identity	Image
03/06/14 08:45:42	28.46 N 87.96 W	2281	Sleeper shark Somniosus sp.	
03/06/14 17:05:04	28.46 N 87.96 W	2286	Bony-eared assfish Acanthonus armatus	
05/30/14 08:21:07	28.46 N 87.96 W	2283	Crab Neolithodes agassizii	

Date/ Time	Location	Depth (m)	Likely Identity	Image
05/30/14 08:23:54	28.46 N 87.96 W	2281	Penaeoid shrimp Aristaeidae	

3.6.5 MC762

A few observations of great barracuda and a chimaera *Rhinochimaera atlantica* were provided by an Oceaneering ROV deployed from the multiservice vessel (MV) *Ocean Intervention IV*.

Table 15. Biological Observations from MC762

Date/ Time	Location	Depth (m)	Likely Identity	Image
09/28/18 09:53:10	28.16 N 89.24 W	91	Great barracuda Sphyraena barracuda	
10/10/13 07:46:03	28.18 N 89.29 W	956	Fish Rhinochimaera atlantica	
10/10/13 07:46:03	28.18 N 89.29 W	956	Fish Rhinochimaera atlantica (same individual as 07:46:03)	

3.6.6 MC806

Shell's Mars platform provided a large number of interesting observations collected by Oceaneering ROVs working from ROV support vessels. This site is relatively shallow (~920 m) and has soft sediments that show evidence of abundant marine life. Invertebrates included sea stars *Nymphaster arenatus*, holothurians *Enypniastes eximia*, *Pseudostichopus, Psychropotes* sp., shrimps *Nematocarcinus* sp., a large scaled squid *Pholidoteuthis adami*, and red crabs *Chaceon quinquedens*. The latter were abundant and the ROV collected an observation of large numbers consuming a carcass of indeterminate origin. Fishes near the seabed consisted of chimaeras *Rhinochimaera atlantica*, a catshark *Apristurus* sp, synaphobranchid eels, cusk eels, and macrourids. Near the surface, great barracudas *Sphyraena barracuda* and tunas were common. The ROV also imaged a silky shark *Carcharhinus falciformis* that had what appeared to be a plastic ring or cord entangled around its head. Water column surveys recorded a large pyrosome *Pyrosoma spinifera*, a relatively uncommon genus of cydippid ctenophore *Aulacoctena* sp., and several different physonect siphonophores.

Table 16. Biological Observations from MC806

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/13/13 15:50:57	28.17 N 89.22 W	927	Sea star Nymphaster arenatus	
10/13/13 15:53:28	28.17 N 89.22 W	926	Sea star Nymphaster arenatus	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/13/13 15:57:18	28.17 N 89.22 W	925	Shrimp Nematocarcinus sp.	
10/13/13 15:58:25	28.17 N 89.22 W	925	Fish Macrouridae Gadomus longifilis	
10/13/13 16:17:35	28.17 N 89.22 W	925	Holothurian *Pseudostichopus* sp.	

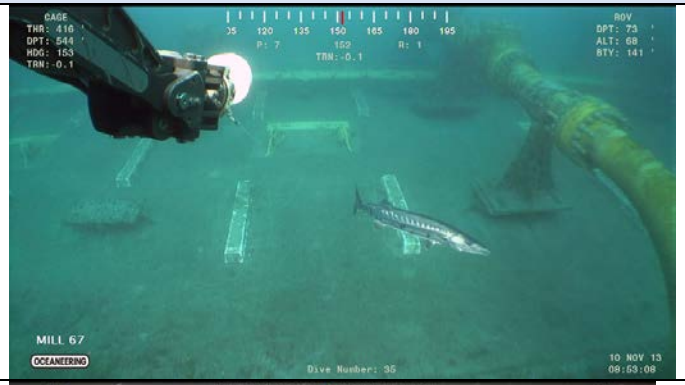
Date/ Time	Location	Depth (m)	Likely Identity	Image
10/13/13 16:20:05	28.17 N 89.22 W	925	Synaphobranchidae Illyophis sp.?	
10/14/13 10:32:16	28.17 N 89.22 W	944	Holothurian Enypniastes eximia	
10/14/13 16:21:52	28.17 N 89.22 W	924	Red crabs mating Chaceon quinquedens	

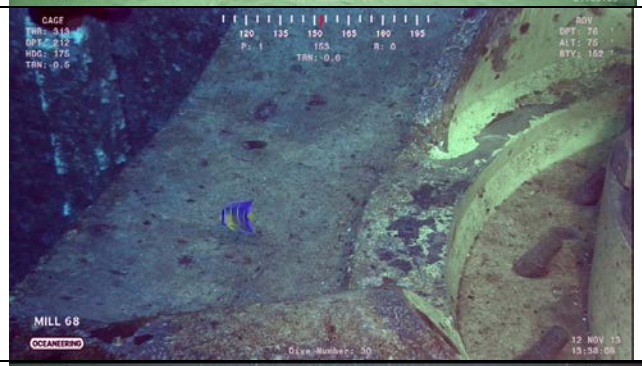
Date/ Time	Location	Depth (m)	Likely Identity	Image
10/14/13 16:54:15	28.17 N 89.22 W	924	Cutthroat eel *Synaphobranchus* sp.	
10/14/13 16:54:51	28.17 N 89.22 W	924	Unidentified squat lobster	
10/15/13 08:01:05	28.17 N 89.22 W	960	Fish Ophidiidae Bassogigas gilli	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/16/13 01:25:36	28.17 N 89.22 W	874	Aggregation of red crabs *Chaceon quinquedens* feeding on unidentified material. Approximately 14 crabs.	
10/16/13 01:26:48	28.17 N 89.22 W	874	Aggregation of red crabs *Chaceon quinquedens* feeding on unidentified material. Approximately 14 crabs.	
10/25/13 18:04:36	28.17 N 89.22 W	954	Unidentified shrimp	

Date/ Time	Location	Depth (m)	Likely Identity	Image
10/26/13 02:47:24	28.17 N 89.22 W	958	Holothurian Psychropotes sp.	
10/26/13 18:11:56	28.17 N 89.22 W	954	Unidentified shrimp	
10/27/13 04:55:11	28.17 N 89.22 W	393	School of unidentified tunas	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/01/13 16:06:38	28.17 N 89.22 W	935	Ctenophore Kiyohimea sp.	
11/07/13 10:35:58	28.17 N 89.22 W	907	Holothurian Enypniastes eximia	
11/09/13 12:39:35	28.17 N 89.22 W	920	Ctenophore *Aulacoctena* sp	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/10/13 08:53:08	28.17 N 89.22 W	22	Great barracuda Sphyraena barracuda	
11/10/13 11:02:00	28.17 N 89.22 W	922	Unidentified physonect siphonophore fishing	
11/10/13 11:02:10	28.17 N 89.22 W	922	Unidentified physonect siphonophore fishing (same colony as 11:02:00)	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/11/13 21:59:29	28.17 N 89.22 W	944	Rhinochimaera atlantica	
11/11/13 21:38:08	28.17 N 89.22 W	23	Juvenile queen angelfish Holacanthis ciliaris	
11/12/13 11:06:34	28.17 N 89.22 W	943	Holothurian Enypniastes eximia	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/15/13 10:06:22	28.17 N 89.22 W	34	Great barracuda Sphyraena barracuda	
11/20/13 16:08:05	28.17 N 89.22 W	41	Silky shark *Carcharhinus falciformis* with plastic line or bag wrapped around its head.	
11/20/13 16:08:08	28.17 N 89.22 W	41	Silky shark *Carcharhinus falciformis* with plastic line or bag wrapped around its head. (Same individual as 16:08:06)	

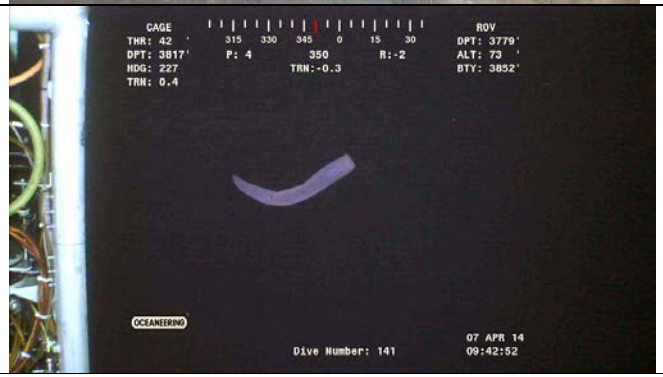
Date/ Time	Location	Depth (m)	Likely Identity	Image
11/20/13 18:34:29	28.17 N 89.22 W	804	Pyrosome *Pyrosoma spinosum*	
11/20/13 20:15:42	28.17 N 89.22 W	912	Catshark *Apristurus* sp.	
11/21/13 12:21:55	28.17 N 89.22 W	911	Unidentified physonect siphonophore	

Date/ Time	Location	Depth (m)	Likely Identity	Image
11/22/13 06:49:08	28.17 N 89.22 W	943	Squid Pholidoteuthis adami	

3.6.7 MC809

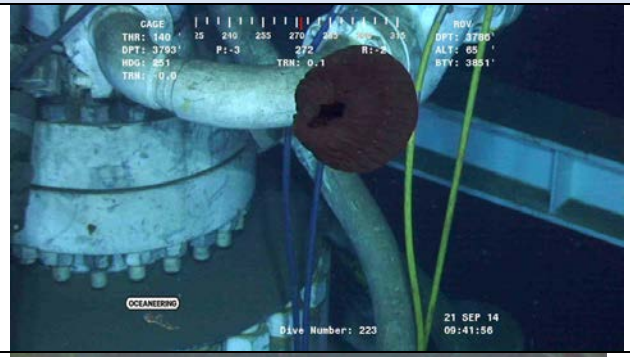
In June 2014, an Oceaneering ROV, Millennium 111, operating from the drillship Noble Don Taylor under contract to Shell, was able to image the abundant fishes beneath the site. Macrourids were predominant; however, a pair of chimaeras *Rhinochimaera atlantica* and a catshark *Apristurus* sp. were also observed. Red crabs *Chaceon quinquedens* and lithodid crabs *Neolithodes agassizii* were present. Opportunistic encounters included large tunas at over 1000 m depth.

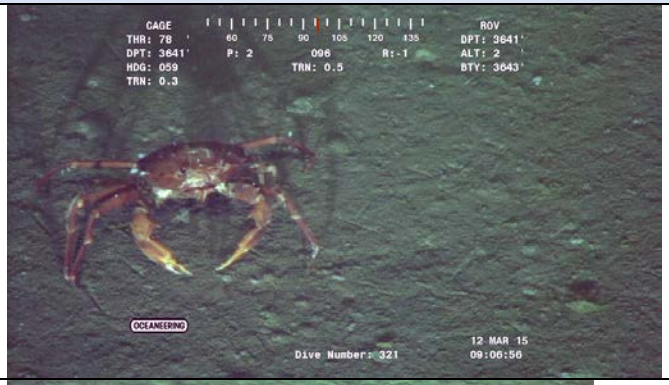
Table 17. Biological Observations from MC809

Date Time	Location	Depth (m)	Identity	Image
04/07/14 09:01:50	28.17 N 89.12 W	1204	Red crab *Chaceon quinquedens* and cusk eel Ophidiidae	
04/07/14 09:42:52	28.17 N 89.12 W	1152	Pyrosome Pyrosoma spinifera	

Date Time	Location	Depth (m)	Identity	Image
04/07/14 09:42:52	28.17 N 89.12 W	1174	Lithodid crabs Neolithodes agassizii	
04/07/14 09:42:52	28.17 N 89.12 W	1175	Red crab Chaceon quinquedens	
04/07/14 08:42:52	28.17 N 89.12 W	1066	Tuna Thunnus sp.	

Date Time	Location	Depth (m)	Identity	Image
04/07/14 08:44:47	28.17 N 89.12 W	1071	Tuna Thunnus sp.	
04/07/14 08:44:58	28.17 N 89.12 W	1077	Tuna Thunnus sp.	
04/07/14 08:45:53	28.17 N 89.12 W	1057	Tuna Thunnus sp.	

Date Time	Location	Depth (m)	Identity	Image
06/21/14 09:41:56	28.17 N 89.12 W	1154	Scyphomedusa Periphyllopsis braueri	
03/12/15 09:00:32	28.17 N 89.12 W	1109	Fish Macrouridae Coryphaenoides sp.	
03/12/15 09:04:25	28.17 N 89.12 W	1109	Fish Macrouridae Coelorinchus sp.	

Date Time	Location	Depth (m)	Identity	Image
03/12/15 09:05:56	28.17 N 89.12 W	1110	Red crab Chaceon quinquedens	
03/12/15 09:14:38	28.17 N 89.12 W	1110	Shrimp Glyphocrangon sp.	
03/12/15 09:15:35	28.17 N 89.12 W	1110	Eel Synaphobranchidae Illyophis sp.	

Date Time	Location	Depth (m)	Identity	Image
03/12/15 09:16:28	28.17 N 89.12 W	1110	Eel Synaphobranchidae Synaphobranchus sp.	
03/12/15 09:17:04	28.17 N 89.12 W	1110	Catshark Apristurus sp.	
03/12/15 09:17:14	28.17 N 89.12 W	1110	Catshark *Apristurus* sp. (Same individual as 09:17:04)	

Date Time	Location	Depth (m)	Identity	Image
03/12/15 09:19:18	28.17 N 89.12 W	1110	Shrimp Glyphocrangon sp.	
03/12/15 09:20:40	28.17 N 89.12 W	1110	Abundant fishes at the seabed	

3.6.8 MC811

Oceaneering's Millennium 115, working under contract for Shell, provided data from this site. MC811 is an intermediate depth site with the seabed at approximately 1360 m. Though most surveys were of midwater fauna, the ROV imaged chimaeras *Hydrolagus alberti*, cutthroat eels *Synaphobranchus* sp., nettastomatid eels *Venefica procera*, and large lithodid crabs *Neolithodes agassizii* on the seabed. The water column surveys provided observations of a diverse fauna including ctenophores, siphonophores and scyphomedusae. The highlight was the observation of a pair of telescope fish *Gigantura* sp. at 1064 m. These fish have been reported to form pair bonds, possibly as a strategy for ensuring access to a mate (Kupchik et al. 2018). This observation is the third direct confirmation that *Gigantura* does form pairs. One of the other observations was from Gulf SERPENT observations in Walker Ridge.

Table 18. Biological Observations from MC811

Date Time	Location	Depth (m)	Identity	Image
06/29/14 15:08:40	28.18 N 89.00 W	764	Undescribed red cydippid ctenophore	
06/29/14 15:08:45	28.18 N 89.00 W	764	Undescribed red cydippid ctenophore (same individual as 15:08:40)	

Date Time	Location	Depth (m)	Identity	Image
06/29/14 15:11:05	28.18 N 89.00 W	763	Lobate ctenophore *Ocyropsis* sp. with unidentified medusa in frame.	
06/29/14 15:14:52	28.18 N 89.00 W	765	Unidentified shrimp	
06/29/14 15:14:52	28.18 N 89.00 W	765	Larvacean house	

Date Time	Location	Depth (m)	Identity	Image
06/29/14 15:14:52	28.18 N 89.00 W	765	Ctenophore Eurhamphaea sp.	
06/29/14 15:14:52	28.18 N 89.00 W	765	Physonect siphonophore Apolemia sp.	
06/29/14 15:23:05	28.18 N 89.00 W	772	Lobate ctenophore Ocyropsis sp	

Date Time	Location	Depth (m)	Identity	Image
06/29/14 15:25:34	28.18 N 89.00 W	777	Lobate ctenophore Ocyropsis sp.	
06/29/14 15:14:52	28.18 N 89.00 W	770	Unidentified physonect siphonophore	
06/29/14 15:14:52	28.18 N 89.00 W	770	Abandoned larvacean house	

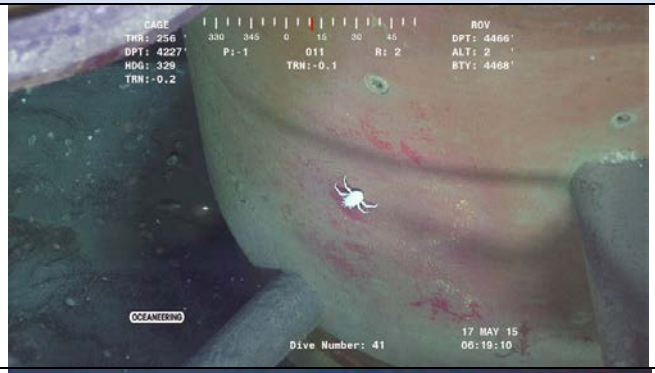
Date Time	Location	Depth (m)	Identity	Image
03/08/15 09:55:13	28.18 N 89.00 W	635	Ctenophore Eurhamphaea sp.	
03/08/15 10:07:19	28.18 N 89.00 W	611	Pyrosome Pyrosoma atlanticum	
03/16/15 10:07:31	28.18 N 89.00 W	1063	Medusa Periphyllopsis braueri	

Date Time	Location	Depth (m)	Identity	Image
03/16/15 10:08:54	28.18 N 89.00 W	1064	A pair of Giganturidae Gigantura chuni	
03/16/15 10:09:38	28.18 N 89.00 W	1064	A pair of Giganturidae Gigantura chuni Same pair as 10:08:54	
03/16/15 10:12:12	28.18 N 89.00 W	1064	Ctenophore Bathocyroe fosteri	

Date Time	Location	Depth (m)	Identity	Image
03/16/15 10:13:34	28.18 N 89.00 W	1062	Unidentified radiolarian	
03/20/15 09:14:37	28.18 N 89.00 W	1362	Fish Chimaeridae Hydrolagus alberti	
03/28/15 10:25:42	28.18 N 89.00 W	921	Medusa Poralia rufescens	

Date Time	Location	Depth (m)	Identity	Image
03/28/15 10:26:27	28.18 N 89.00 W	921	Medusa Poralia rufescens Same individual as 10:25:42	
04/03/15 08:14:19	28.18 N 89.00 W	1362	Witch eel Nettastomatidae Venefica procera	
04/03/15 08:16:56	28.18 N 89.00 W	1362	Cutthroat eel Synaphobranchidae *Synaphobranchus* sp. (right side)	

Date Time	Location	Depth (m)	Identity	Image
04/29/15 14:44:09	28.18 N 89.00 W	1362	Fish Chimaeridae Hydrolagus alberti	
05/08/15 08:36:11	28.18 N 89.00 W	651	Fish Gonostomatidae	
05/08/15 08:37:19	28.18 N 89.00 W	658	Medusa Halicreas sp.	

Date Time	Location	Depth (m)	Identity	Image
05/27/150 6:19:10	28.18 N 89.00 W	1362	Unidentified squat lobster	
05/27/150 9:16:30	28.18 N 89.00 W	581	Unidentified medusa	
05/27/150 9:19:51	28.18 N 89.00 W	579	Squid Taonius pavo	

Date Time	Location	Depth (m)	Identity	Image
05/27/1509:20:06	28.18 N 89.00 W	579	Squid Taonius pavo Same individual as 09:19:51	
05/27/1509:22:45	28.18 N 89.00 W	480	Ctenophore *Eurhamphaea* sp.	
05/27/1509:24:28	28.18 N 89.00 W	570	Physonect siphonophore	

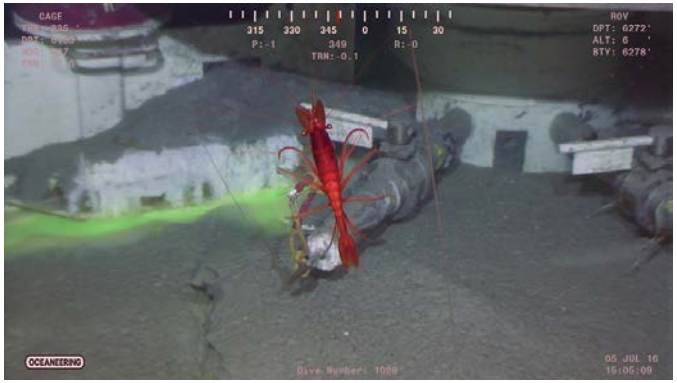
Date Time	Location	Depth (m)	Identity	Image
05/27/1509:25:14	28.18 N 89.00 W	569	Chaetognath	
05/31/15 08:24:43	28.18 N 89.00 W	306	Ctenophore Thalassocalyce inconstans	
06/28/150 8:36:38	28.18 N 89.00 W	1362	Unidentified	

Date Time	Location	Depth (m)	Identity	Image
06/28/1508:53:25	28.18 N 89.00 W	1365	Neolithodes agassizi	

3.6.9 MC822

Data from this location were provided by Oceaneering's Millennium 80 and 82 ROVs operating from the Transocean *Development Driller III* rig under contract to BP. The seabed at this site is remarkable flat and water clarity was excellent during the surveys. This factor combined with the intense lights of the ROV provided some excellent images. A few stalked glass sponges and isolated small corals growing on hard surfaces comprised the sessile invertebrate fauna. *Nematocarcinus* sp. shrimp were abundant along with fewer *Cerataspis monstrosa* and several other unidentified shrimps swimming just above the seabed. A few large lithodid crabs *Neolithodes agassizii* were present; however, no red crabs *Chaceon quinquedens* were observed. *Synaphobranchus* eels dominated the fishes along with some tripodfish *Bathypterois quadrifilis*, halosaurs, and cusk eels *Bassogigas gilli*. One notable observation on the seabed was part of the carapace of a sea turtle. In the water column, a nice example of the squid *Grimalditeuthis bonplandi* was imaged along with the fish-eating physonect siphonophore *Erenna* sp.

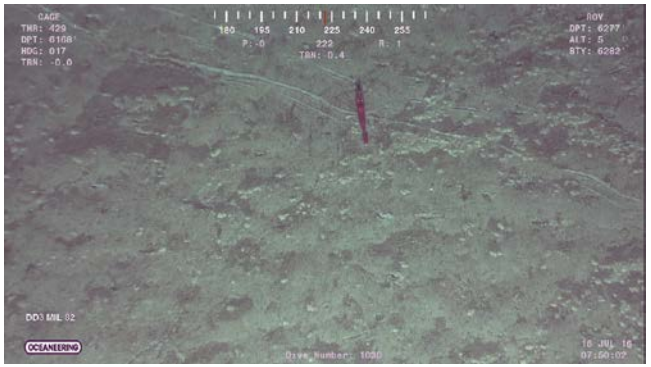
Table 19. Biological Observations from MC822

Date Time	Location	Depth (m)	Identity	Image
07/15/16 15:05:09	28.15 N 88.48 W	1912	Shrimp Cerataspis monstrosa (formerly Plesopenaeus armatus)	

Date Time	Location	Depth (m)	Identity	Image
07/15/16 15:13:11	28.15 N 88.48 W	1913	Holothurian Benthothuria sp.	
07/15/16 15:26:40	28.15 N 88.48 W	1912	Fish Macrouridae Coryphaenoides macrocephalus	

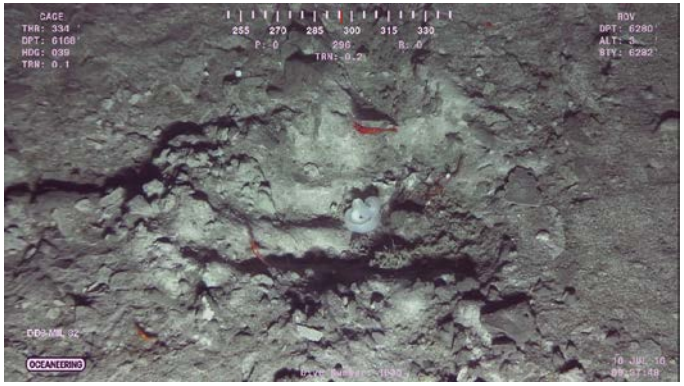
Date Time	Location	Depth (m)	Identity	Image
07/15/16 15:27:29	28.15 N 88.48 W	1912	Shrimp *Nematocarcinus* sp. and hormathiid anemones	
07/16/16 07:43:33	28.15 N 88.48 W	1915	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 07:46:44	28.15 N 88.48 W	1915	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	
07/16/16 07:48:00	28.15 N 88.48 W	1915	Fish Ipnopidae Bathypterois quadrifilis	

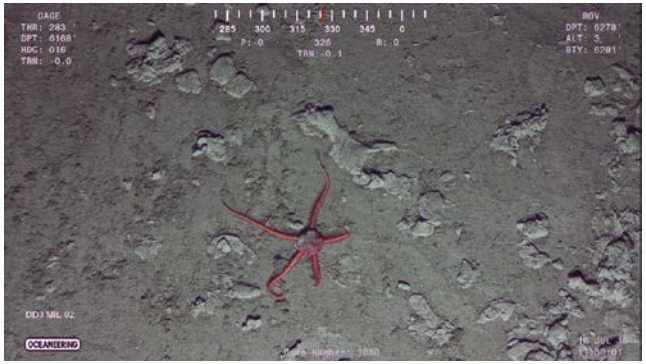
Date Time	Location	Depth (m)	Identity	Image
07/16/16 07:50:02	28.15 N 88.48 W	1915	Red shrimp Nematocarcinus sp.	
07/16/16 07:53:14	28.15 N 88.48 W	1913	Shrimp Unidentified	
07/16/16 08:04:16	28.15 N 88.48 W	1915	Shrimp Cerataspis monstrosa	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 08:21:20	28.15 N 88.48 W	1915	Squat lobster Unidentified	
07/16/16 08:36:22	28.15 N 88.48 W	1914	Coral Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 08:46:46	28.15 N 88.48 W	1915	Glass sponge Hexactinellidae Unidentified	
07/16/16 08:51:50	28.15 N 88.48 W	1915	Glass sponge Hexactinellidae Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 09:09:21	28.15 N 88.48 W	1914	Partial sea turtle carapace	
07/16/16 09:37:48	28.15 N 88.48 W	1915	Holothurian Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 09:59:00	28.15 N 88.48 W	1915	Cutthroat eel Synaphobranchidae Synaphobranchus sp.	
07/16/16 10:17:12	28.15 N 88.48 W	1914	Fish Halosauridae Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 10:27:40	28.15 N 88.48 W	1914	Fish Ipnopidae Bathypterois quadrifilis	
07/16/16 11:30:01	28.15 N 88.48 W	1914	Brittle star Unidentified	
07/16/16 12:11:33	28.15 N 88.48 W	1915	Sea pen Umbellula sp.	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 12:18:42	28.15 N 88.48 W	1915	Fish Ophidiidae Bassogigas gilli	
07/16/16 12:21:15	28.15 N 88.48 W	1915	Fish Halosauridae Unidentified	
07/16/16 12:25:31	28.15 N 88.48 W	1915	Brittle star Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 12:29:42	28.15 N 88.48 W	1915	Lithodid crab Neolithodes agassizii	
07/16/16 12:37:57	28.15 N 88.48 W	1914	Swimming holothurian Unidentified (Elpididae?)	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 12:53:54	28.15 N 88.48 W	1914	Fish Ophidiidae Bassogigas gilli	
07/16/16 13:01:22	28.15 N 88.48 W	1915	Coral Unidentified	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 13:07:06	28.15 N 88.48 W	1915	Holothurian Unidentified	
07/16/16 19:32:50	28.15 N 88.48 W	1914	Lithodid crab Neolithodes agassizii	
07/16/16 20:10:18	28.15 N 88.48 W	1914	Fish Ophidiidae Bassogigas gilli	

Date Time	Location	Depth (m)	Identity	Image
07/16/16 20:11:45	28.15 N 88.48 W	1912	Fish Halosauridae Unidentified	
07/17/16 03:35:02	28.15 N 88.48 W	1676	Calycophoran siphonophore Unidentified (Same individual as 09:54:14)	
07/17/16 03:38:54	28.15 N 88.48 W	1676	Squid Grimalditeuthis bonplandi	

Date Time	Location	Depth (m)	Identity	Image
07/17/16 09:54:14	28.15 N 88.48 W	1237	Physonect siphonophore Erenna sp.	

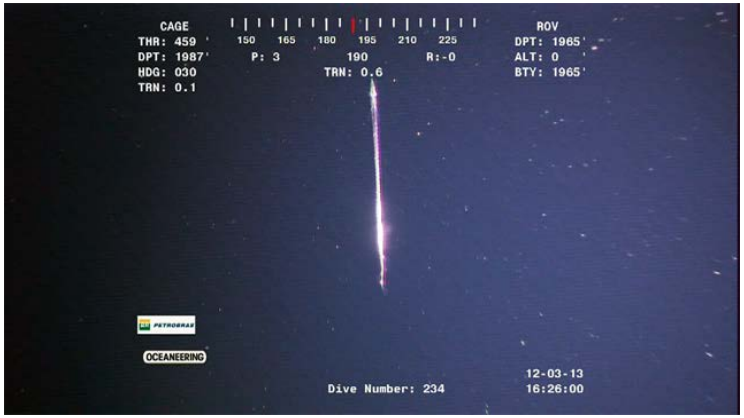
3.7 Walker Ridge

3.7.1 WR467

Surveys at this site located far offshore were conducted in cooperation with Petrobras America. All surveys were conducted in the water column.

Table 20. Biological observations from WR467

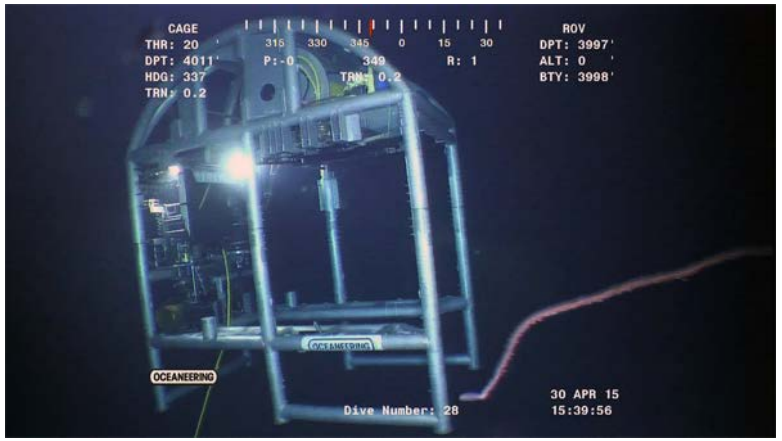
Date Time	Location	Depth (m)	Identity	Image
12/03/13 15:41:33	26.52 N 90.53 W	1796	Larvacean Unidentified	
12/03/13 15:46:15	26.52 N 90.53 W	1797	Lobate ctenophore *Bathocyroe fosteri*	

Date Time	Location	Depth (m)	Identity	Image
12/03/13 16:26:00	26.52 N 90.53 W	599	Trichiuridae Unidentified	
12/03/13 16:26:00	26.52 N 90.53 W	599	Physonect siphonophore	

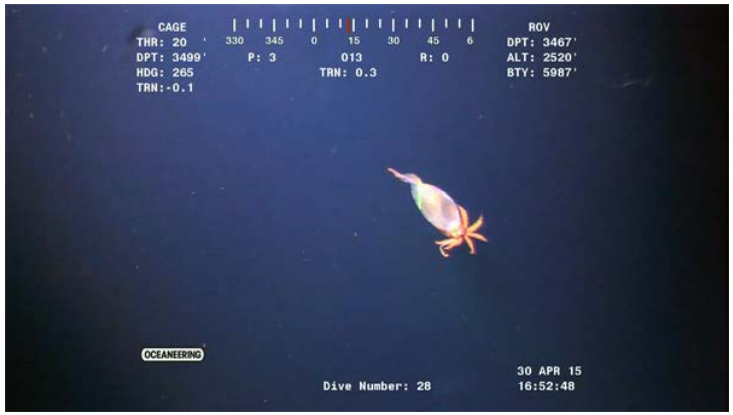
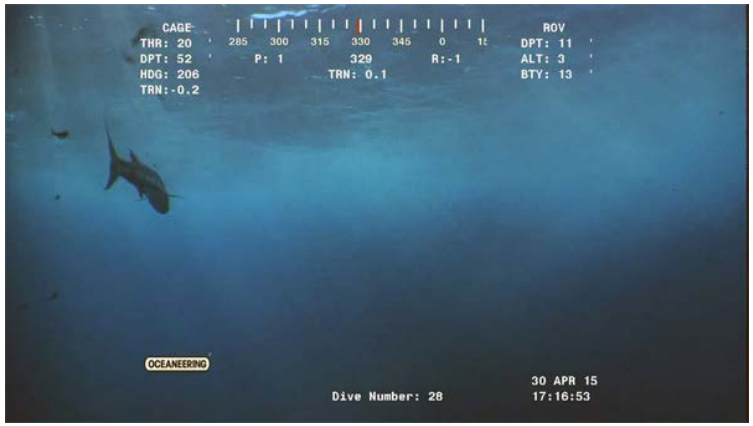
Date Time	Location	Depth (m)	Identity	Image
12/06/13 20:27:17	26.52 N 90.53 W	1291	Piglet squid Helicocranchia sp.	

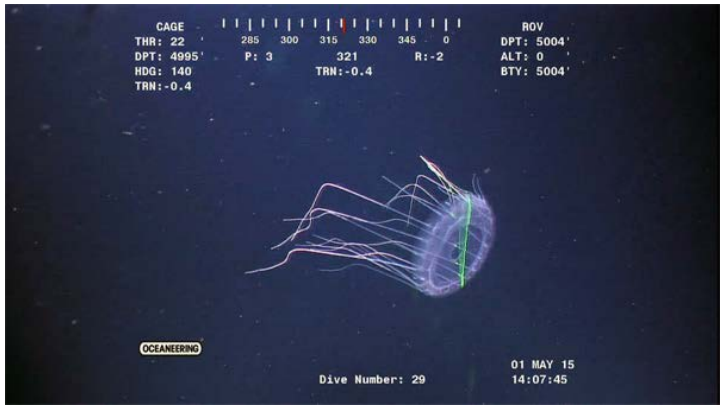
Date Time	Location	Depth (m)	Identity	Image
01/30/15 15:06:25	26.52 N 90.53 W	459	Pyrosome *Pyrosoma atlanticum*	
03/31/15 10:27:14	26.52 N 90.53 W	2704	Ophidiidae Bony-eared assfish *Acanthonus armatus*	

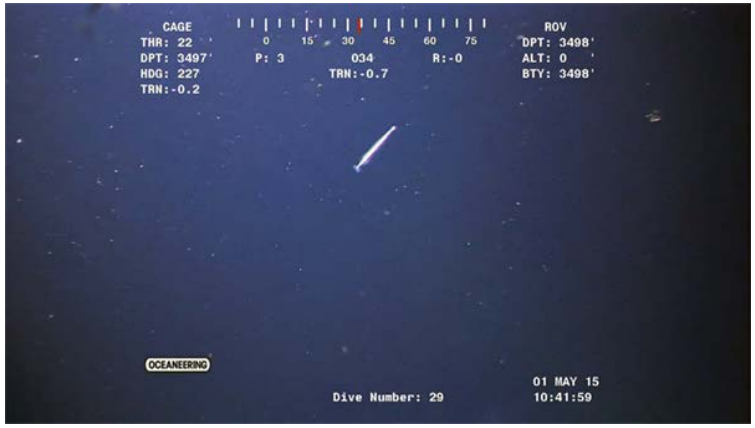
Date Time	Location	Depth (m)	Identity	Image
03/31/15 10:27:14	26.52 N 90.53 W	5	Carangidae Rainbow runner Elagatis bipinnulata	
03/31/15 10:27:22	26.52 N 90.53 W	3	Kyphosidae Bermuda chub Kyphosus sectator	

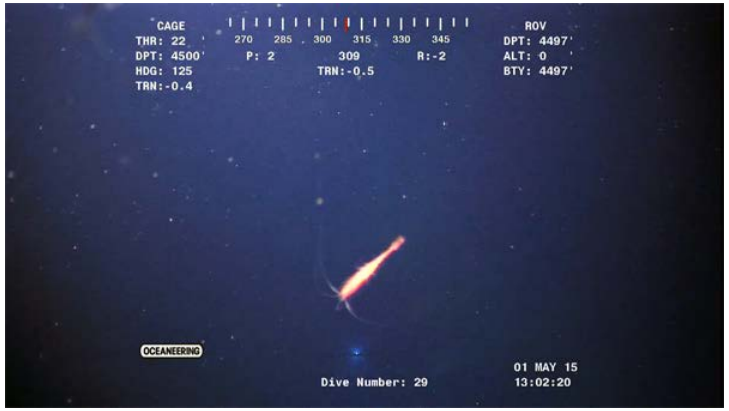
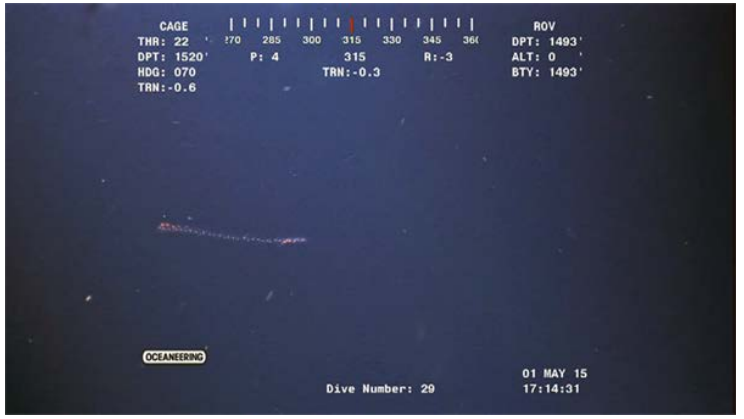
Date Time	Location	Depth (m)	Identity	Image
04/29/15 16:54:04	26.52 N 90.53 W	13	Balistidae Gray triggerfish Balistes capriscus	
04/30/15 15:39:57	26.52 N 90.53 W	1218	Physonect siphonophore *Apolemia* sp.	

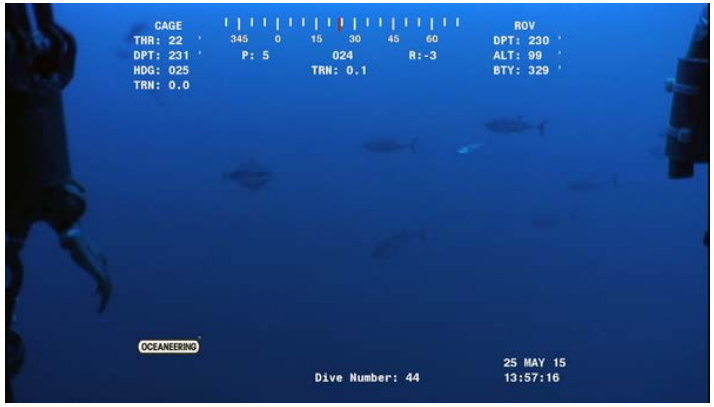
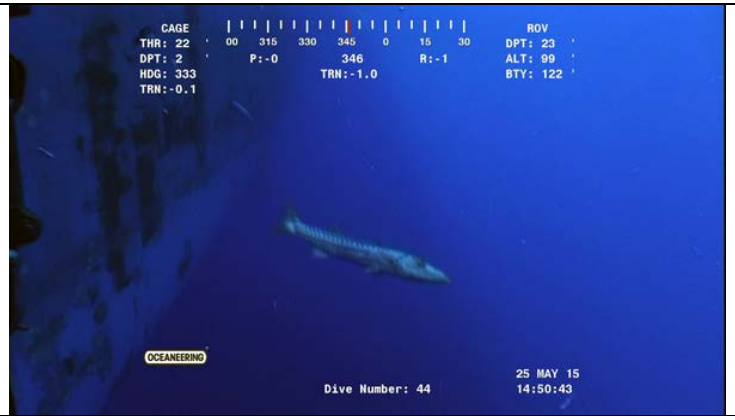
Date Time	Location	Depth (m)	Identity	Image
04/30/15 15:26:07	26.52 N 90.53 W	1066	Trachymedusa Halitrephes valdiviae	
04/30/15 16:52:01	26.52 N 90.53 W	1061	Cranchid squid Megalocranchia sp.	

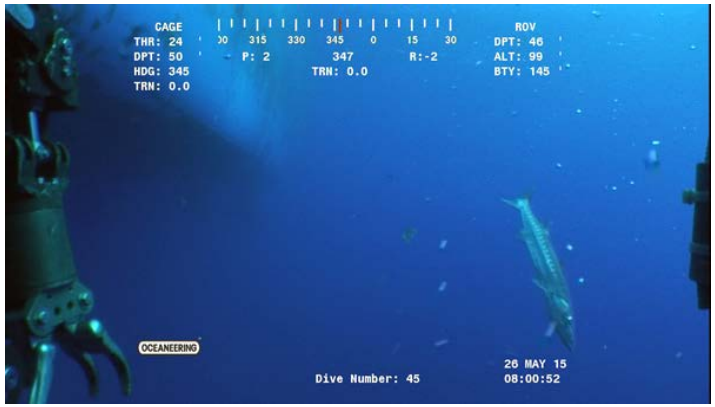
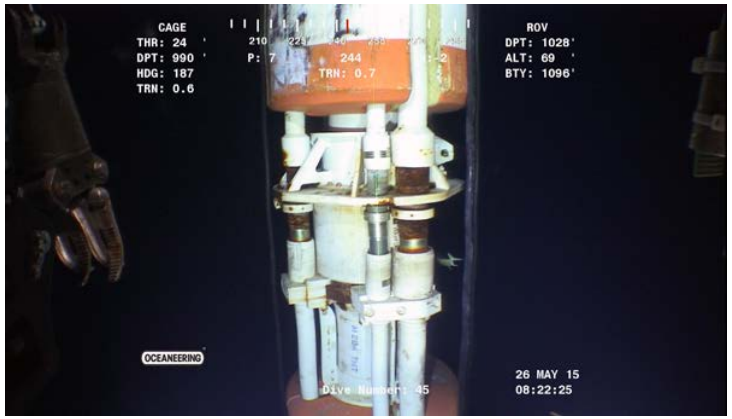
Date Time	Location	Depth (m)	Identity	Image
04/30/15 16:52:48	26.52 N 90.53 W	1057	Cranchid squid Megalocranchia sp. (same individual as 16:52:01)	
04/30/15 17:16:53	26.52 N 90.53 W	3	Sphyraenidae Great barracuda Sphyraena barracuda	

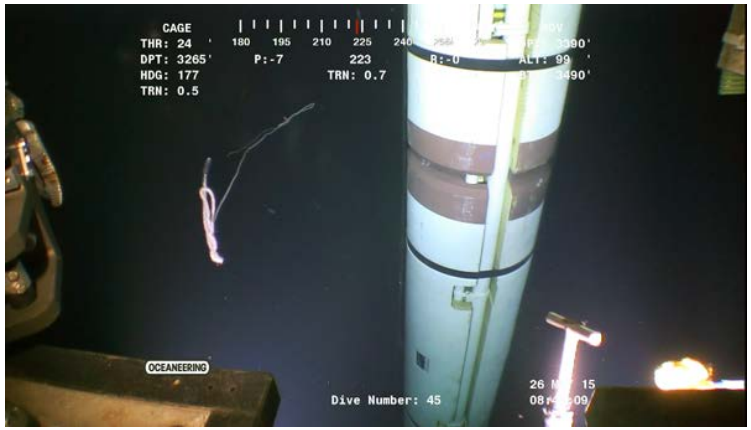
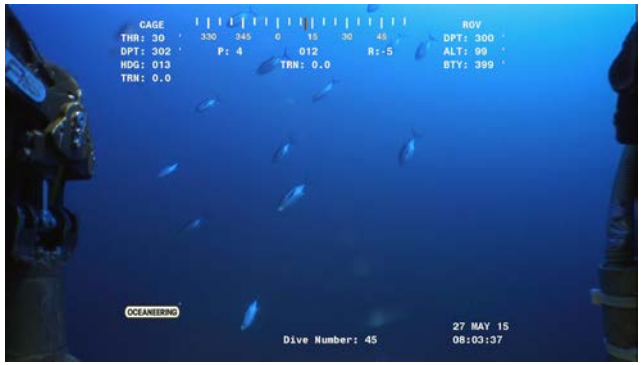
Date Time	Location	Depth (m)	Identity	Image
05/01/15 06:45:05	26.52 N 90.53 W	754	Phronimidae Hyperiid amphipod Phronima sp.	
05/01/15 14:07:45	26.52 N 90.53 W	1525	Narcomedusa *Solmissus* sp.	

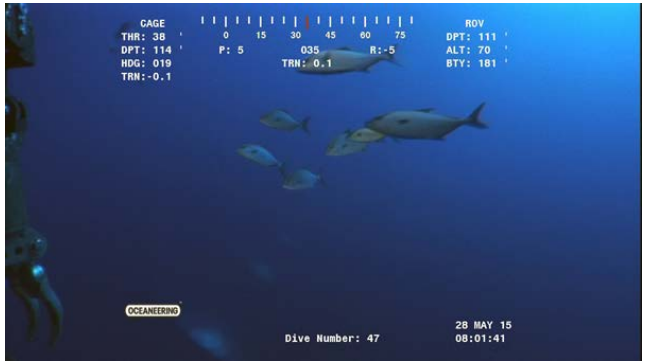
Date Time	Location	Depth (m)	Identity	Image
05/01/15 10:41:59	26.52 N 90.53 W	1066	Chaetognath Undentified	
05/01/15 11:25:11	26.52 N 90.53 W	1216	Shrimp Unidentified	

Date Time	Location	Depth (m)	Identity	Image
05/01/15 13:02:20	26.52 N 90.53 W	1371	Shrimp Unidentified	
05/01/15 17:14:31	26.52 N 90.53 W	455	Siphonophore Unidentified	

Date Time	Location	Depth (m)	Identity	Image
05/25/15 13:57:16	26.52 N 90.53 W	70	Scombridae Blackfin tuna Thunnus atlanticus	
05/25/15 14:50:43	26.52 N 90.53 W	7	Sphyraenidae Great barracuda Sphyraena barracuda	

Date Time	Location	Depth (m)	Identity	Image
05/26/15 08:00:52	26.52 N 90.53 W	14	Sphyraenidae Great barracuda Sphyraena barracuda	
05/26/15 08:22:27	26.52 N 90.53 W	313	Carangidae Unidentified	

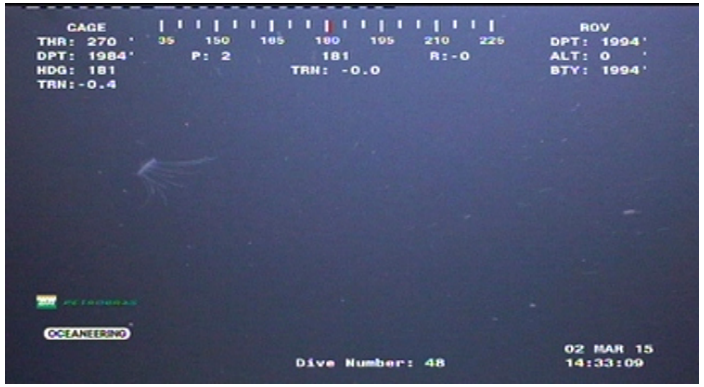
Date Time	Location	Depth (m)	Identity	Image
05/26/15 08:45:09	26.52 N 90.53 W	1033	Physonect siphonophore *Apolemia* sp.	
05/27/15 08:03:37	26.52 N 90.53 W	91	Scombridae Blackfin tuna Thunnus atlanticus	

Date Time	Location	Depth (m)	Identity	Image
05/28/15 08:01:41	26.52 N 90.53 W	34	Carangidae Almaco jack Seriola rivoliana	

3.7.2 WR469

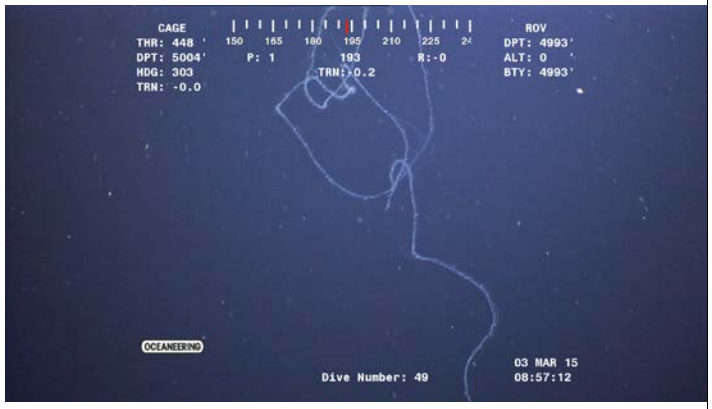
This site was operated by Petrobras-America and the surveys consisted of water column observations. Physonect siphonophores dominated with some ctenophores and medusae.

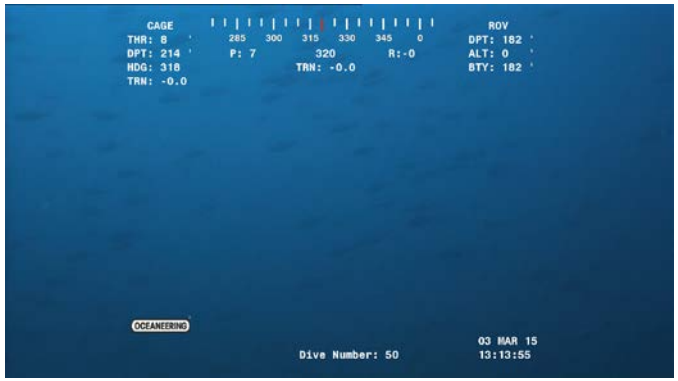
Table 21. Biological Observations from WR469

Date Time	Location	Depth (m)	Identity	Image
03/02/15 14:30:27	26.52 N 90.53 W	608	Gonostomatidae Cyclothone sp.	
03/02/15 14:33:09	26.52 N 90.53 W	608	Narcomedusa Solmissus sp.	

Date Time	Location	Depth (m)	Identity	Image
03/02/15 15:31:39	26.52 N 90.53 W	913	Lobate ctenophore Bathocyroe fosteri	
03/02/15 15:33:17	26.52 N 90.53 W	913	Lobate ctenophore Possibly *Ocyropsis* sp.	

Date Time	Location	Depth (m)	Identity	Image
03/02/15 17:20:14	26.52 N 90.53 W	9	Ocean triggerfish Balistiidae Canthidermis sufflamen?	
Date Time	**Location**	**Depth (m)**	**Identity**	**Image**
03/03/15 08:03:27	26.52 N 90.53 W	1521	Physonect siphonophore Unidentified	

Date Time	Location	Depth (m)	Identity	Image
03/03/15 08:45:04	26.52 N 90.53 W	1523	Physonect siphonophore Unidentified	
03/03/15 08:57:12	26.52 N 90.53 W	1521	Physonect siphonophore Apolemia sp.	

Date Time	Location	Depth (m)	Identity	Image
03/03/15 13:13:55	26.52 N 90.53 W	55	Tunas Thunnus sp.	
03/03/15 14:35:56	26.52 N 90.53 W	2136	Holothurian Enypniastes eximia	

4. Vertical Distribution Patterns of Selected Organisms

4.1 Introduction

The oil and gas industry conducts regular inspections of subsea equipment using remotely-operated vehicles (ROVs). These inspection videos frequently image marine life in the vicinity of their target structures. Some of the primary targets for inspections are the risers that extend from the blow-out preventer (BOP) to near the surface production facilities. The upper limit for most riser inspection videos examined for this project was approximately 15–20 m (50–70 feet). These inspections are usually conducted annually. Extending through the entire water column for thousands of meters, these risers provide a hard surface upon which sessile organisms can attach (Fig. 3). The vertical distribution patterns of these organisms can potentially reveal their ideal depth and growth optima. Comparisons of the same sections of a structure from inspections spanning multiple years can provide estimates of growth rates.

In addition to providing data on vertical distributions of sessile species, inspection videos contain information on the vertical distributions of mobile fishes and invertebrates. This provides biogeographical information on the presence of endemic as well as invasive species (e.g., lionfish). Many locations also have down-looking acoustic sensors (ADCPs) that provide the rig with data on current speed and direction through the water column. These sensors also record backscattering intensity data (receive signal strength intensity: RSSI) that is derived from echoes off biological targets. The inspection videos can provide data that assists in the interpretation of the sources of various acoustical scattering layers.

Figure 3. Part of the riser field below Shell's Mars (MC807A) platform.

Although BOEM sometimes mandates some biological ROV surveys before drilling, the majority of video collected by industrial ROVs does not target biota. Instead the focus is on the integrity and condition of subsea equipment. The information that these inspection videos contain represents a unique opportunity to extract biological time-series data. This section illustrates some of the potential data opportunities contained in inspection videos. A comprehensive examination of all the biological data contained in these videos would require hundreds of hours of effort. Although all companies collect inspection data, the following analyses were based on video provided to Gulf SERPENT by Shell through their online video archive maintained by Oceaneering.

4.2 Target Organisms

4.2.1 Tuna Vertical Migration Patterns

Three species of tunas belonging to the genus *Thunnus* are common in the oceanic waters of the Northern Gulf of Mexico. These include bluefin tuna *T. thynnus*, yellowfin tuna *T. albacares*, and blackfin tuna *T. atlanticus.* These fishes undertake extensive vertical migrations in order to forage on small fishes, cephalopods, crustaceans, and other zooplankton.

Tunas are frequently observed during riser inspections. A series of riser inspection videos collected during June 2017 below Shells MC807A Mars Platform provided an opportunity map the vertical movements of tunas in relation to acoustic scattering features in the water column. Videos were downloaded from the Shell's video archive[1] in Motion Picture Expert Group 4 (MPEG4) format. These had a resolution of 1080i (1920 x 1080 pixels). Videos from twenty (1–11, 13–20) of the 23 production risers that were inspected were examined for tuna observations. Individual videos were inspected using Quicktime software. Tunas were observed below nine of the risers (A2, A3, A4, A5, A7, A8, A9, A17, and A19). Frames containing regions of interest (tunas) were copied and saved in Portable Network Graphics (PNG) format using the MacOS Preview Application. The filename of each frame used the convention of yyyy_mm_dd_hh_mn_ss_zzzzxnn.png, where: yyyy=year; mm=month; dd=day; hh=hour; mn=minute; ss=second; zzzz=depth in feet; xnn=number of individuals in the frame. All times were taken from the video overlay and were in local time. Filenames were read into Matlab and the structure of the filename was converted to numeric values using the str2num function. Each observation was then converted to a local time in year-day format (x value) and a corresponding depth converted to meters (y value). This general approach was used to analyze the depth distributions of other taxa discussed later in this chapter. The trajectories of each inspection were estimated as straight lines between the start point (time, depth) and end point (time, depth). This is a simplification since the ROV frequently paused at anodes and areas that needed additional observation; however, given the time for each inspection (>1 h) this linear approximation provided a reasonable picture of the position of the ROV in time and space.

ADCP backscatter intensity data were obtained for the Mars Platform (NDBC Station 42363) from the National Data Buoy Center[2]. Data were imported into Matlab and times were converted to year-day format and then corrected to local times from GMT. Backscatter intensity pseudocolor plots were visualized in Matlab using the pcolor function after averaging echo intensity (receive signal strength intensity) values among beams 1 and 2. The data from beams 3 and 4 could not be used because beam 4 contained only zero values for the time period of interest and beam 3 appeared to be impacted by an obstruction. Bad data that produced strong vertical banding was identified and masked out in Matlab.

Video frames containing a total of 327 tunas were isolated. In most frames the tunas were recognizable due to their size and shape; however, since the risers were to intended video targets, focus was usually not sharp because the tunas were generally behind the focal point of the camera. In addition, the tunas were

[1] See https://omvshell.oiigds.com/
[2] See www.ndbc.noaa.gov

fast-moving targets and seldom slowed sufficiently to reduce the substantial motion blur associated with most images. This motion blur combined with poor focus (e.g., Fig. 4) made it difficult to identify the species of tuna though the morphology appeared consistent with the genus *Thunnus*. Based on the relative geometry of the pectoral fins in relation to the posterior dorsal fin, position of the anal fin, and colors of finlets, yellowfin tuna are the most probable species.

Tuna were primarily encountered within the midwater scattering layer centered near 500 m (Fig. 5). Some individuals were also observed deeper between 600m and the seabed (895 m). It was evident from the videos that the tunas were foraging. Swimming speed was rapid and the fish often undertook rapid changes in direction. The gaps in the ADCP record meant that it was not possible to associate all observations to the acoustic scattering record. In order to overcome this issue, daily acoustic patterns from June 5–June 9, 2017 were combined and averaged to produce a mean acoustic day below the Mars platform (Fig. 6).

When tuna observations color-coded by numbers per frame are superimposed on the mean acoustic day a clearer pattern of the foraging behavior of these yellowfin tuna emerges. Feeding was only documented at depth during the morning. From approximately 03:00–04:00, foraging occurs in the midwater scattering layer (400–600 m) and just above the seabed. From ~03:30 until 07:00 tunas feed on the descending scattering layer as it returns from the surface to mid-depth. Some feeding occurs in, and just below the midwater scattering layer until approximately 11 am. No tuna were observed in the afternoon or evening.

Just what the tuna were feeding on was not clear. In many cases there were not obvious prey organisms collocated with the foraging tuna. In some cases, small fishes, squids, and unidentified zooplankton were observed near or in the same section of the water as the tunas. The small fishes (Fig. 7) appear to be deepwater cardinalfishes (family Epigonidae). They did not actively school in a coordinated manner but occurred in aggregations of individuals that swam sluggishly in different directions.

The observations of tuna foraging underscore the value of ROV inspection video. Most tuna vertical migration behavior is obtained from tagging studies using acoustic or archival tags (e.g., Schaefer et al. 2007; Weng et al. 2009). This example came from a relatively small quantity of video collected over a few days at a single site. With time a more comprehensive picture of the daily and annual changes in movements of tunas could be assembled from additional data at this, and other sites.

Figure 4. Example frames showing tunas imaged during riser inspections below Shell's Mars platform.

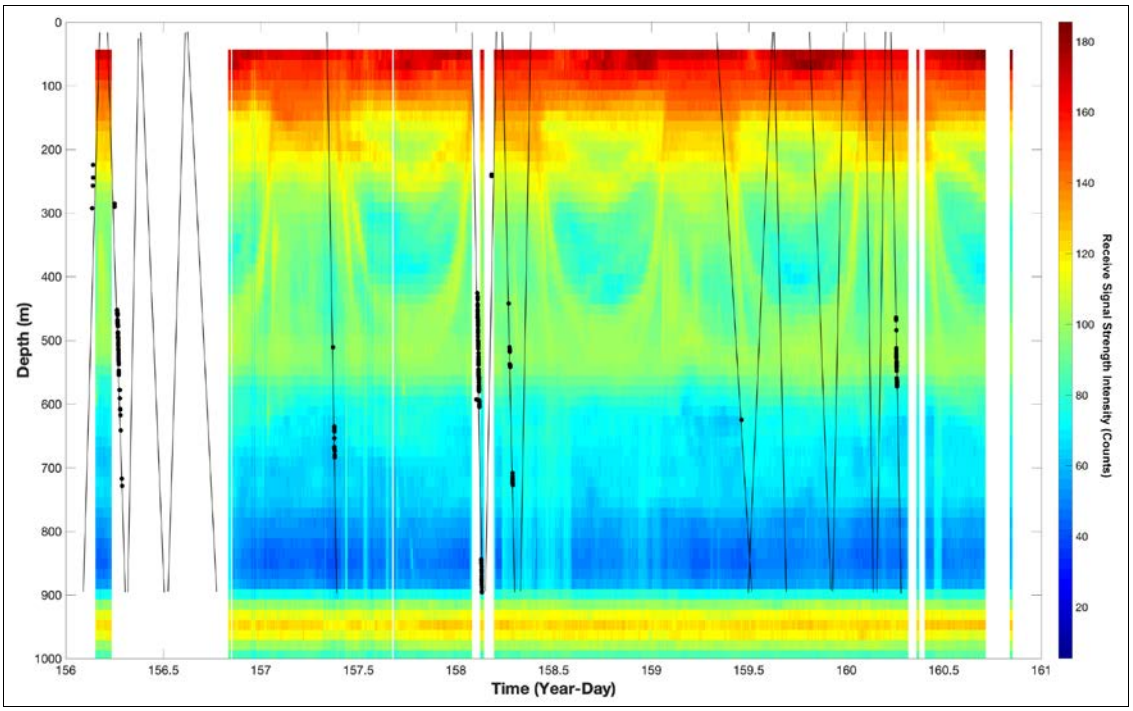


Figure 5. Observations of yellowfin tuna (●) superimposed on acoustic backscatter from the Mars ADCP from June 5–10, 2017.
Black lines indicate the average trajectory of the ROV. Tuna observations may contain more than one individual.

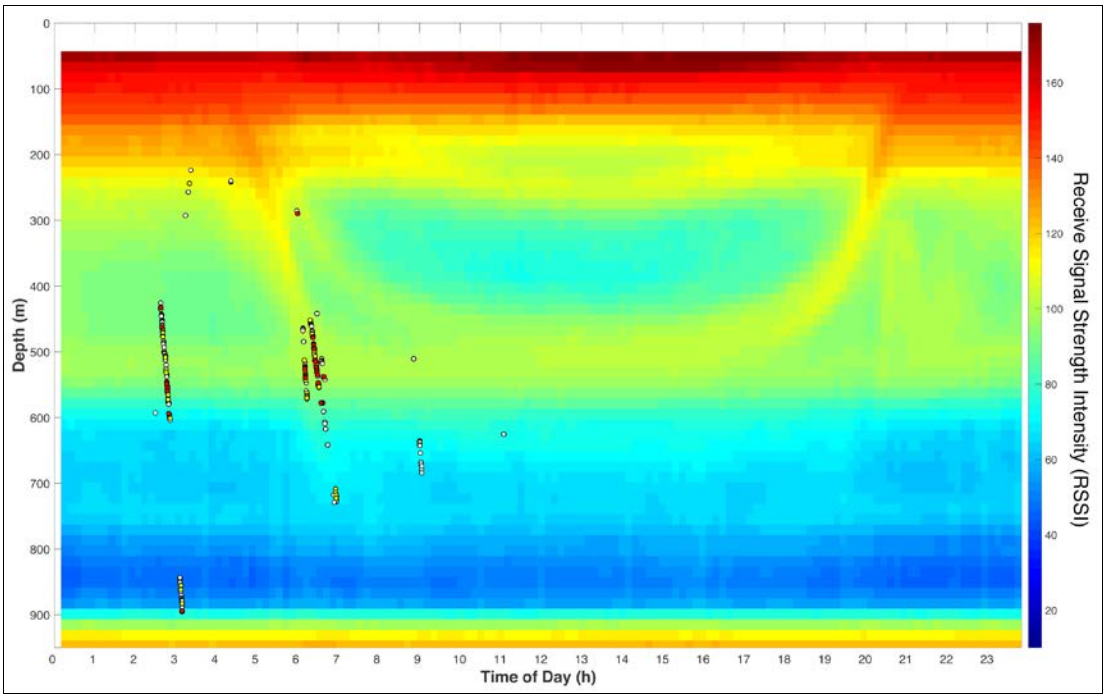


Figure 6. An average acoustic day below the Mars platform for the period June 5–10, 2017.
Tuna observations are overlaid on the acoustic backscattering pattern and are color-coded by abundance (white=1, yellow=2-3, red=>3).

Figure 7. Small fish observed in aggregations near, and coincident with foraging yellowfin tuna. These are likely a species of deepwater cardinalfishes (Family Epigonidae Epigonidae). The sizes of these fish could not be estimated accurately but they appeared to be 3–5 centimeters in length.

4.2.2 Great Barracuda *Sphyraena barracuda*

Great barracuda *Sphyraena barracuda* are commonly observed in the near surface waters around oil and gas structures in the Northern Gulf of Mexico (Fig. 8). The vertical distributions of these large predators have usually been determined using tags (e.g., O'Toole et al. 2010; Hansen and Kerstetter 2015). Great barracuda appear unafraid of ROVs and will often approach the vehicles very closely while the systems are conducting inspections. This provided a means of estimating their vertical distributions based on the relative numbers of observations at different depths.

Individual frames containing great barracudas were extracted from inspection videos recorded below Shell's MC809A Ursa and GB426 Auger platforms in 2018. Frame grabs were saved with a filename structure that was the same one used for tunas (yyyy_mm_dd_hh_mn_ss_zzzzxnn.png). Depth was estimated as the ROV depth even when barracudas were imaged slightly above or below the vehicle because there was no way to estimate the vertical offset. Given that target fish were generally close to the ROV suggesting an error of less than a few feet, this error would not be important since our depth bin intervals (2 m) were likely larger than the positioning error.

At Ursa, observations were collected between August 9–16, and October 16, 2018. The Auger observations spanned March 31–April 16, 2018. In both locations, although ROV operations occurred on a 24 h basis, most observations of barracudas were confined to daylight periods because the ROV lights were normally directed at a riser or other structure and were generally inadequate to illuminate a sufficient amount of the water in front of the vehicle to detect barracudas and other targets at night.

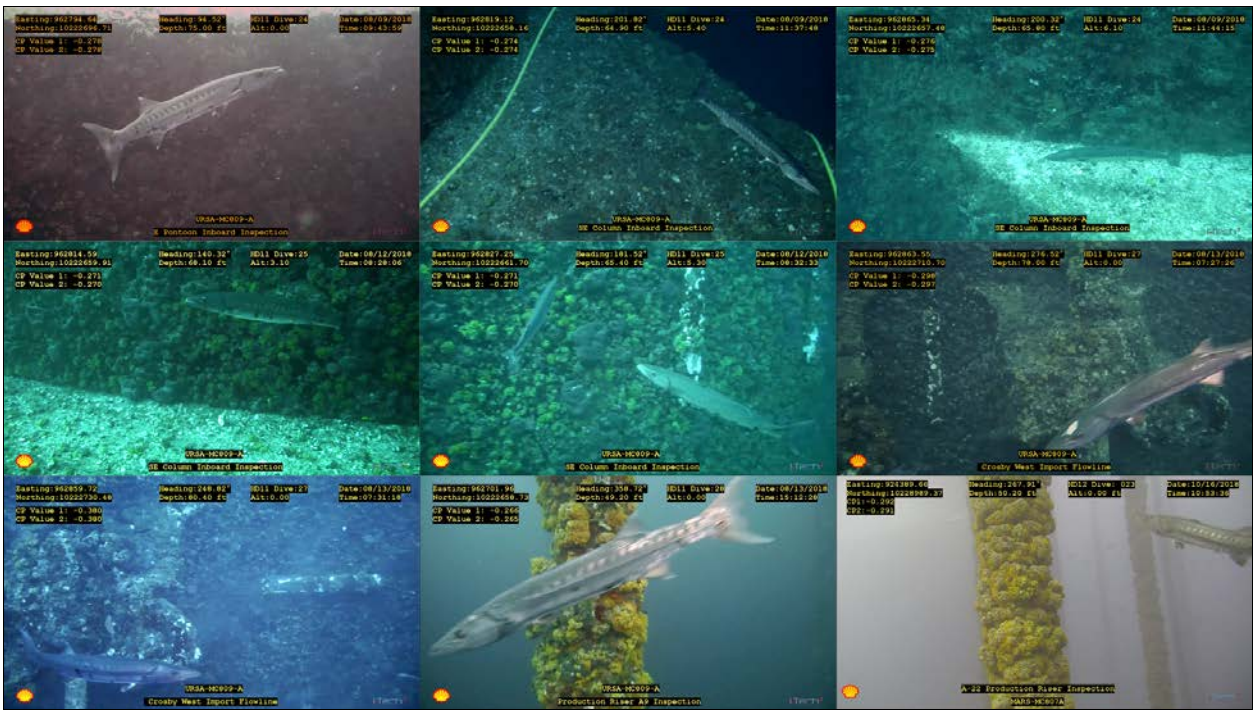


Figure 8. Examples of great barracuda *Sphyraena barracuda* below Shell's Ursa platform in 2018.

Below Ursa, the vertical distribution of great barracuda was confined to a narrow zone within the upper 42 m of the water column (Fig. 9) with a mean vertical depth of 22.2 m. The ROVs did not operate above approximately 15 m, which constrains estimation of their complete distribution in the upper water column. When the ROV panned the camera upwards it was common to see multiple barracuda just below the surface (Fig. 9 inset). Below Auger the distribution pattern was quite different (Fig. 10). The mean vertical depth was deeper (38.7 m) and the distribution extended deeper down to 85.3 m. The sample size at Auger (n=110) was double that of Ursa (n=55), though the patterns were so different that sample size was not likely a contributing factor. In both sites the fish were constrained to the same depths. Both distributions were obtained from daytime data, therefore, vertical migration differences can be ruled out.

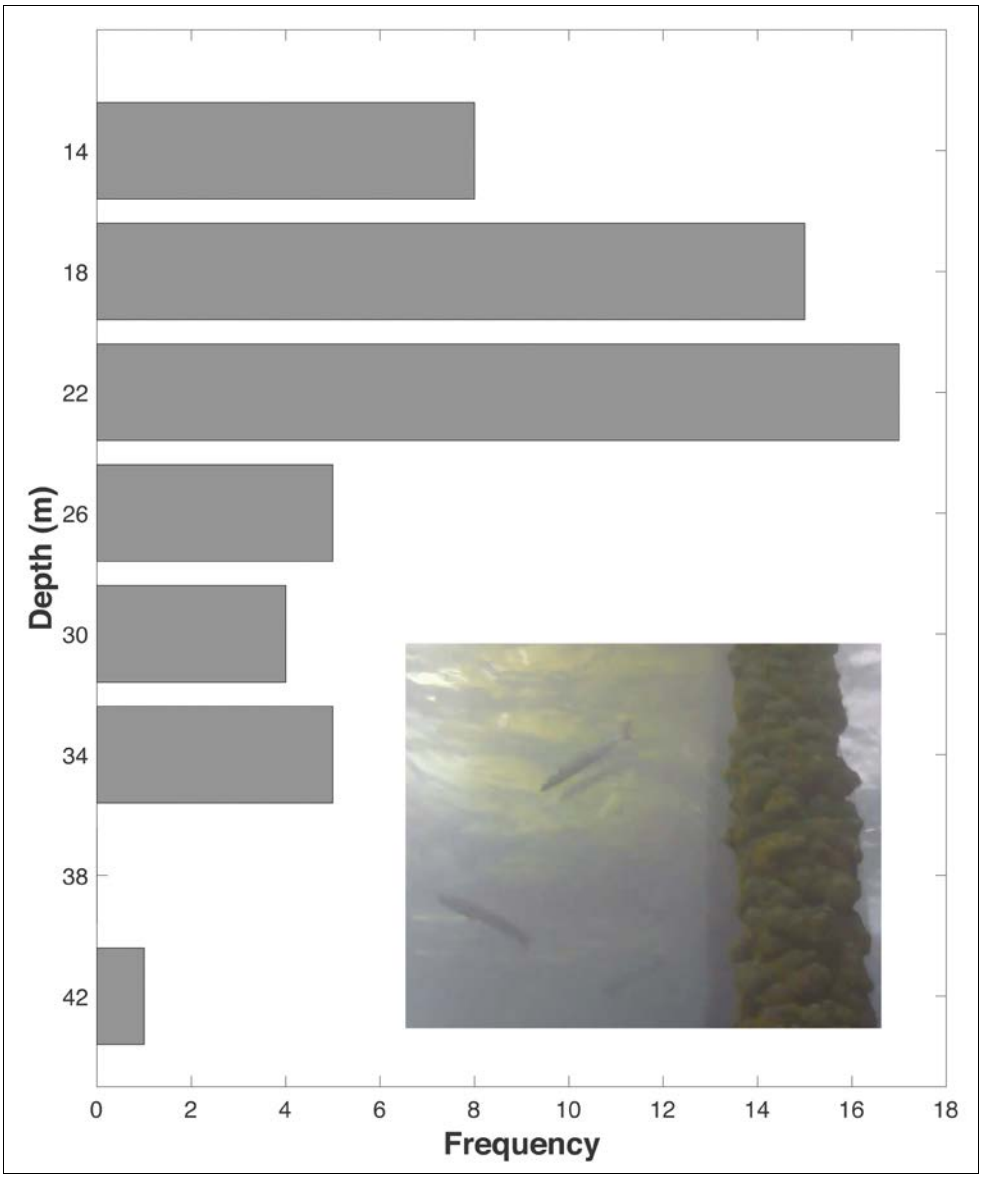


Figure 9. Vertical distribution of great barracuda *Sphyraena barracuda* beneath Shell's Ursa platform.

The inset image shows barracudas just below the surface. Fish located shallower than 14 m could not be enumerated by the ROV because it did not operate in that region.

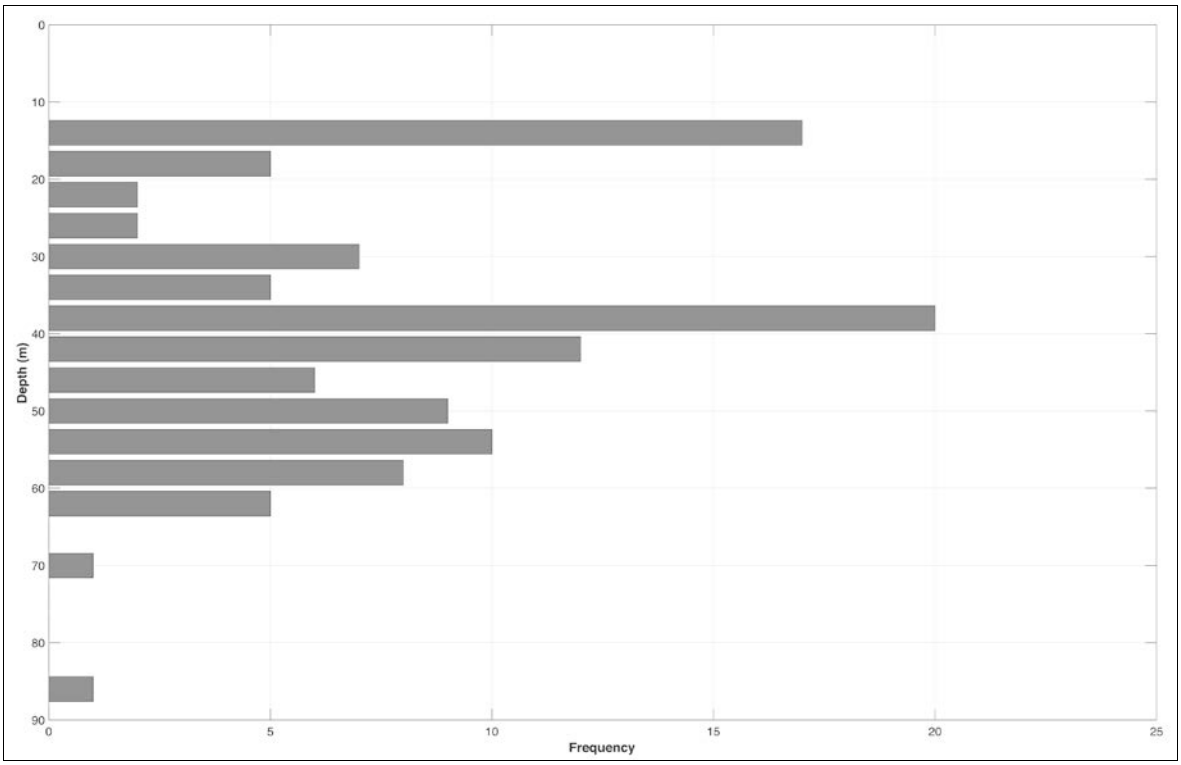


Figure 10. Vertical distribution of great barracuda *Sphyraena barracuda* beneath Shell's Auger platform.

4.2.1 Juvenile Caribbean Moonfish Selene brownii

One of the benefits of access to large amounts of inspection video is the opportunity that it affords for unexpected discoveries. The presence of juvenile moonfish *Selene setapinnis* (Carangidae) is one such example. During examinations of riser inspection videos below the Ursa platform, numerous small, silver, laterally-compressed fish were observed near the riser in the 300–688 ft (102.2–203.7 m) depth range (Fig. 11). These were identified as juvenile Caribbean moonfish, a species that is normally an upper epipelagic inhabitant with juveniles occurring in estuaries and off river mouths (Cervigón 1993). The presence of these fish down into the base of the epipelagic zone was an unusual observation and a series of riser inspections from August 2018 were used to evaluate its vertical distribution pattern.

Caribbean moonfish were initially observed in inspection videos from Shell's Ursa platform of the 18 Inch Oil Export riser. Only two individuals were seen on that riser and the video quality was poor. Additional videos were examined to construct a clearer picture of this species' vertical distribution pattern at that site. Caribbean moonfish were documented on the following risers: Crosby West Import, Princess Gas Lift SCR, Princess Water Flood Umbilical, Production A2, A3, and A4. Criteria for riser selection were video quality, lack of missing video segments, and water clarity.

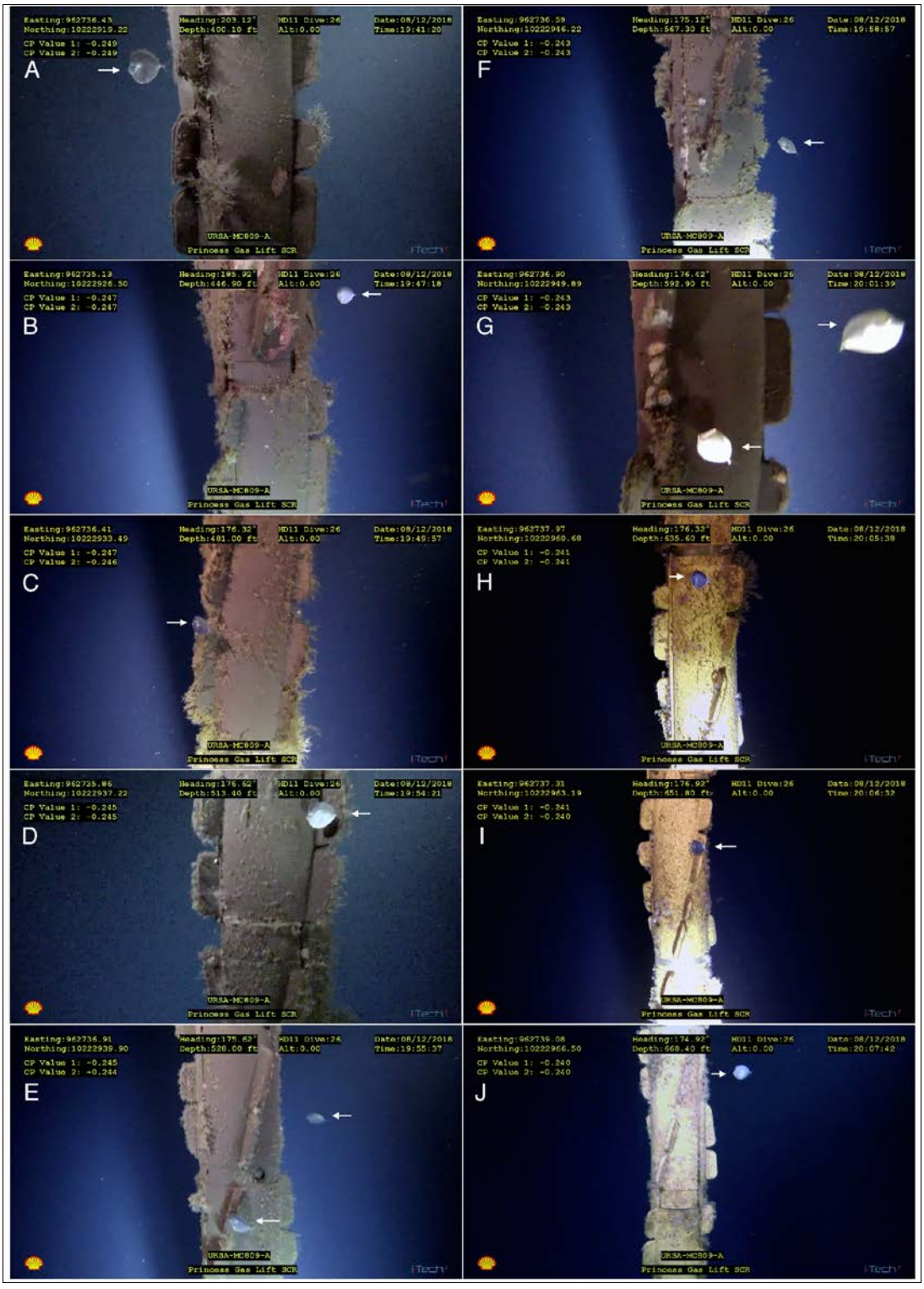


Figure 11. Example frame grabs of Caribbean moonfish *Selene brownii* on risers below Shell's Ursa platform.

Depths (m): A: 121.9; B: 136.2; C: 146.6; D: 156.5; E: 160.9; F: 173.0; G: 180.7; H: 190.4; I: 198.7; J: 203.7.

The vertical distribution patterns on six risers below Ursa indicate that juvenile *S. brownii* use sections of riser in the lower half of the mesopelagic zone and extend in some cases, into the upper mesopelagic zone (Fig. 12). Abundances were quite variable, perhaps indicating local patchiness in settlement. This is the first time that this species has been documented in association with oil and gas structures. Whether this is a regular pattern and what the seasonality of riser use will require examination of additional inspection videos at Ursa and other sites. The implications of this habitat for the population of *S. brownii* is an interesting question. There are a lot of risers and similar artificial habitat on rigs and platforms in the Gulf of Mexico. This additional juvenile habitat could provide an important supplemental nursery area. In many videos, individuals appeared to be grazing on epibionts attached to the riser. In the event of a spill, this is another species that may be at risk to hydrocarbons in the epipelagic zone.

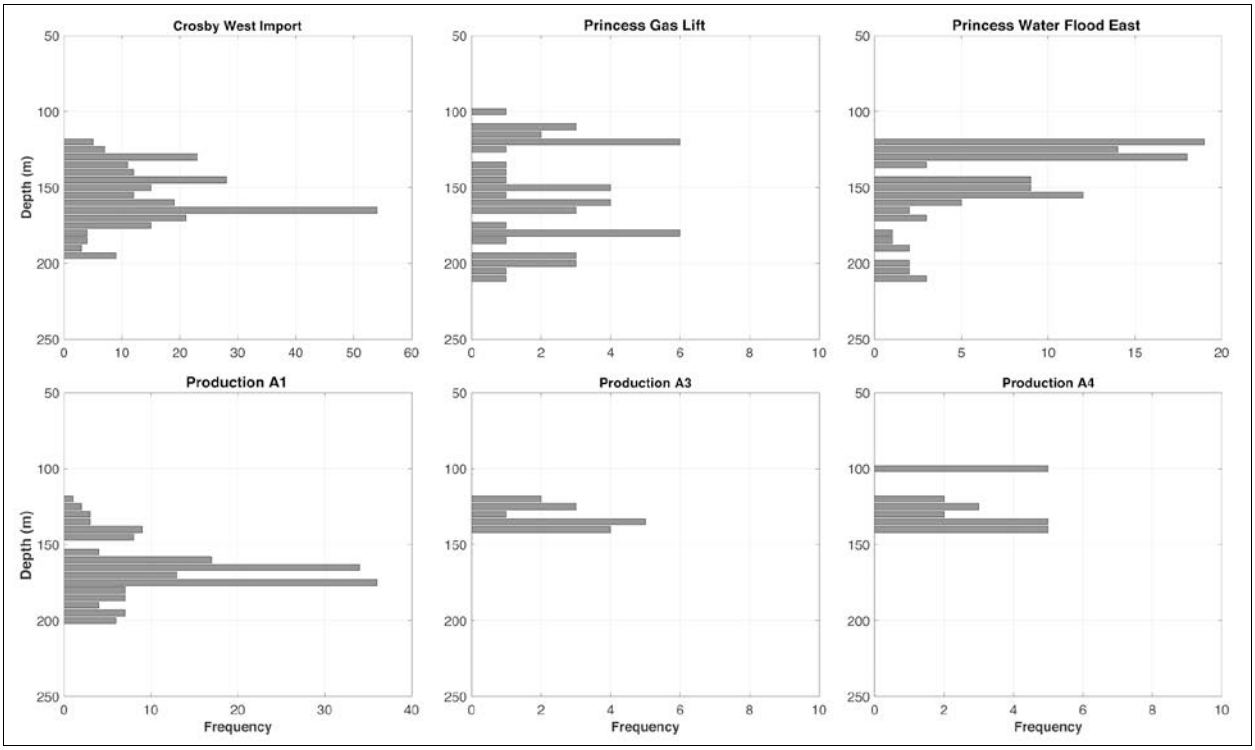


Figure 12. Vertical distribution patterns of juvenile Caribbean moonfish on six risers below Shell's Ursa platform in August 2018.

4.2.2 Coldwater Coral *Lophelia pertusa*

Lophelia pertusa is a coldwater coral that occurs throughout the North Atlantic (Davies et al. 2008) and extends into the Gulf of Mexico where conditions are favorable (Schroeder 2007). Within the Gulf of Mexico it is found on hard structures including hydrocarbon extraction structures (Larcom et al. 2014).

Routine ROV inspection videos archived by Shell Oil were used to document the distribution of *L. pertusa* colonies on various risers connecting subsea wells or pipelines with surface facilities at Shell production facilities (Mars MC807A, Ursa MC809A) in the Northern Gulf of Mexico. The risers are conduits for hydrocarbons that run vertically between the seabed and the surface. ROVs collect video of the risers by ascending or descending in close proximity to the riser while facing them and recording video. The external diameters of the production risers extending from the wells are 24.4 cm.

At MC807A, we used all available well riser surveys from October 2013 that contained abundant *L. pertusa* growth, were complete, and were free from playback problems. A series of videos from 2013 collected at 14 wells (Table 37) met these criteria. Videos were downloaded from an archival site in MPEG-4 format. Although the original videos were recorded at (1980 x 1080 pixels) resolution using Oceaneering's OceanPro system, the archived videos from 2013 were stored at reduced resolution (320 x 240 pixels). Each video is identified by the date it was recorded and is associated with a specific facility and riser. We used the most recent inspection video available, unless there was evidence that the riser had been cleaned, in which case, we used the most recent video containing undisturbed coral growth. The local time (hh:mm:ss), depth (feet), and location (easting and northing when available) were obtained from the video overlay. Downloaded videos were visually processed using MPEG Streamclip software on a Mac computer.

Table 22. Locations, Depths, Survey Dates And Construction Dates of 14 Well Risers

These risers, which extend 897 m below Mars (MC807A), were examined for *Lophelia pertusa* vertical distributions.

Riser	Easting (m)	Northing (m)	Survey Date (mm/dd/yy)	Riser Installed	Number of Colonies
Well A1	281756.53	3117786.80	10/02/13	2005	461
Well A2	281739.48	3117812.95	10/01/13	2004	424
Well A4	281754.41	3117802.99	10/08/13	2004	419
Well A5	281747.16	3117809.76	10/01/13	2004	341
Well A6	281752.86	3117807.41	10/01/13	2004	391
Well A7	281760.20	3117805.05	10/01/13	2004	110
Well A10	281761.36	3117800.46	10/08/13	2005	329
Well A12	281744.32	3117802.67	10/01/13	2005	366
Well A15	281739.12	3117801.02	10/01/13	2005	324
Well A17	281751.86	3117796.26	10/02/13	2005	309
Well A18	281759.13	3117793.71	10/02/13	2005	120
Well A21	281747.76	3117793.76	10/02/13	2005	338
Well A22	281754.89	3117791.16	10/02/13	2005	326
Well A24	281749.84	3117789.50	10/02/13	2005	171

In 2013, two metrics of *L. pertusa* abundance were estimated: number of colonies and percent cover. In the case of the former, when *L. pertusa* colonies were observed, a frame grab (PNG format) was saved for each colony (Fig. 13) using a filename that identified the location, date, time, and depth of the observation. For each riser inspection (Table 37) the resultant filenames were read into Matlab and the depths were parsed out. The water column was then separated into 10 m vertical bins and the frequency of colonies was estimated for each bin using the interp1 function in Matlab. The mean distribution pattern at each site was estimated by averaging the colony abundances in each 10 m vertical bin across all risers at each site. For percent cover, the amount of coral covering the riser was estimated from frame grabs collected at 10 m depth intervals. First area of the riser (sum of pixels) was estimated from a parallelogram bounding the top, bottom, and edges of the riser using Adobe Photoshop®. Then the area of *L. pertusa* colonies covering the riser within its boundary (sum of pixels) was divided by the riser area.

Lophelia pertusa distributions were also evaluated below Shell's Ursa platform based on inspections conducted in 2018. The risers and tendons selected for examination were: Crosby West Import; Production Riser A6; and tendons T1, T5, and T10. Only colony abundance was estimated from these videos, which were obtained in full HD (1080i) resolution. Because of the very different abundances of colonies on these structures, each histogram was converted to percentages of the total before averaging to estimate the mean distribution pattern.

In 2013 at Mars, *Lophelia pertusa* colonies were observed within a 443.5 m vertical zone extending between 280.1–723.6 m (Fig. 14). The maximum colony abundance of 48 $10m^{-1}$ was observed on well A2 at 490m. The mean colony abundance estimated over all 14 wells was approximately normally distributed with a maximum of 27.4 $10m^{-1}$ (95% confidences on the mean = 22.0–32.9), which also co-occurred with the modal colony density at a depth of 490 m (Fig. 14). Most wells had similar colony abundances although three wells: A7, A18, and A24, had lower colony abundances albeit with similar vertical distribution patterns (Fig. 14).

The pattern of percentage coverage by *L. pertusa* (Fig. 15) in 2013 below Mars was generally similar to the colony abundance (Fig. 14). The percentage of the visible half of the riser that was covered by *L. pertusa* ranged from 0–87.6% (Well A4) with an overall mean coverage (between 250–650 m) of 6.4%. The mean coverage distribution was approximately Gaussian reaching a maximum of 30.2% (95% C.I. = 17.2–43.2%; Fig. 15).

The 2018 videos below Ursa indicated a generally similar vertical distribution pattern to those observed below Mars in 2013. The exception was the Crosby West Import riser which had an irregular pattern (Fig. 16). The remaining riser and tendons indicated a Gaussian distribution that was generally confined to the zone between 300–750 m. Abundances were generally higher on the tendons (possibly due to their larger diameter and therefore greater surface area) than on the risers. The maximum colony abundance (116 colonies $10m^{-1}$) was observed on tendon T1 at 530 m. The overall maximum abundance based on the average distribution (Fig. 16) occurred at 520 m depth (Fig. 16).

Figure 13. Example frame grabs of *Lophelia pertusa* colonies on risers below the Mars platform.

Lophelia pertusa has been reported in many locations in the Northern Gulf of Mexico. Its presence was first reported by Moore and Bullis (1960) who identified a large reef at a depth of 420.6–512.1 m, that was approximately 1219 m in length with variable, but undefined width. Schroeder (2002) reported a *L. pertusa* reef in the Viosca Knoll lease block on an authigenic carbonate mound at a depth of approximately 434 m. Reed et al. (2006) noted that high relief *L. pertusa* reefs occurred within the 490–550 m zone of the Blake Plateau off the Georgia coast and at 500 m off the West Florida escarpment. Cordes et al. (2008) reported *L. pertusa* at 4 sites in the Northern Gulf of Mexico where the species occurred at depths ranging from 313–525 m. Larcom et al. (2014) examined *L. pertusa* distributions on oil and gas structures and three shipwrecks in the Northern Gulf. Their study included only one structure (a riser) that extended throughout the water column. They found *L. pertusa* distributed between 201–801 m, a similar but slightly broader distribution than what we observed below the Mars platform. The depth zone 503–518 m contained the highest density of *L. pertusa*, which is slightly deeper than our observed

maximum below Mars located at 490 m but generally consistent with the depth zone where we found abundant coral. The factors that appear to be responsible for *L. pertusa* include: suitable substrate; topography; hydrographic conditions; and food availability (Mortensen et al. 2001). Two or more of these factors may be correlated.

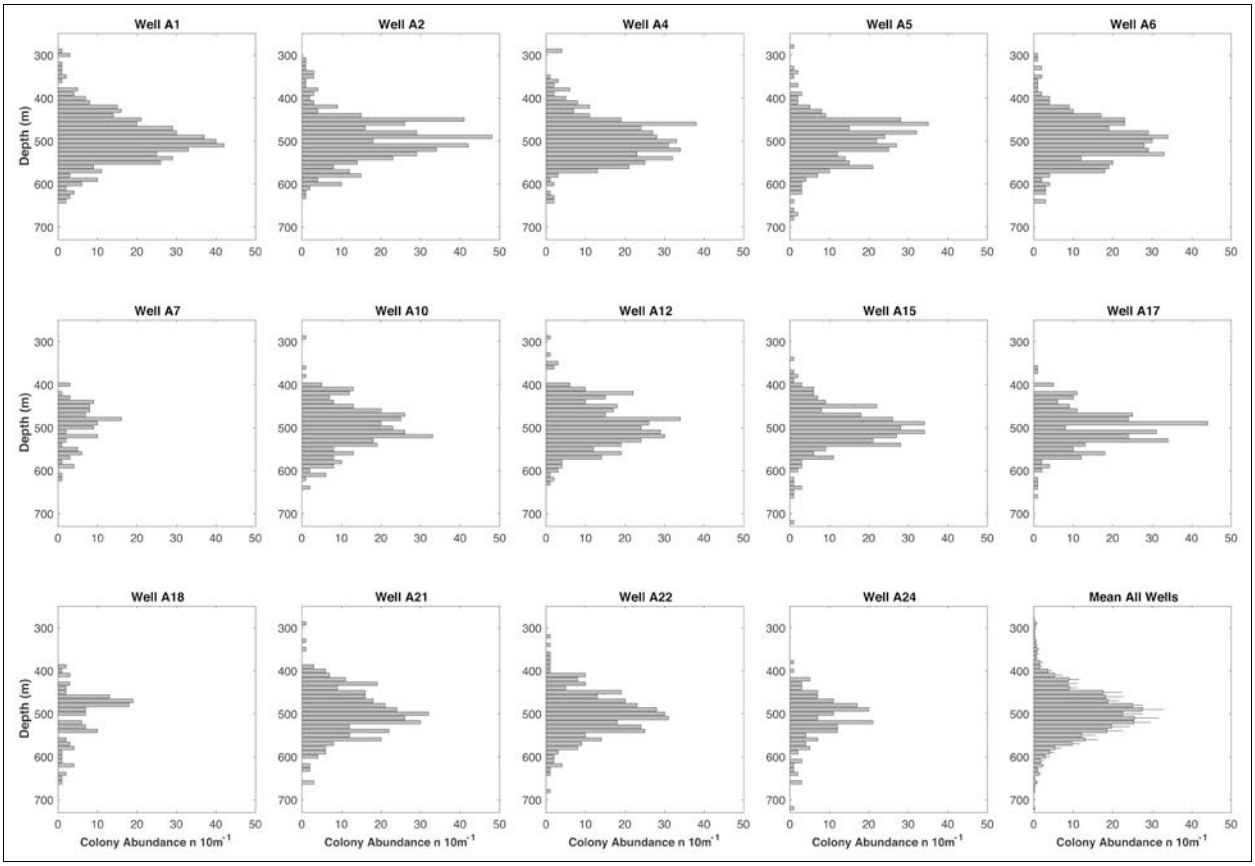


Figure 14. *Lophelia pertusa* colony abundance on risers below Shell's Mars platform in October 2013.

Though we did not attempt to measure the sizes of all individual colonies, it was notable that the size of colonies did not appear to increase from the edges of the vertical distribution towards the depth of maximum abundance. In many cases, the sizes of individual colonies near the edges of its vertical range were frequently quite large (Fig. 17).

One of the primary values of using these inspection surveys is that they provide a picture of the ideal settlement pattern of *L. pertusa* and other sessile organisms given uniform hard structure that extends throughout the water column. NOAA has produced habitat suitability index models that predict where cold water corals may occur in the Gulf of Mexico. These models appear to be driven primarily by temperature and depth. The recent release by BOEM of 3-D seismic amplitude data[3] and high-resolution bathymetry[4] collected by the oil and gas industry has the potential to allow identification of areas that fall within the depth zone favorable for *L. pertusa*. If combined with side-scan sonar to identify hard surfaces,

[3] See https://www.boem.gov/oil-gas-energy/mapping-and-data/map-gallery/seismic-water-bottom-anomalies-map-gallery
[4] See https://www.boem.gov/Gulf-of-Mexico-Deepwater -Bathymetry/

then the habitat suitability model could be updated. Combining the presence of hard surfaces with the habitat suitability index model and the *L. pertusa* settlement patterns would enable a much better predictive capability for where this species will likely occur.

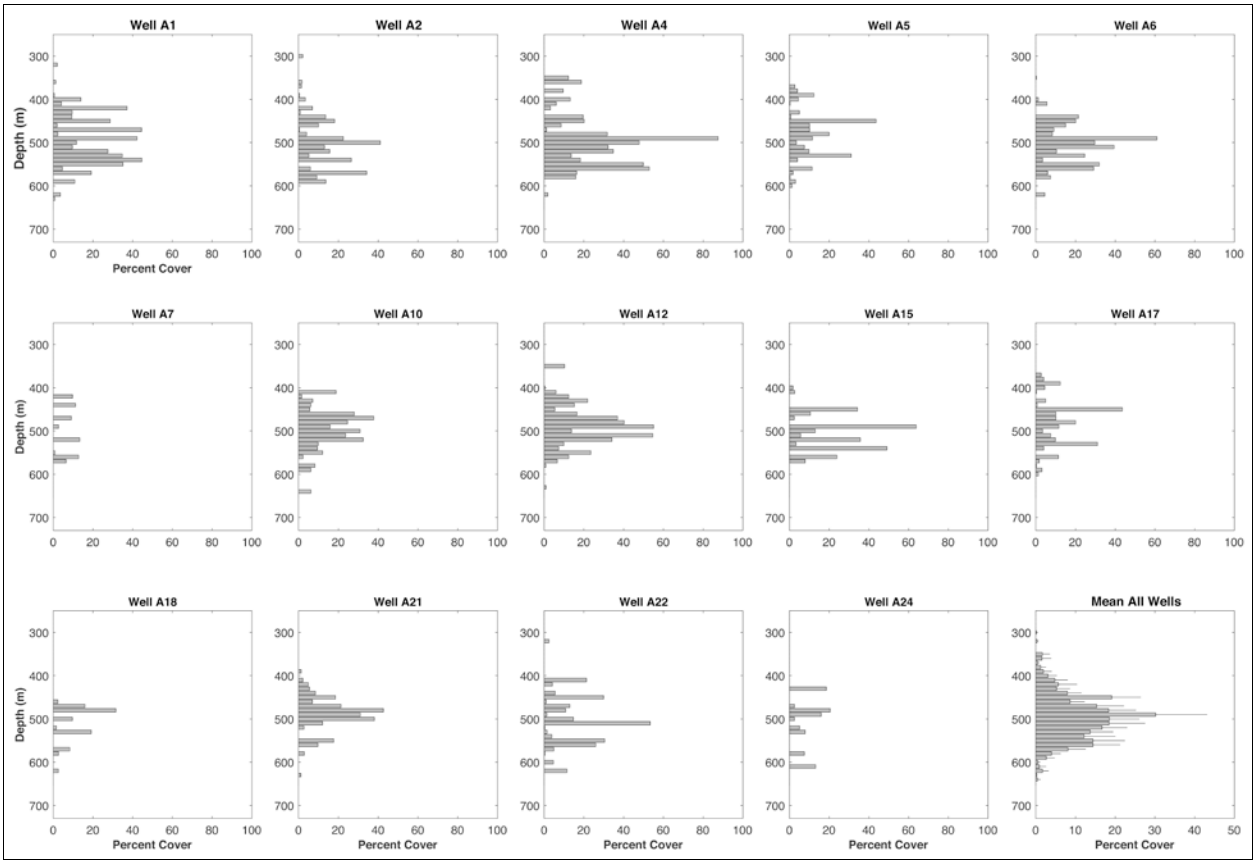


Figure 15. Percent coverage of risers below Shell's Mars platform by *Lophelia pertusa* in October 2013.

There are challenges associated with the surveys that will require coordination with the operator of the structure to reduce them. Risers are cleaned from time to time using an ROV-mounted high-pressure water jet. The frequency varies among locations and depends upon the amount of growth and the frequency of ROV surveys. Unfortunately there is no ready mechanism to determine when areas will be cleaned in advance. This may have been why the distribution on Ursa's Crosby West Import riser in 2018 was so patchy and irregular. Other factors such as strong currents could also dislodge larger *Lophelia* colonies, though this is unlikely to explain the pattern on Crosby West since other structures retained what appeared to be normal distributions.

The abundance estimates are certainly underestimates. The ROV can only observe one side of the circular riser at any time. When colonies growing on the other side protruded beyond the edge of the riser and were visible, they were counted. Colonies usually assumed a spherical geometry which made them easy to delineate and count when they were sparse. Once they grew closer together and the colonies merged, distinguishing one from another was challenging. This also contributed to an underestimate of their numbers.

The definition of a coral reef varies. It may refer to a submerged structure that rises from the seafloor (Wood 1999). Davies et al. (2008) defined *L. pertusa* reefs as biogenic structures that alter sediment

deposition, provide habitat structure, and are subject to both growth and bioerosion. The *L. pertusa* stands growing on petroleum risers are a unique example of a kind of midwater reef, isolated from the seabed, with limited relief extending away from the riser, and possessing few of the megafauna associated with traditional reefs. The only obvious inhabitants of the colonies that were observed with any regularity were squat lobsters likely belonging to the genus *Umunida* sp.

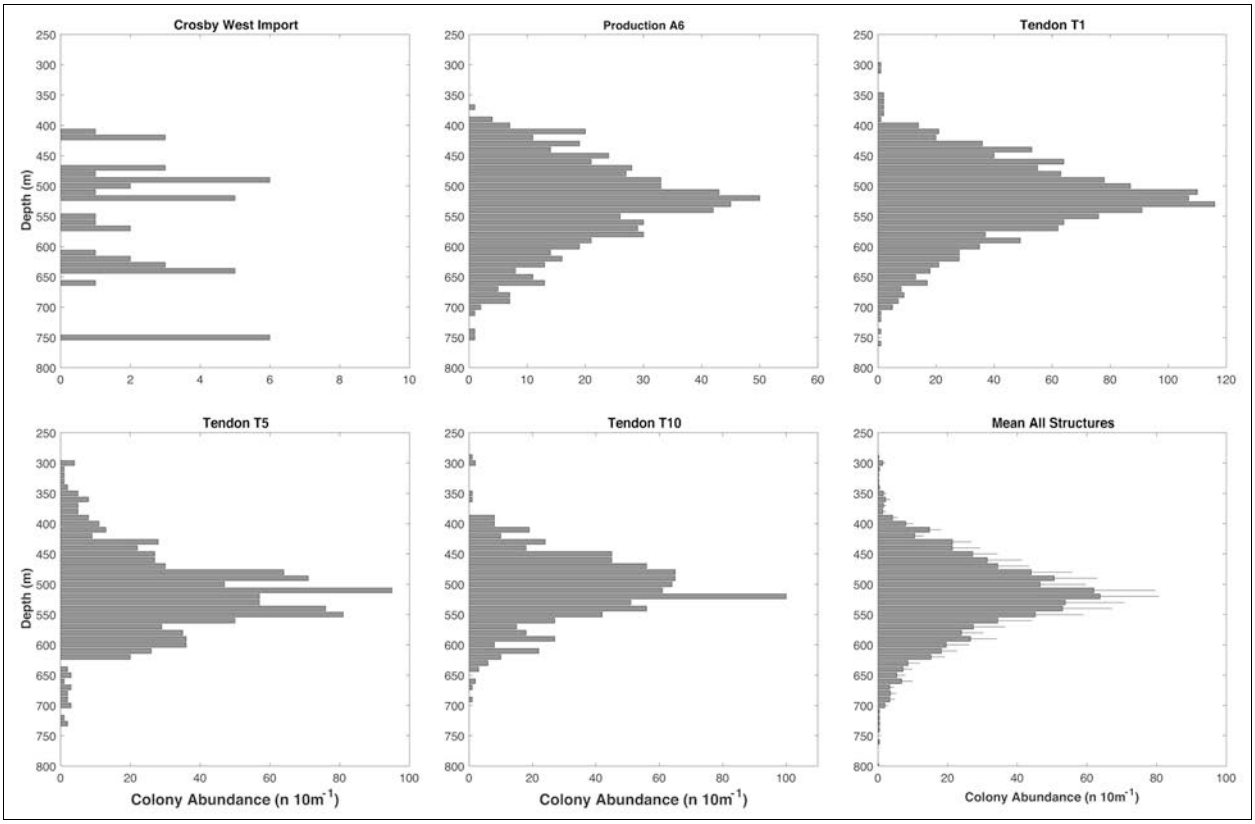


Figure 16. Vertical distribution of *Lophelia pertusa* colonies below Shell's Ursa platform in December 2018.

Error bars in the lower right panel are 1 standard error on the mean.

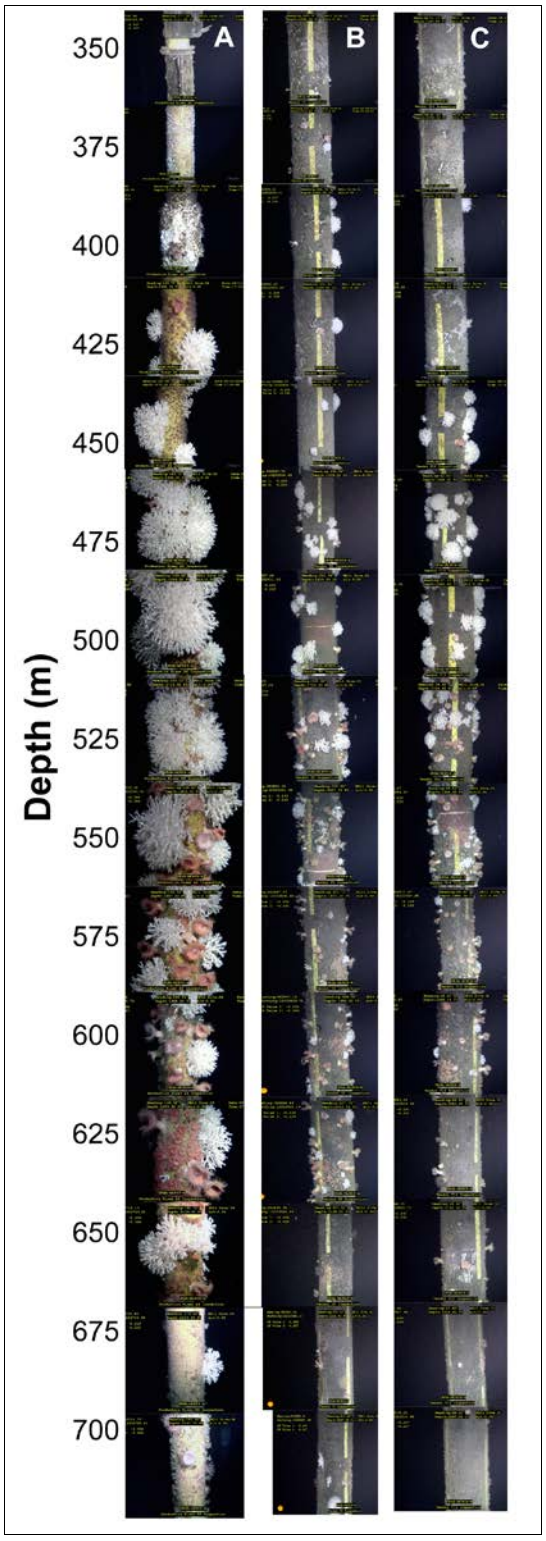


Figure 17. Examples of *Lophelia pertusa* colonies on risers and tendons below Shell's Ursa platform in 2018.
A: Production Riser A6; B: Tendon T5; C: Tendon T10.

4.2.1 Deepwater Soft Coral *Anthomastus* sp.

The mushroom coral *Anthomastus* sp. is a member of the family Alcyoniidae (true soft corals) that occurs on hard surfaces in the Gulf of Mexico and elsewhere. Frequent observations (Fig. 18) of this species on the deepest sections of risers during inspections suggested it was sufficiently common on some systems to be suitable for an estimation of its vertical distribution pattern. Risers from Ursa (MC809A) were selected for analysis because the depth of this site was sufficient to encompass the vertical distribution of *Anthomastus* sp. Risers used for the analysis were: Crosby West Import and Production Risers A3, A4, A5, A6, and A7. These inspections were conducted on August 13–14, 2018 by an iTech7 ROV.

Extraction of images and filename conventions followed the same approach as described for the previous taxa. Coral colonies were binned into 5 m depth bins in an attempt to better resolve their vertical distribution because they had a narrower distributional range than a species such as *Lophelia pertusa*.

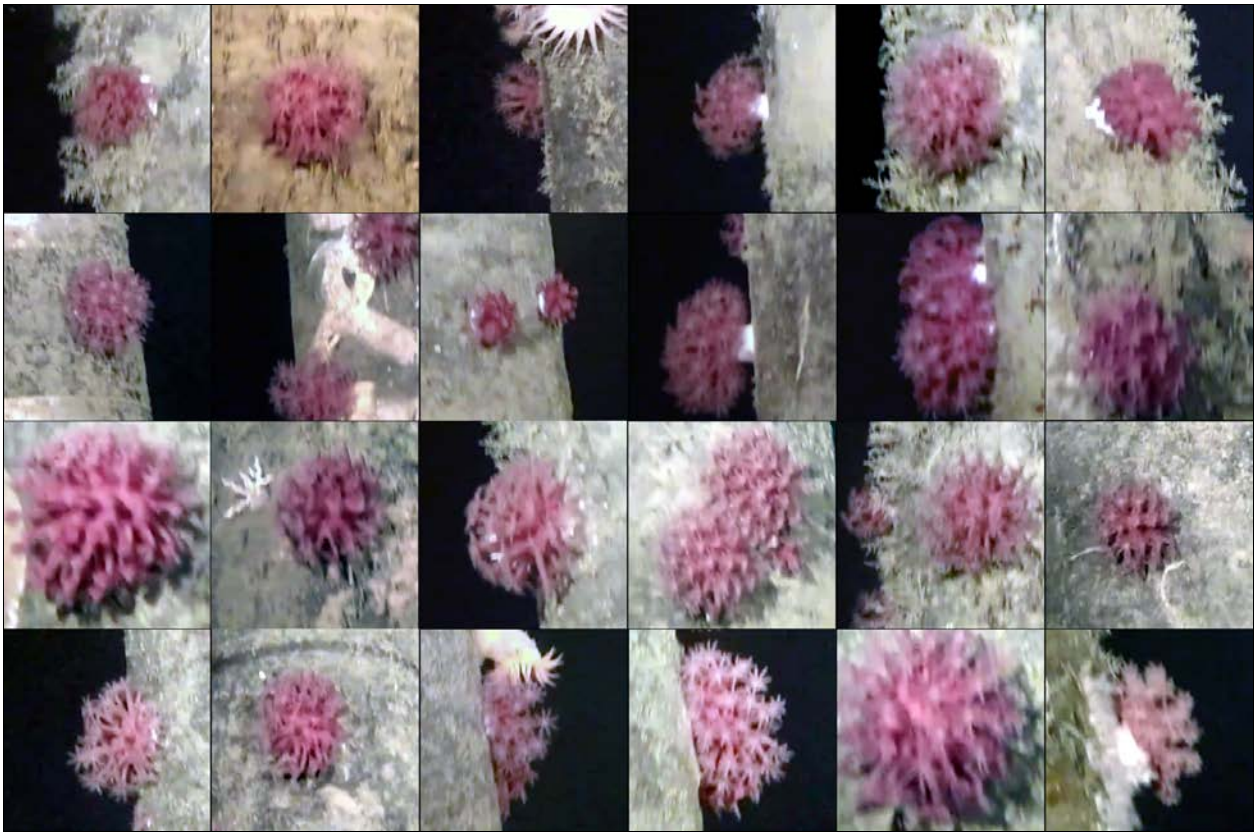


Figure 18. Images of the deepwater soft coral *Anthomastus* sp. imaged during an inspection of the Crosby West Import riser at MC809A.

The abundances of *Anthomastus* sp. varied among the surveyed risers from 14 (A4) to 135 (Crosby West Import) with a mean of 62.8 colonies per riser. Colonies occurred between 781.8 m and 1111.6 m. The bottom depth at Ursa was 1159 m indicating that *Anthomastus* sp. has a distribution that extends to within ~50 m above the seabed. The distribution patterns (Fig. 19) among risers generally indicated a Gaussian distribution skewed towards the seafloor with mean depths of 1061 m (Crosby West Import), 983 m (A3), 1013 (A4), 975 m (A5), 1054 (A6), and 1026 m (A7). The overall mean colony depth was 1035 m; however, the mean distribution pattern (Fig. 20) suggested the peak density could be slightly deeper, based on a mode at 1086 m.

Anthomastus sp. was not observed at Auger (GB426A) or Mars (MC807A). The depths of these sites were 868.1 m and 715.7 m, respectively. The absence of *Anthomastus* sp. from Mars is not unexpected, given that the shallowest colony observed below Ursa was deeper than the maximum depth at this site. Auger was deeper than the shallowest observations at Ursa; however, the degree of sedimentation or possibly the absence of a sufficiently large population in the vicinity reduces the likelihood of recruitment to that site. Olympus (MC807B) with a bottom depth of 925 m was within the expected zone where *Anthomastus* sp. colonies could be expected. No colonies were observed between 715 m and the bottom. The relative youth of the risers in that location may explain this species' absence. Olympus produced first oil in 2014 and the risers show little evidence of colonization and growth by any species except small hydroids.

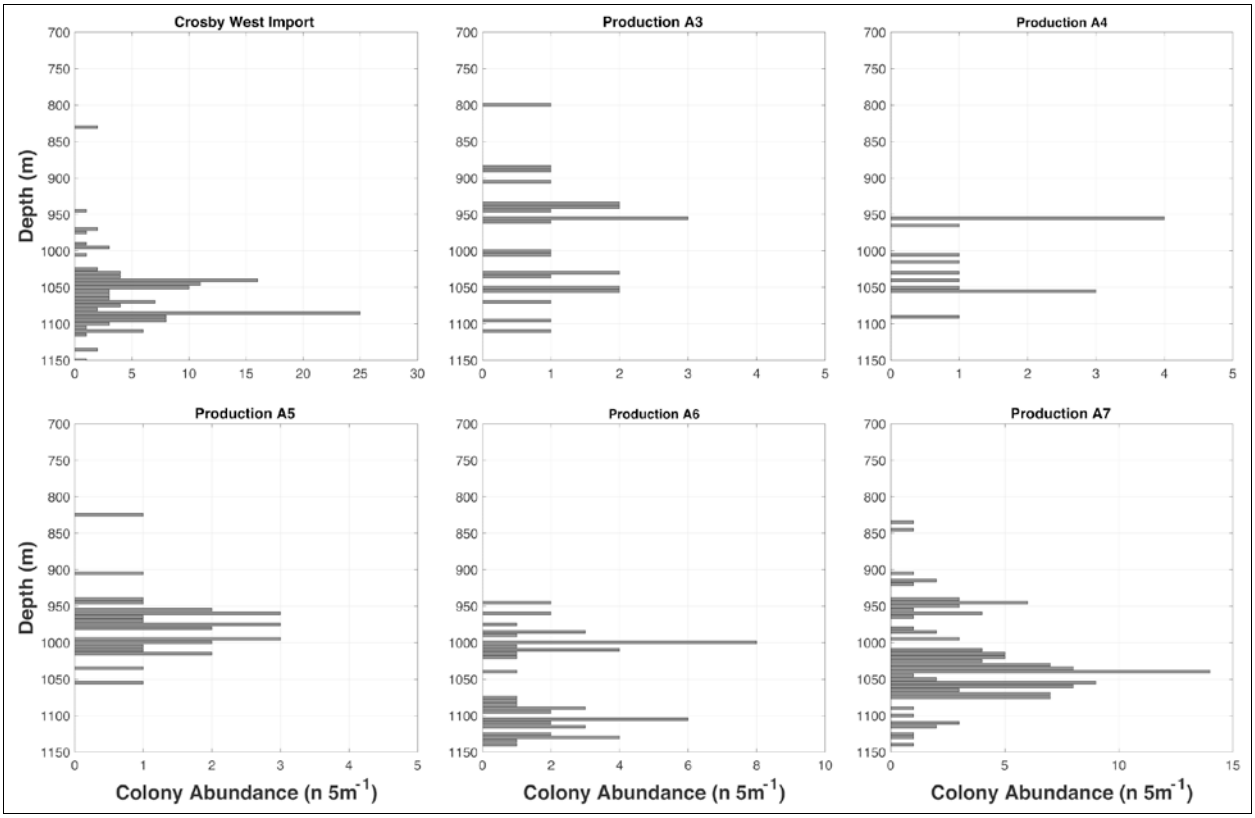


Figure 19. Distributions of *Anthomastus* sp. colonies on six risers below Shell's Ursa platform in 2018.

The absence of *Anthomastus* sp. from the zone within ~50 m of the seabed may reflect temperature or currents that are unfavorable. Another possibility is that there is too much sedimentation within that zone to allow the survival of new recruits. Some of the risers at Mars slant away from vertical and approach the seabed at a shallow angle. Heavy accumulations of sediment were evident on the tops of the risers near the seabed indicating heavy sedimentation rates.

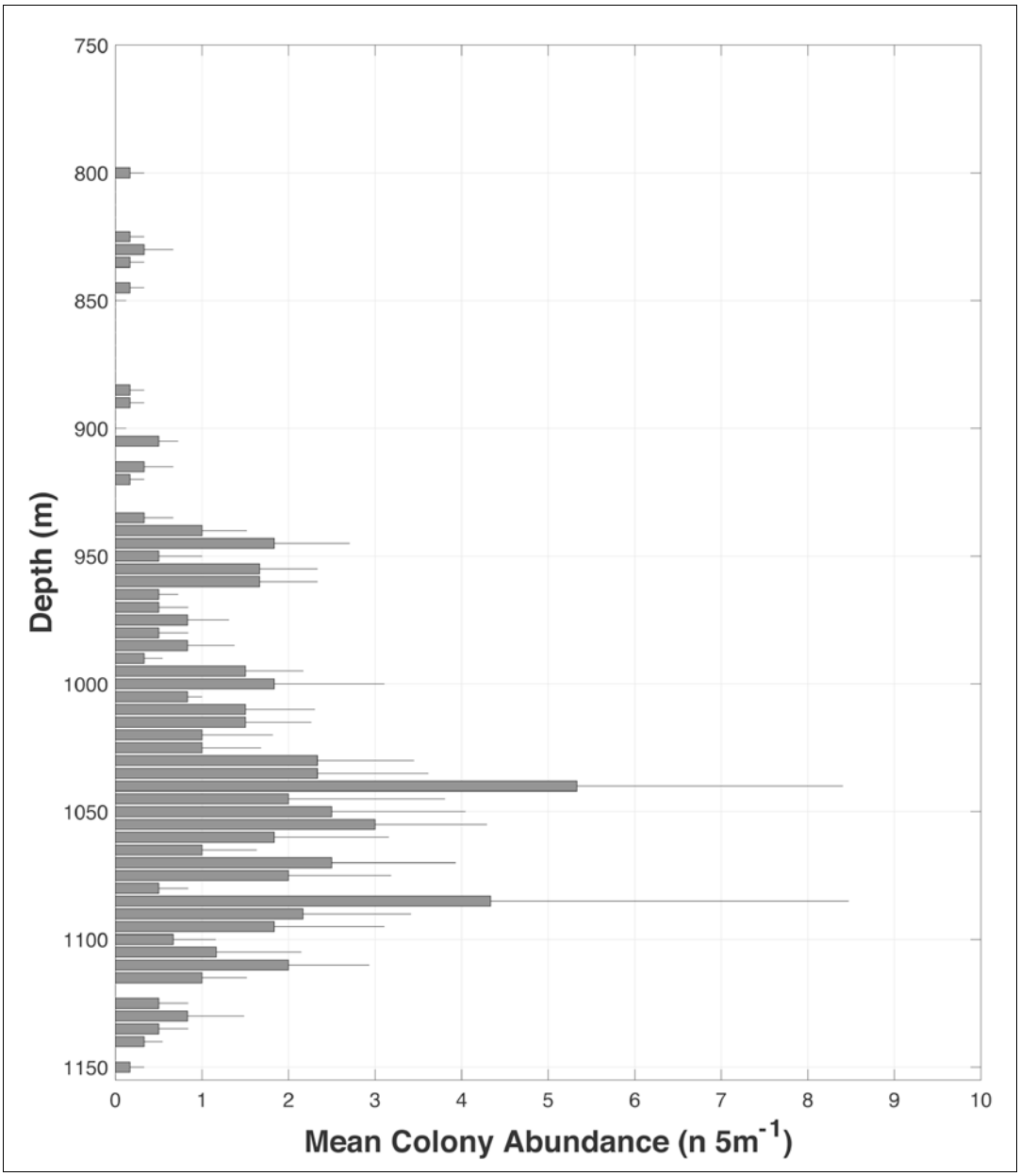


Figure 20. Average vertical distribution pattern of *Anthomastus* colonies for the six Ursa risers.

4.2.2 Other Potential Candidate Organisms for Assessment

The risers, subsea equipment, and surface structures of deepwater production facilities are colonized and used as habitat by in incredibly diverse group of organisms. There is a need for an inventory of biodiversity on these structures. Understanding the depth ranges of as many of these taxa as possible has several values. First, a clear picture of their depth distributions will inform models that predict where species occur. Second, many of these sessile organisms have the potential to serve as sentinels in the event of another oil spill. The sensitivity of corals to oil from the *Deepwater Horizon* spill (White et al. 2012) supports the use of corals as indicators of adverse impacts. Creation of a database showing where different coral species occur would enable these sites to be monitored in the event of a spill. Because of the density of oil and gas facilities in the deepwater region of the Northern Gulf of Mexico, such a

network might allow a clearer picture of the spatial extent of injury to be obtained in a more efficient manner than simply searching the seafloor for signs of damaged coral. Third, understanding where different organisms occur on artificial structures will assist in the siting of deepwater artificial reefs. By ensuring that new reefs are created down-current from existing populations on both natural and artificial substrates, the likelihood of successful recruitment can be increased.

4.2.2.1 Coldwater Corals

A variety of coldwater corals grow on deepwater risers (Fig. 21). Diversity generally increases with depth below the *Lophelia pertusa* zone although densities may be sparse. The latter factor will likely require surveys of multiple risers to assemble a composite picture of their distributions. The taxonomy of these cnidarians can often require a sample; however, collection of reference material by ROVs would be a simple value-added task for vehicles that already have manipulator arms and could be equipped with collection chambers.

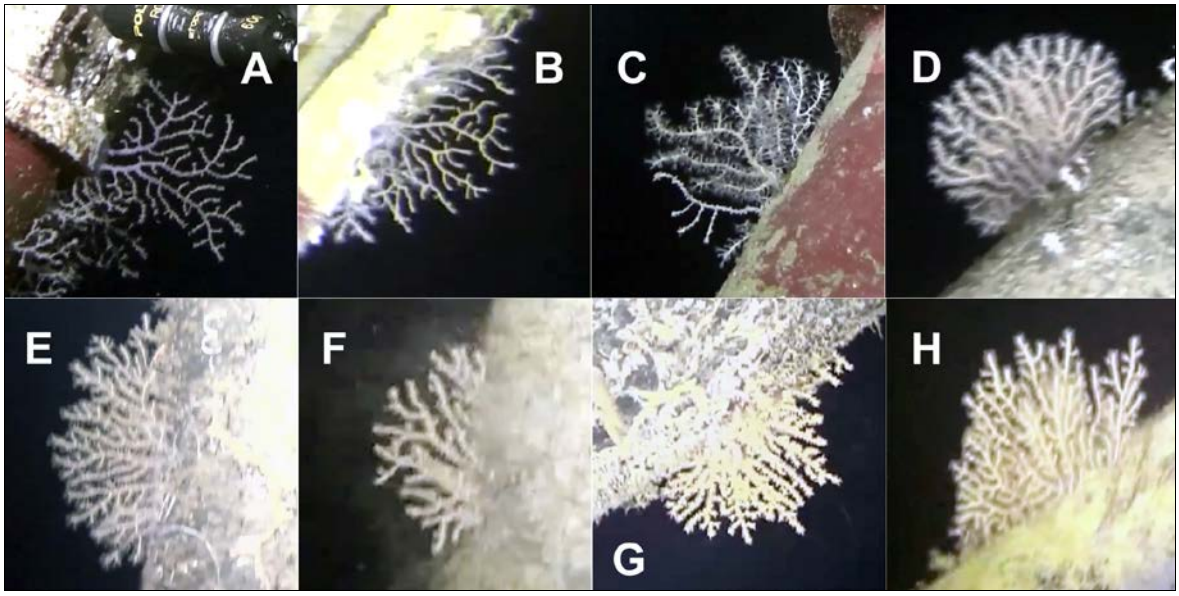


Figure 21. Examples of coldwater corals on risers below Shell's Auger (GB426A) platform.
These all appear to be octocorals that are members of the family Plexauridae; however, identifications to species are challenging given the limited resolution of the images. Depths are A: (759 m); B: (826 m); C: (828 m); D: (850 m); E: (747 m); F: (806 m); G: (863 m); H: (858 m).

4.2.2.2 Brisingid Sea Stars

Brisingid sea stars (family Brisingidae) are suspension feeders that attach to hard surfaces. They are generally present on risers (Fig. 22) though they are not highly abundant. Relatively little is known about their spatial distribution in the Gulf of Mexico. Like coldwater corals, they may have the potential to serve as indicators of environmental stress. ROVs have been used elsewhere to document their presence (Campos et al. 2010) and are the only feasible means of documenting these sea stars given their depth range.

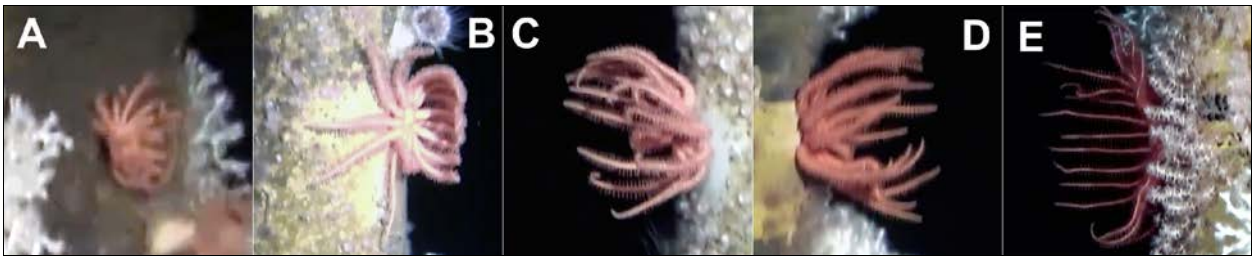


Figure 22. Examples of brisingid sea stars on risers and tendons below Shell's Ursa platform.
A–D appear to belong to the genus *Novodinia*. Depths: A: 497 m; B: 385 m; C: 387 m; D: 411 m; E: 544 m.

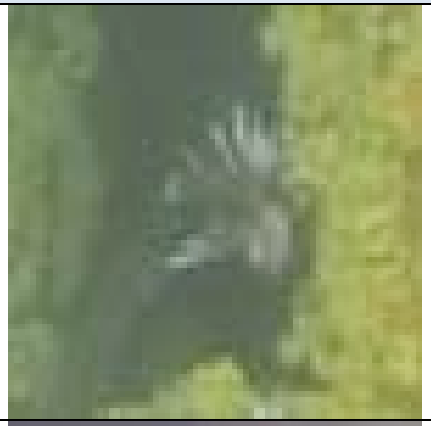
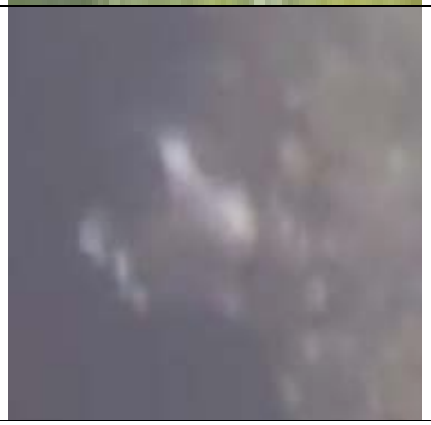
4.2.2.3 Lionfish

Lionfish (*Pterois* sp.) are invasive members of the family Scorpaenidae that are endemic to the tropical Indo-Pacific. Since their release into the South Atlantic, they have spread through the Caribbean and Gulf of Mexico. Two species are present: *Pterois volitans* and *P. miles*; however, they are morphologically similar and difficult to distinguish based on images. Lionfish are highly effective predators and pose a potentially serious threat to native fishes. Their depth distribution extends from the surface to at least 112 m (Nuttall et al. 2014). ROVs have reported the presence of lionfish during routine operations (Fig. 23) and the network of ROVs operating in deepwater provides a useful monitoring capability to document any changes in abundance or range extensions. The USGS maintains a sighting submission page for lionfish[5].

During examination of ROV inspection videos from all sites, care was taken to locate and document lionfish. Lionfish are very cryptic and many were missed during initial video inspections. Though they may not be abundant, they are certainly present in the oceanic region of the Northern Gulf of Mexico. One potential observation of a lionfish occurred at the Ursa platform. Only one set of pectoral fin rays was visible in the image. A reexamination of videos documented 13 individuals (Table 23), primarily at Ursa but also at other facilities. The average observation depth was 29.3 m. Monitoring of inspection videos for lionfish is one of the few time-series available to detect their presence and potential spread into the deepwater region.

[5] See https://nas.er/usgs.gov/sightingreport.aspx

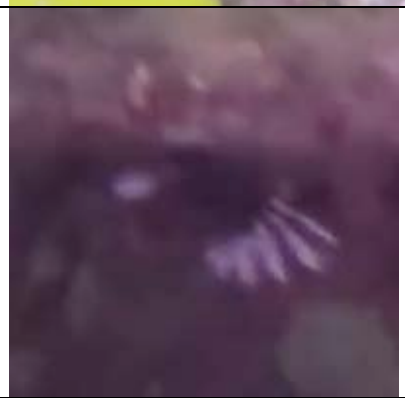
Table 23. Locations of Lionfish *Pterois* sp. Observed by ROVs

Date	Depth (m)	Facility	Easting	Northing	Image
08/09/16	49.4	Unknown	783853.2	Bad value	
09/29/17	81.7	GB172	599650.1	3079737.9	

Date	Depth (m)	Facility	Easting	Northing	Image
05/27/18	23.7	SS241A	638883.4	Bad value	
07/26/18	20.7	MC807B	280161.9	3116797.1	

Date	Depth (m)	Facility	Easting	Northing	Image
07/28/18	24.1	MC807B	282609.6	3113102.1	

Date	Depth (m)	Facility	Easting	Northing	Image
07/28/18	23.4	MC807B	299441.1	3141834.0	

Date	Depth (m)	Facility	Easting	Northing	Image
07/28/18	23.3	MC807B	299441.2	3141834.0	
07/28/18	20.8	MC807B	280105.1	3116808.9	

Date	Depth (m)	Facility	Easting	Northing	Image
08/06/18	18.8	MC807B	280094.4	3116782.1	
08/06/18	19.2	MC807B	280103.2	3116797.1	
08/06/18	26.2	MC807B	280098.6	3116804.3	

Date	Depth (m)	Facility	Easting	Northing	Image
04/12/18	22.5	GB426	554943.0	3046938.4	

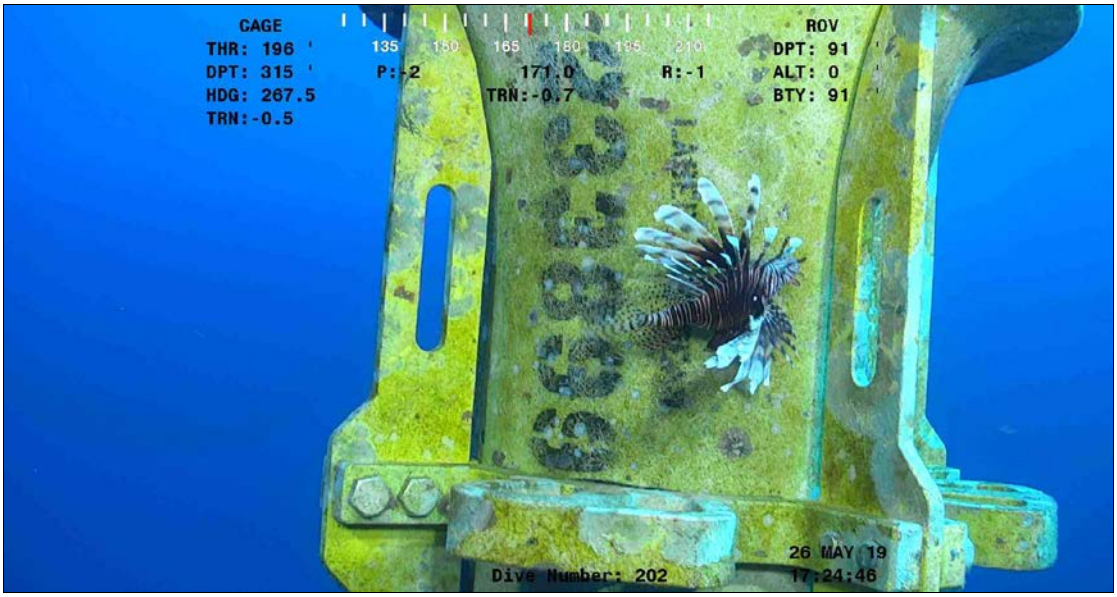


Figure 23. A lionfish observed by an industrial ROV operating in Walker Ridge 29 during May 2019.

4.2.2.4 Orange Cup Coral *Tubastrea coccinia*

The orange cup coral *Tubastrea coccinia* is an invasive anthozoan that colonizes hard structure (Fig. 24). The orange cup coral has spread throughout the Northern Gulf of Mexico and is particularly prevalent on hydrocarbon extraction structures (Fenner 2001; Sammarco et al. 2004). During decommissioning, one option is to convert structures into artificial reefs. The depths at which reefing is conducted will have an impact on the survival and growth of both existing and newly recruited *T. coccinia*. Information on the vertical distribution patterns of this species gained from ROV inspection videos can inform site selection for decommissioning to ensure that subsequent survival and growth of this invasive species is reduced.

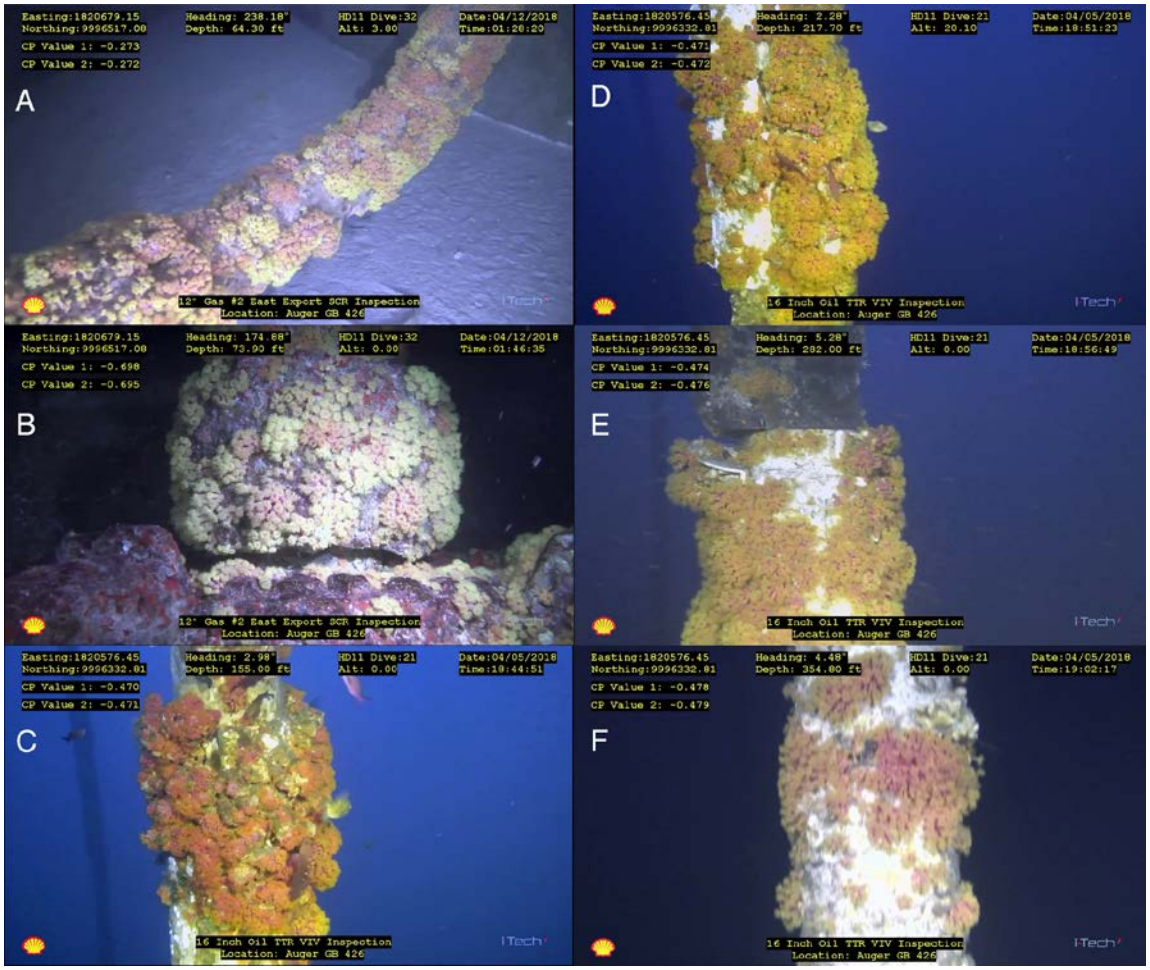


Figure 24. Orange cup coral *Tubastrea coccinia* at different depths on various Auger platform (GB426) structures during a 2018 survey.
A: 19.6 m; B: 24.2 m; C: 47.2 m; D: 66.4 m; E: 86.0 m; and F: 108.1 m.

Estimation of the vertical distribution of *T. coccinia* is challenging because of its density and the fact that it is frequently interspersed among other organisms that are of similar color or shape. Moreover, since it often forms a dense covering over risers, it becomes difficult to determine the actual boundary of the riser beneath the cup coral. This makes it difficult to estimate the area underneath the coral that is being covered by the coral.

Orange cup coral was observed on every deepwater structure for which inspection videos were obtained. In general it is abundant down to approximately 91 m (300 feet) and then its abundance diminishes rapidly until it disappears between 91–122 m. A simple approach to determine the lower boundary of the zone in which it is abundant is to measure the greatest depth at which it occurs as dense aggregations of polyps (rather than as isolated polyps). Results for this method are shown for the Mars platform based on October 2018 surveys (Fig. 25). The maximum depths that small aggregations of polyps were observed on 18 different risers were very consistent with a mean depth of 118 m (standard error = 1.8 m, range of 97–123 m). Measurements of orange cup coral maximum depths need to be undertaken at other locations to confirm the generality of the findings from Mars; however, when combined with data from other sites, appropriate reefing depths can be established to reduce the probability that orange cup coral will continue to grow on the reefed structure.

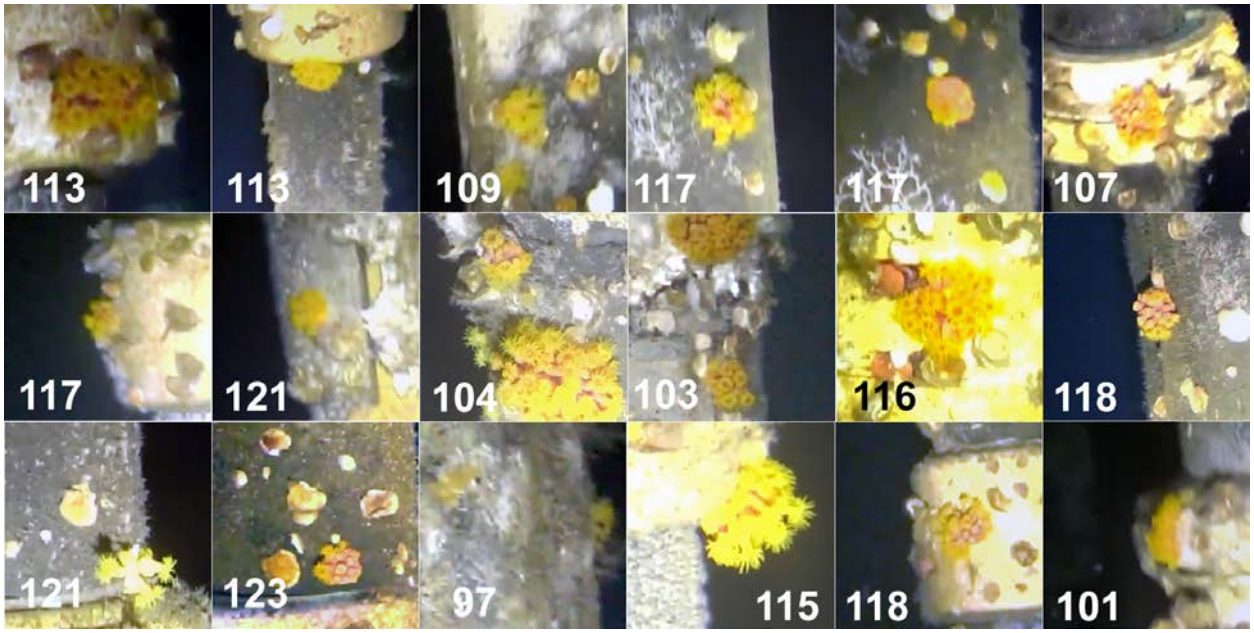


Figure 25. Deepest observations of aggregations of *Tubastrea coccinia* polyps on 18 production risers below Shell's Mars platform.
Numbers indicate the depth of each observation in meters.

4.2.2.5 Flytrap-like Anemones

The flytrap anemone *Actinoscyphia* sp. is a large anthozoan predator that occurs on hard substrates as well as on soft sediments (Aldred et al. 1979). In the Gulf of Mexico, it is frequently found on hard substrates. Most bilobed anemones growing on hard surfaces are referred to as flytrap anemones and are mistakenly identified as *Actinoscyphia.* Anemones are one of the most abundant organisms on deepwater risers (Fig. 26). The challenge is determining their taxonomy from images. After determining that the anemones in our images likely represented several different genera and were not actually *Actinoscyphia* sp. but more likely members of the family Hormathiidae, determining the vertical distributions was halted. Nonetheless, these predators are conspicuous and represent another potential candidate group for use as sentinel organisms.

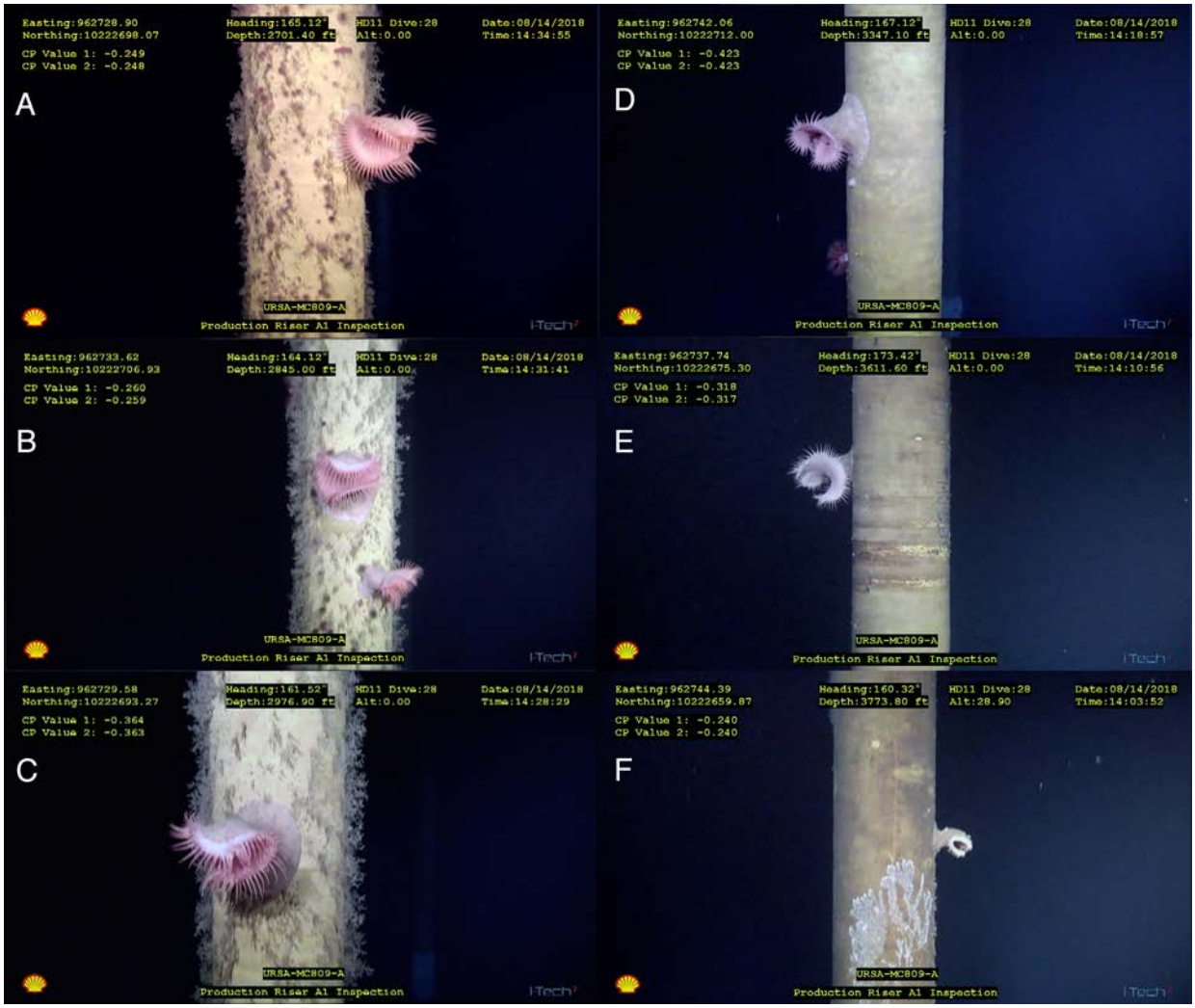


Figure 26. Flytrap-like anemones at different depths on an Ursa platform (MC809) riser during a 2018 survey.

A: 823.4 m; B: 867.2 m; C: 907.4 m; D: 1020.2 m; E: 1100.8 m; and F: 1150.3 m.

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