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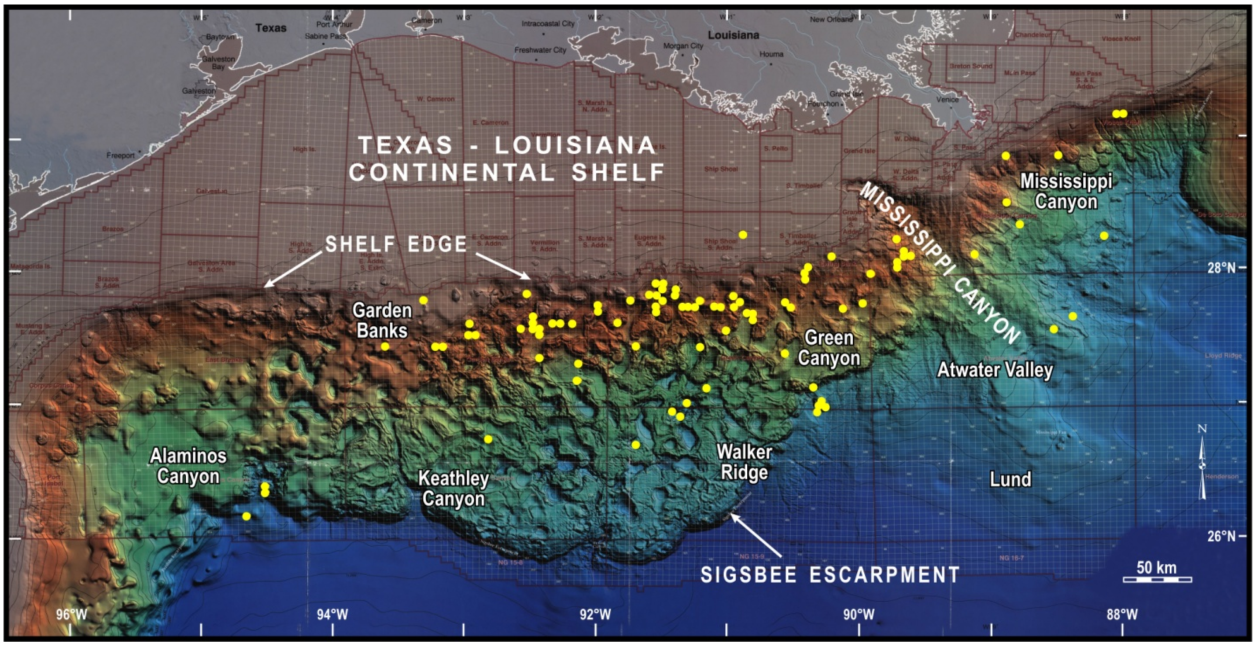
Coastal Marine Institute

Digital Conversion of Dive Video from Fifteen Dive Seasons



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Digital Conversion of Dive Video from Fifteen Dive Seasons

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ABSTRACT

Since the mid-1980s, the Minerals Management Service, now Bureau of Ocean Energy Management, and other national funding agencies have supported studies of natural hydrocarbon seeps on the continental slope of the northern Gulf of Mexico. These investigations used research submersibles to observe and sample the benthic biology and geology of seep sites. A key part of the database generated from these studies is video of the seafloor associated with each site visited. Over the nearly three decades of video collection, several different analog video formats and resolutions were used. The present project was designed to convert these various analog datasets to a common digital format to archive these important datasets and make the data more accessible to users. The video data were archived on DVDs. This archive represents 144 submersible dives from 48 different lease block areas. A total of 3,341 clips of 5 minutes duration each representing a total of 280 hours of bottom time comprise the digital video data archive. Summary statistics for all dives and similar summaries for lease blocks are included as appendices to this report. Seep communities were found in all but four dives, although sparse community development was common.

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ACKNOWLEDGMENTS

This project was designed to convert 15 dive seasons of analog video to a common digital format; it was supported by the Minerals Management Service (MMS, now the Bureau of Ocean Energy Management [BOEM]) under contract number 0104CA32806. The purpose of the project was to archive the dive video database at BOEM in a format that would provide easy access to users. Most of the original data were held at LSU by researchers who had participated in the study of hydrocarbon seeps and seep-related communities over the 15 dive seasons. The authors would like to thank the various agencies that have funded seep-related research since the mid-1980s, particularly MMS. We would also like to express our gratitude to the crews of the various submersibles used to generate the exceptional video record of dive sites visited over the 15 dive seasons. Dr. Greg Boland is gratefully acknowledged for his administrative and funding support of the project and use of his Beta format video player necessary for accessing tapes acquired early in the history of hydrocarbon seep studies in the Gulf of Mexico.

INTRODUCTION

This report accompanies a set of DVD disks formatted to be viewed using a DVD player or a computer with similar functionality and an external drive of video clips stored for viewing directly with a computer. The files on the disks and the drive preserve, in a common format, seafloor video, in multiple formats, that have been archived at Louisiana State University during studies directed primarily at chemosynthetic communities and hydrocarbon seep geology. The scientific results of those studies have been previously published (USDI MMS 1992; Roberts, 2013; MacDonald et al 2002; Brooks et al. 2009). This report provides details on the full process of video digitization, file handling, and DVD authoring in order to facilitate users' access and any future updating of formats and storage medium.

Starting in the mid-1980s, research submersibles became an important technology for investigating benthic biology and seabed geology of the complex northern Gulf of Mexico continental slope. Before this period, high resolution acoustic data and sediment cores collected in preparation for oil and gas activities beyond the shelf edge, identified a complexity of seafloor geology not previously imagined. This geologic complexity derives from a long history of sediment influx from one of the world's great rivers (the Mississippi) and its ancestors in a basin characterized by thick subsurface salt deposits. Given sufficient time, salt deforms plastically in response to sedimentary loading. Thick accumulations of rapidly deposited sediment causes the underlying salt to "flow" away from the epicenter of loading resulting in the formation of thick intraslope basins that are overpressured at depth. This geologic framework, coupled with the presence of abundant deep subsurface source rocks, promotes oil and gas formation at depth; and because of the numerous faults caused by the salt-sediment interaction, many migration pathways for fluids and gases are created. Vertical migration of hydrocarbons into reservoirs at various subsurface depths has made the northern Gulf one of today's most important deep water oil and gas provinces. Many migration routes intersect the seafloor where geopressure and buoyancy forces cause hydrocarbons, formation fluids, and sometimes fluidized sediment to be expelled at the sediment-water interface. These sites of fluid-gas expulsion are also sites of thriving communities of benthic organisms, chemosynthetic communities that live on the chemical products (e.g., hydrogen sulfide and hydrocarbon gases) of hydrocarbon seeps and higher flux rate vents. Hardgrounds are formed at these sites as by-products of microbial oxidation of hydrocarbons. The carbonate forms simultaneously with the establishment of chemosynthetic communities. Resulting hardgrounds also function as substrates for non-chemosynthetic deepwater coral communities.

Although seismic profiles and side-scan sonar images of the seafloor collected in the 1970s and early 1980s indicated a variety of seafloor types, including fluid-gas expulsion features, it wasn't until thriving communities of benthic organisms living on the products of oil and gas seepage were discovered in the Gulf that a detailed "look" at the seabed using research submersibles became critically important. The discovery of gas hydrates and chemosynthetic communities in the northern Gulf initiated a broad range of both site-specific and regional studies focused on the unusual benthic habitats created by both fluid and gas expulsion. The early studies by Childress et al., (1986); Kennicutt et al. (1985), and Brooks et al. (1985, 1987, 1989, and 1990) were both geochemical and biological in scope; study sites were selected from results of coring programs and geohazards data sets acquired before drilling and production activities. Manned submersibles played an important role in collecting site-specific samples (grab samples of organisms and sediment, cores, water samples, etc.) used to characterize these important benthic environments. From 1985 into the early 1990s, numerous studies of the upper continental slope were initiated on a variety of sites where oil and gas were being transported from the deep subsurface to the modern seafloor. These studies ranged from general associations of hydrocarbon seepage and chemosynthetic communities (Kennicutt et al., 1988) to the descriptive biology of chemosynthetic mussels (Fisher et al., 1987) and tube worms (Fisher et al., 1990) to habitat patterns (McDonald et al., 1990; Carney, 1994). At the same time, studies of seafloor lithification as a byproduct of microbial oxidation of hydrocarbons were being conducted throughout the upper slope province (Roberts and Aharon, 1994, Roberts et al., 2010a). More recent geoscience investigations have been focused on the geochemistry of seeps (Rempel and Buffett, 1997; Sassen et al., 1994; Joye et al, 2010) and the use of 3-D seismic technology, for stratigraphic, structural, and surface attribute analysis, to better identify sites of fluid and gas expulsion and the geologic characteristic of these sites (Roberts et al, 2010b). Biological studies have now progressed through descriptive geological and geochemical controls of community structure to the biology of restrictive groups such as microbial communities (Joye et al, 2010), tube worms (Cordes et al, 2007), and mussels (Cordes et al, 2010). Sites of hydrocarbon seepage and their unique benthic communities have now been investigated over the full depth range of the northern Gulf of Mexico's continental slope.

Because the Bureau of Ocean Energy Management (BOEM) is tasked with protecting sensitive benthic communities from impacts of operational activities on the outer continental shelf and continental slope, locating these communities is an important task. Although use of surface attributes, particularly strength of seabed reflectivity (from 3-D seismic data) has been very successful in identifying areas of hard bottom (seep-related carbonate) and gas-filled sediment (Roberts et al, 2010), visual evidence is still considered the best and most irrefutable data. The submersible video database made easily accessible through this project's analog-to-digital conversion of video collected over 15 dive seasons will provide a valuable foundation of observational data for cold seep communities on the northern Gulf of Mexico continental slope. An explanation of video recording formats, procedures of analog-to-digital conversion, and production of archival DVDs follows.

SUBMERSIBLE VIDEO RECORDING

Submersibles and Video Systems Used

The Human Occupied Vehicle *Alvin*

Photographic images, both as 35mm stills and cine, have been an integral part of deep submersible studies since their inception. The dive logs of the Human Occupied Vehicle (HOV) *Alvin*, dive number 1 on June 26, 1964 note the exposure of 50 feet of movie film. On dives 305 and 306 in October 1968 a total of two 400 foot roles were recorded on the upper slope at ~200m depth. The *Alvin* sank two days after those recordings were taken, but once it was in operation again (Dive 309 May 17, 1971), still 35mm photography was the primary image-collecting activity. This form of photography was used through most of that decade, with video "reels" of unspecified format and Video Home System VHS cassettes being noted as dive products only after 1976. These data suggest that consumer video equipment was used in the *Alvin* almost as soon as it came on the market.

During the 60s, 70s, and 80s, dive activities were usually logged onto hand-held audio cassette drives in conjunction with externally-mounted 35mm cameras and hand-held 35mm cameras shooting through observer ports. When good quality video was needed, hand-held 16mm cine cameras were used. A low-light Silicon Intensifier Target (SIT) camera was mounted on the top of the *Alvin* and recorded on consumer-grade VHS cassettes, but it provided very poor quality monochrome images.

The importance of high-quality video was most fully recognized in conjunction with the initial discovery of hydrothermal vents in 1977, but was very important in the initial ecological investigations two years later. Video was a very important part of the 1979 cruise to the Galapagos vent site due to the National Geographic Society's participation and production of a television program. The use of a specially housed new 3-chip Sony® camera and broadcast-quality U-matic® format recording, made it obvious that high-quality video could serve both a research and an outreach purpose. Such cameras and recorders, however, remained optional equipment that had to be provided by the user.

As the quality and utility of video equipment improved, continuously running recorders have become the standard operating procedure for the *Alvin* program, effectively eliminating the use of voice recorders for event logging. The *Alvin* group at Woods Hole Oceanographic Institution has provided open access to video dating back to 1988 through their Frame Grabber website (http://4dgeo.whoi.edu/alvin). *Alvin* Frame-Grabber provides image and environmental data starting with a single dive in 1988. Single images have been extracted from the video at 15 second intervals and displayed at 720x480 pixels.

Human-Occupied Vehicle Johnson Sea Link (JSL)

The Johnson Sea Link (JSL) submersibles I and II came into operation in 1971 and 1975 respectively. , The design of both submersibles placed a high priority on the ability to collect quality imaging, with panoramic acrylic spheres and diver lock out capability.

In the late 70s the JSLs had various handheld cameras in the sphere, starting with a Panasonic camera going to a reel to reel recorder, then a JVC camera and a ½” VHS cassette camcorder deck. Benthos still cameras and strobes were on the submersible from about 1975. Sometime in the early 2000s a Deep Sea Systems digital still camera was added and replaced the Benthos 35 mm film camera. In the early 80s an external video camera was made by Hydro-Vision. There is little available information on the recording format for that camera. One of the Hydro-Vision cameras was a Silicon Intensifier Target (SIT) low light level type and the other was a still with a strobe. They did not stay on the submersible for long.

Sometime in the early 80s, the JSL switched to a camera made by the company Marine Optical Systems (MOS). The first generation was the TVP 3000 camera, which had a through-the-lens still camera built in. This camera had many problems. It was replaced by the MOS VZ11, which was a good camera and had a very good Fuginon zoom lens. Both cameras recorded to Sony® U-matic® tape format. This MOS camera remained in service until 1992. Also in the early to mid-80’s, the cameras were put on pan and tilt systems made by Euro Sub, which are still in service. A Benthos still camera and strobe were employed and outfitted with an 85mm lens and crossed two lasers at the focus point for that camera to allow the pilot to get a perfect 35mm film picture almost all the time.

In 1992, the Harbor Branch Oceanographic Institution purchased a Photo Sea 3000 camera with a Cannon® 6-48 mm zoom lens. In the 1990–1992 timeframe, Harbor Branch switched the record format from U-matic® to straight 8mm, but that format lasted only a short time and the Hi8® format was employed by the next season. In the mid 90s, Digital S recording capability was added, along with the Hi 8® but not many people used it because of the high cost of the cassettes, and because they would need to have access to a Digital S playback unit. In 1999 Harbor Branch upgraded (in house) the Photosea camera to a new camera body which was a Panasonic® AWE 600 (digital 3 chip) with more resolution. This system switched from Hi 8® to Mini DV tape and got rid of the Digital S capability. The upgraded Photosea is still the main camera with MiniDV as the record medium to date.

The Human Occupied Vehicle *Pisces*

A Pisces-class submersible was employed for investigation of seep communities in 1988. It was operated by Research Submersibles Limited, which is no longer in business. The video system employed the same Marine Optical System recording onto U-matic® tape as had been used in the Johnson Sea Link. No additional information is available about the Pisces systems.

Video Formats Used

As part of the video conversion process, the present study had to contend with the full range of advancements seen in consumer video recording. The existing tapes were initially stored in an uncompressed analog signal following the specification of the National Television Standards Committee.

Analog Video and the Origin of Video Resolution

Video cameras and tape drives used in submersibles prior to the digital transition were designed to produce a signal stream compliant with the National Television System Committee standards (NTSC). These standards addressed limitations in vacuum-tube technology, cameras, television sets, broadcast technologies, and human perception. Each still image in a NTSC signal represents approximately 1/30th of a second. In that fraction of a second, the camera produces 525 horizontal scan lines. The image information is contained in only 486 horizontal lines; and this sets a strict limit on the image resolution measured along the vertical axis. The resolution of the analog image measured along the horizontal axis lacks a strict standard. It varies substantially with the quality of the circuit response times of the camera and/or tape drive. A good analog television displaying a broadcast signal had a horizontal resolution of about 330 dots along a line. The U-matic®-SP (Superior Performance) used in early *Johnson Sea Link* and *Pisces* dives could produce this same 330 dots. Therefore these tapes are sometimes referred to as "broadcast quality". Video Home System (VHS) tapes were initially lower quality at only 240 dots, but underwent improvements ending in Super VHS with 420 dots. The Sony® Hi8® format quickly replaced Super VHS in submersible video even though the resolution of the two formats was the same. The 8mm cassette was much smaller and required much less space in the submersible and less electrical power. The Hi8®, format, however, never became a distribution medium for movies, and this limited its wider adoption.

A very important aspect of analog video is that it is a sample of the actual scene; information has been lost. System developers of color television realized that color information (chroma) about a scene did not have to be provided to the viewer at the same resolution as black and white information (luminance). Measured along the horizontal axis, chroma resolution is roughly 1/3–1/4th the luminance resolution, yet we perceive an acceptable color picture.

Digital Video and Compression

Digital video displays images on a pixel matrix. The 486 horizontal scan lines of the NTSC has been replaced by 480 pixels in the x direction (rows) and 720 pixels in the y direction (columns). This size is now referred to as Standard Definition TV (SDTV). Digital video has markedly improved resolution measured along the horizontal axis when compared with the best analog devices.

The DVCAM is a professional format of Sony®'s that records a digitized image onto 6.35mm width tape. A large format cassette can record two hours of high-quality video and sound. The smaller MiniDV records 1 hour at similar quality. The HOV *Alvin* and ROV *Jason* programs at Woods Hole Oceanographic Institution set the *de facto* academic research standards and have largely converted to direct recording to DVD although they retain DVCAM recorders as the highest-quality option available at the time of this writing.

The improved resolution measured along the horizontal of DVCAM along with the small size of the recording media is possible due only to scene sampling and digital compression of the image. Prior to compression, luminance information is sampled at 4 times the rate of either of the two Chroma components (4:1:1) in consumer grade cameras. The luminance and the reduced chroma data are then compressed based on the content within each image (intra-frame compression). Digital compression and decompression are carried out by software called Codecs. Many different Codecs can be functionally equivalent. Having multiple Codecs for the same functionality can lead to numerous conflict problems in the computer. For this project only two Codec packages were employed. The first is that provided by Adobe® for its video software. The second is the library that comes with the FFmpeg open source software. Quality of the final image is determined by the type of compression carried out by the Codecs selected. Intra-frame Codecs compress each frame of video making use of only the content of that frame. The DVCAM used to compress frames onto tape is intra frame and is carried out by proprietary hardware used in the DVCAM systems. Audio-visual interchange (AVI) is the most common video format on Microsoft® Windows®-based computers. This Microsoft®-developed format also uses intra-frame compression.

Even greater image compression can be achieved by inter-frame compression in which the video frames are split into multi-frame groups and frames compressed based upon comparison to a reference frame in the group. Motion Picture Expert Group (MPEG) compression is used for video DVDs and is inter-frame.

The consequences of video compression are entirely dependent on scene content. Intra-frame compressions produce the most visually appealing results when foreground objects fill a relatively small area of the image and the background is homogenous with respect to color and texture. Inter-frame compression will be most visually appealing when there is minimum change frame to frame and the background is homogenous. Unfortunately, seafloor survey video frequently shows the bottom moving under the camera. Inter-frame compression destroys the detail of the bottom.

Digitization of analog video signals has progressed during the course of this project. Initially stand-alone digitizers received the video signal and sent digital output to a computer. Subsequently, analog video input was incorporated into medium-priced graphics boards. When the input is analog, use of a graphics card is still the primary manner for digitization.

The commercial software Adobe® Premier® Pro was selected for this project since it interfaces easily with other Adobe® products, such as Photoshop®, Illustrator, and Encore, for the production of DVDs. However, every step of processing needed can be carried out with free open source software as well as very modestly-priced shareware.

METHODOLOGY FOR VIDEO DIGITIZATION AND DATA DEVELOPMENT

Digitization Procedure

Audio-visual analog-to-digital converters are now common in personal computers either on the motherboard or incorporated in advanced graphics boards. For consistency across the multiple computers used in this program the necessary digitization was carried out using a Sony® DSR 45 DVCAM deck. Communication with desktop computers was via a DV (digital video) to IEE 1394 (firewire) connector.

Playing Source Tapes

The U-matic® tapes were played on a Sony® VO 8800 portable U-matic® SP unit. Connection to the DSR 45 was composite video via coaxial cable and BIC connectors. Audio was via coaxial cable with XRL and RCA® type connectors. There is no computer control for the VO8800, requiring that the tape be started and stopped at 5-minute intervals to create 5 minute clips.

The VHS and SVHS tapes were played on a Mitsubishi® U790 S-VHS deck. Lacking computer control, these tapes were also started and stopped manually to create the 5 min clips. Connection to the DSR 45 was via S-video cable and connectors. Sound was via stereo RCA connectors and coaxial cable.

The Hi-8 tapes were played on a Sony® EVO9077 editing deck. This unit can be well controlled by its own digital circuits allowing starting and stopping within 3 frames of an edit point. Connection to the DSR 45 was via S-video cable and RCA® connectors for sound.

While the primary purpose of this project was to digitize old analog tapes, it should be noted that the DSR 45 and similar units can be fully controlled by computer. When one is playing a DVCAM or mini-DV tapes, the task of producing 5-minute clips can be fully automated. It should also be noted, as an indication of the problems associated with digitizing old tapes, all of the players used in this project failed, requiring e-Bay purchases of used equipment and borrowing equipment from other sources.

Five Minute Clips

The decision to archive video at 5 minute digital clips was largely pragmatic. The choice produces 12 clips per hour. Such a short time is quickly viewed for content logging. The naming convention for the AVI-format was as follows:

Vehicle_Dive#_Tape#_clip_##.avi   for example ALVIN_2202_1_clip_05.avi

The .avi files reside with the School of Ocean and Environment at LSU on approximately 1000 optical disks. Creation of the DVDs and the drive images required compression into the .mpg format. The naming convention for those files is:

Vehicle_Dive#_Tape#_clip_##.mpg for example ALVIN_2202_1_clip_05.mpg

The utility of this naming convention was that on the drive the file name could be parsed and then searched at the discretion of a user. Underscores ("_") rather than blanks were used to assure compatibility across various operating platforms. Inclusion of the tape number allows location of the original tape. The video files on the DVD follow the authoring convention explained below and have the file extension .vob (Video Object). They are .mpg files and can simply be renamed rather than converted.

Clip Size and Compression

Conversion of 5 minutes of video to AVI format using Microsoft® default settings produced files of approximately 1 gigabyte size. Only 4 such files (20 min) could fit on a DVD. At this highest archive resolution, the entire set of tapes occupies about 1000 DVDs, a number too large for practical image access. These files were then compressed using the lossy inter-frame MPEG (mpg) standards. The original name was retained and the extension .mpg used. Compression was carried out using WinFF (http://winff.org/). This utility is a Microsoft® Windows® version with a graphic user interface of the open source program FFmpeg (http://ffmpeg.org/). The default settings produce mpeg files of approximately 0.26 gigabytes, roughly 1/4 the size of the AVI archival file.

DVD Authoring for DVD-Player Viewing

Authoring is the process of putting the video data and other data files into the “wrapper” required by the playback system. This project was undertaken with the assumption that the archived video would be viewed using DVD players rather than computers. Thus the video clips that are to be played on commercial DVD players need to be recorded onto a blank DVD disk in a specific .vob (Video Object) file. The vob files are in a Video Title Sets (Video_TS) folder along with other files needed by the player. In this project the software Adobe® Encore was used to create the needed files and folders. Free open source authoring programs, such as DVD Styler (http://www.dvdstyler.org) could also be used. The primary advantage of Encore is that it can interface with other Adobe® products such as Premier® Pro and Photoshop®. The graphic user interfaces are relative easy to use. Authored DVDs contain menus which allow users to select the particular 5 minute clip a viewer wants. The actual audio-visual files are placed in wrappers with the extension .VOB. These extensions are simply MPEGS and the extension can be changed without causing any problems. For most DVDs, 12 clips were put on each disk producing a higher quality video than the more commonly used two hours per disk.

Data Development

Development of observational data was carried out by LSU undergraduate students recruited from an introductory oceanography course. They were trained to recognize basic seep-system features. Video clips were observed at normal speed and the 24 data categories filled in

(Table 1). These student-developed data were then reviewed and edited for consistency. Due to the extreme range of image quality, taxonomic distinctions were kept to a rudimentary level.

Table 1. Video clip data categories scored by student observers.

Index	Integer number associated with clips sorted by dive and clip name. Used for reference to database maintained at LSU.
Dive Date	MM/DD/YYYY format dive date obtained from deck notes and or data overlay of video.
BOEM Drive	File name as it appears in the directory of the hard drive submitted to BOEM
Dive	Dive designation in format of Vehicle_Number.
Folder Name	Folder containing dive clips on the BOEM Drive of the format Vehicle_Number_MPG. This can be used to generate a dynamic link when the designation of the BOEM drive is added.
Blk	BOEM lease block number within the area.
Depth m	Depth in meters (typical data form with *Alvin* and *Jason*)
Depth ft	Depth in feet (typical data form with Johnson Sea Link)
W Long	Degrees west longitude in format Degrees Decimal Min. Note the values are shown as positive.
N Lat	Degrees north latitude in format Degrees Decimal Min.
W Long	Degrees Longitude in format Digital Degrees.
N. Lat	Degrees Latitude in format Digital Degrees.
Quality	Integer value 1 to 5. 0 represents poorest video quality. 4 represents best. 5 indicates content of special interest. Values based on student subjective assessments.
Transit	Integer 1 or 0. 1 indicates that the clip is primarily movement over bottom. 0 indicates content is primarily fixed in space.
Fixed	Integer 1 or 0. 1 indicates that the clip is primarily fixed in space. 1 indicates movement. largely redundant with Transit but included so that complex start and stop scenes could be noted.
Equipment	Integer 1 or 0. 1 indicates that clip shows equipment in use. 0 indicates no special focus on equipment.
Seep	Integer 1 or 0. 1 indicates presence of notable seep conditions. 0 indicates non-seep.
Rock	Integer 1 or 0. 1 indicates presence of notable rock substrate.
BM	Integer indicating presence of bacterial mats.
TW	Integer indicating presence of tubeworms.
M	Integer indicating presence of mussels.
Comment	Comma delimited comments made during clip logging

RESULTS

Development of the DVD Archive

The video archive on DVD disks and external drive represents 144 submersible dives and 3,341 clips of 5 minute duration for a total of approximately 280 hours of bottom time. Those dives occurred in 48 different lease blocks (Figure1). Summary statistics for all dives are presented in Appendix A as a linked Microsoft® Excel® file. Similar summaries based on lease blocks rather than dives is presented in Appendix B as a linked Microsoft® Excel® file. Of particular note is the fact that seep communities were found in all but four dives although sparse community development was common. In terms of blocks, only two lacked development of seep communities: Green Canyon 1003 and 187.

Image corruption on the original tape was the major problem encountered during digitization. This was especially troublesome on the VHS tapes, where image synchronization was often lost for the first and last few minutes of the recording and was probably caused by physical stretching of the tape. Sony® U-matic® and Hi8® analog formats were of higher quality when viewed with the appropriate player than in the digital version. For these tapes digitization resulted in a loss of resolution along the horizontal axis. Video which contained a time code embedded in the analog image tended to be less stable than video without these. These overlays were typically bright white causing the contrast range within the image to be poorly converted.

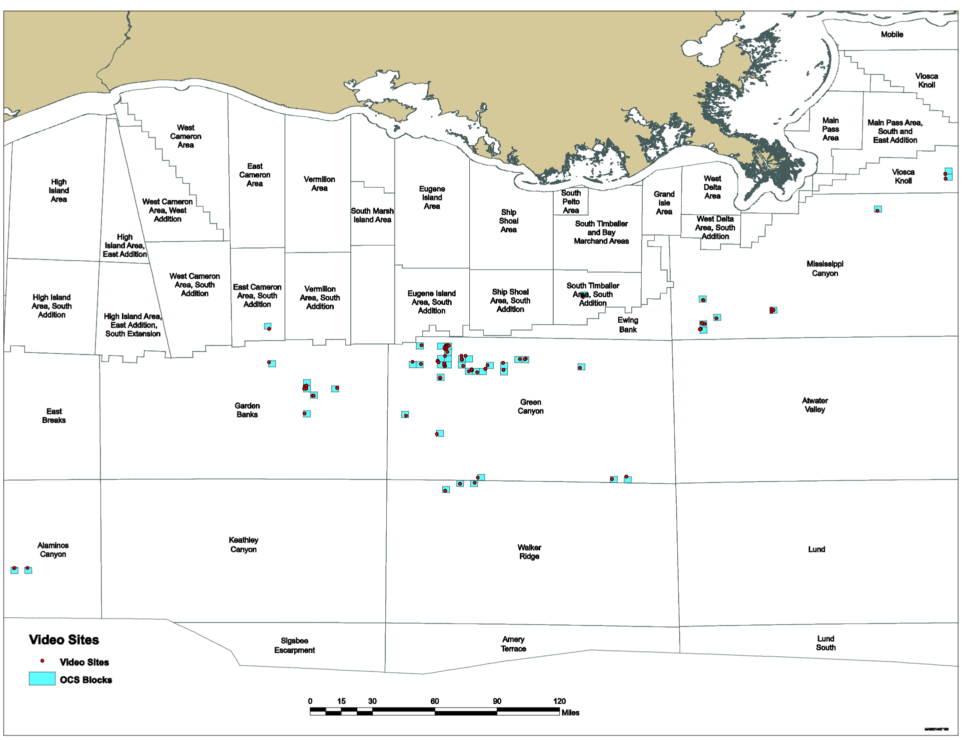

Figure 1. The 144 dives took place in 48 separate lease blocks.

Development of Data Summaries

The full data set on a clip-by-clip basis is presented in Appendix C as a linked Microsoft® Excel® file with 3,340 clips. These data can be linked to the actual videos through the addition of a new column that gives the directory path to the location of the hard drive when installed on a computer. That can be accomplished through use of the Hyperlink function in Microsoft® Excel®.

Considerations about Future Video Data

Video of the seafloor has become an important information source for BOEM, over a wide range of situations. With the increasing use of ROVs and telepresence, it is important and timely that BOEM and other video users give careful thought to optimization.

1. Shared Development - Seafloor investigation is only a tiny component of the very extensive application of digital videography. Developments in commercial as well as consumer-grade equipment are now very fast paced. The community of ocean users needs to stay abreast of these developments and work with the developers to optimize the data value of video in the future.

2. Reviewed Video Standards - When data are to be derived from video, that video must meet stringent standards. It is far too easy to produce bad video. The two most common problems with seafloor video is inadequate light and over compression of the video file. With the rapid advancements in digital video, standards should be frequently reviewed.

3. Identifying Critical Video - When video is recorded continuously on bottom, a tremendous volume of digital information is stored. Some of this information is relatively useless and does not need to be stored at the highest quality. Other scenes are of great scientific and policy relevance and should be archived at the highest quality possible.

4. Serving Video - There is currently no archive set up to provide public access to seafloor video that has been collected from many projects. This is true for the 1 terabyte of video data produced here, and will be even more true with the increasing use of high definition equipment. There are cameras available today with a pixel width of greater than 4,000 and there are new monitors which can display that resolution. This resolution is essentially 16 times the resolution of HDTV. Making old and new video available will be a challenge that must be met.

REFERENCES

Brooks, J.M., B. Cox, W.R. Bryant, M.C. Kennicutt, II, R.G. Mann, and T.J. McDonald, 1985, Association of gas hydrates and oil seepage in the Gulf of Mexico: Organic Geochemistry, v. 10, p. 221-234.

Brooks, J.M. M.C. Kennicutt, C.R. Fisher, S.A. Macko, K. Cole, J.J. Childress, R.R. Bidigare, and R.D. Vetter, 1987, Deep-sea hydrocarbon seep communities: evidence for energy and nutritional carbon sources. Science v. 20, p. 1138-1142.

Brooks, J.M., M.C. Kennicutt II, I.R. MacDonald, D.L. Wilkinson, N.L. Guinasso, Jr., and R.R. Bidigare, 1989, Gulf of Mexico hydrocarbon seep communities: Part IV – Description of known chemosynthetic communities. Proc. 21st Offshore Technology Conference, OTC 5954, pp. 663-667.

Brooks, J.M., C. Fisher, H. Roberts, B. Bernard, I. McDonald, R. Carney, S. Joye, E. Cordes, G. Wolff, E. Goehring. 2009. Investigations of chemosynthetic communities on the lower continental slope of the Gulf of Mexico: Interim Report 2. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2009-046. 360 pp.

Brooks, J.M., D.A. Wiesenburg, H. Roberts, R.S. Carney, I.R. MacDonald, C.R. Fisher, N.L. Guinasso, W.W. Sager, S.J. McDonald, R.A. Burke, P. Aharon, and T.J. Bright, 1990, Salt, seeps and symbiosis in the Gulf of Mexico. EOS, v. 71, p. 1772-1773.

Carney, R.S., 1994, Consideration of the oasis analogy for chemosynthetic communities at Gulf of Mexico hydrocarbon vents: Geo-Marine Letters, v. 14, p. 149-159.

Childress, J.J., C.R. Fisher, J.M. Brooks, M.C. Kennicutt II, R. Bidigare, and A. Anderson, 1986, A methanotrophic marine molluscan symbiosis: mussels fueled by gas, Science, v. 233, p. 1306-1308.

Cordes, E.E., S.L. Carney, S. Hourdez, R.S. Carney, J.M. Brooks, and C.R. Fisher, 2007, Cold seeps of the deep Gulf of Mexico: Community structure and biogeographic comparisons to Atlantic equatorial belt seep communities: Deep Sea Research I, v. 54, p. 637-653.

Cordes, E.E., E.L. Becker, S. Hourdez, and C.R. Fisher, 2010, Influence of foundation species, depth, and location on diversity and community composition at Gulf of Mexico lower-slope cold seeps: Deep-Sea Research II, v. 57, p. 1870-1881.

Fisher, C.R., J.J. Childress, R.S. Oremland, and R.R. Bidigare, 1987, The importance of methane and thiosulphate in the metabolism of the symbionts of two deep sea mussels: Marine Biology, v. 96, p. 59-71.

Fisher, C.R., M.C. Kennicutt II, and J.M. Brooks, 1990, Stable carbon isotopic evidence for carbon limitation in hydrothermal vent vestimentiferaus: Science, v. 247, p. 1094-1096.

Joye, S.B., M.M. Bowles, V.A. Samarkin, K.S. Hunter, and H. Niemann, 2010, Biochemical signatures and microbial activity of different cold-seep habitats along the Gulf of Mexico deep slope: Deep-Sea Research II, v. 57, p. 1990-2001.

MacDonald, I.R., N.L., Guinasso, Jr., J.F. Reilly, J.M. Brooks, W.R. Callender, and S.G. Gabrielle, 1990, Gulf of Mexico hydrocarbon seep communities; VI. Patterns in community structure and habitat: Geo-Marine Letters, v. 10, p. 244-252.

MacDonald, I.R., ed. 2002. Stability and Change in Gulf of Mexico Chemosynthetic Communities. Volume II: Technical Report. Prepared by the Geochemical and Environmental Research Group, Texas A&M University. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 002-036. 456 pp.

Kennicutt, M.C. II, J.M. Brooks, R.R. Bidigare, R.R. Fay, T.L. Wade, and T.J. McDonald, 1985, Vent-type taxa in a hydrocarbon seep region on the Louisiana slope: Nature, v. 317, p. 351-353.

Kennicutt II, M.C., J.M. Brooks, R.R. Bidigare, and G.J. Denoux, 1988, Gulf of Mexico hydrocarbon seep communities – I. Regional distribution of hydrocarbon seepage and associated fauna: Deep-Sea Research, v. 35, p. 1639-1651.

Rempel, A.W., and B.A. Buffett, 1997, Formation and accumulation of gas hydrate in porous media: Journal of Geophysical Research (Solid Earth), v. 102, p. 10151-10164.

Roberts, H.H., and P. Aharon, 1994, Hydrocarbon-derived carbonate buildups of the northern Gulf of Mexico continental slope: A review of submersible investigations: Geo-Marine Letters, v. 14, p. 135-148.

Roberts, H.H., 2001, Improved geohazards and benthic habitat evaluations: Digital acoustic data with ground truth calibrations: OCS Study MMS 2001-050, U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA., 116 p.

Roberts, H.H., D. Feng, and S.B. Joye, 2010a, Cold-seep carbonates of the middle and lower continental slope, northern Gulf of Mexico: Deep-sea Research II, v. 57, p. 2040-2054.

Roberts, H.H., W. Shedd, and J. Hunt, Jr., 2010b, Dive site geology: DSV ALVIN (2006) and ROV JASON II (2007) dives to the middle-lower continental slope, northern Gulf of Mexico: Deep-Sea Research II, v. 57, p. 1837-1858.

Roberts, H.H. 2013. Improving the Predictive Capability of 3-D Seismic Surface Amplitude Data For Identifying Chemosynthetic Communities. US Dept. of the Interior, Bureau of Ocean

Energy Management, Gulf of Mexico Region, New Orleans, LA. OCS Study BOEM 2013-222. 190 pp

Sassen, R., I.R. Macdonald, A.G. Requejo, N.L. Guinasso, McKennicut, S.T. Sweet, and J.M. Brooks, 1994, Organic geochemistry of sediments from chemosynthetic communities, Gulf of Mexico Slope: Geo-Marine Letters, v. 14, p. 110-119.

U.S. Dept. of the Interior, Minerals Management Service, 1992 . Chemosynthetic Ecosystem Study Literature Review and Data Synthesis, Volume III: Appendix. Prepared by Geochemical and Environmental Research Group. U.S. Dept. of the Interior, Minerals Mgmt. Service, Gulf of Mexico OCS Regional Office, New Orleans, LA. 243 pp.

APPENDICES

To access these XL files, save the report as a pdf, then click on the paper clip icon on the left side of the Adobe screen. Select the Appendix you wish to open and double click it.

Appendix A Dive Summaries of Data Categories
(Video_Appendix A.xlsx)

Appendix B Lease Block Summaries of Data Categories
(Video_Appendix B.xlsx)

Appendix C Video Clip Summaries of Data Categories
(Video_Appendix C.xlsx)

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island communities.

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) works to manage the exploration and development of the nation's offshore resources in a way that appropriately balances economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.