Development of standard operating procedures for video analysis and classification, GIS integration, video visualization and image data archiving

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Summary

This research project was initiated to produce standard operating procedures (SOPs) for video analysis and classification, GIS integration, video visualisation, and data archiving. This has been achieved through review of the current state of the art with respect to available video management software, survey design, statistical analysis, and database construction. The SOPs have been refined using a test dataset of geo-referenced video footage taken at the Arc Mounds during CE10014 ROV survey in 2010. Standardisation of video analysis and data management will benefit future users of the national ROV. Comprehensive primary annotation (cataloguing) of video has added value by increasing the likelihood of secondary re-use of video data. The duration of this project was 12 months.

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Introduction

Cold-water corals were first identified in the 18th century (Roberts et al. 2006). However, research on these corals has increased in the last few decades (Ross & Quattrini 2007), due to the increase in fishery and oil exploration activities, as well as a growing interest in past environmental conditions (such as glacial periods), biodiversity and fish habitat (Ross & Quattrini 2007, Dolan et al. 2008). Recent development in seafloor exploration and mapping techniques, such as acoustic surveys and access to both manned and remotely operated submersibles has also allowed more detailed insights into the lives and processes of the deep-sea (Roberts et al. 2006).

It is accepted that cold-water coral reefs form a favourable habitat for macro- and megafaunal biodiversity (Mortensen et al. 1995, Husebo et al. 2002, Costello et al. 2005) compared to the open sedimentary seafloor of the continental slope (Sulak 2007). The 3-dimensional structure of cold-water corals can provide niches to other animals (Costello et al. 2005, Roberts et al. 2006), such as echinoderms and fish.

The environment of the deep-sea – low-light level, high pressure, low temperature and relative low food-availability – makes it difficult to observe deep-sea fauna, especially highly mobile animals, such as fish, in their habitat (Raymond & Widder 2007). However, there are several ways to study the deep-sea and investigate whether cold-water corals provide a habitat to fish and invertebrates. Under-water observations may be used, as well as trawls, gillnets, long-lines and baited traps (Costello et al. 2005). Trawling is not always possible or favourable, especially in fragile coral reefs that restore very slowly because of their low growth rate. Trawling is also a non-preferred method as it only gives a relative abundance of fish. This abundance depends not only on the individual's (or species') chance of being caught in the trawl (Trenkel et al. 2004b), but also on the selectivity of the trawl. The selectivity of the trawl is dependent on several variables, such as mesh-size, mouth area, towing speed, and the number of warps towing the net. Experiments have shown that the abundance of several decapod and fish species differs depending on the trawl used (Cartes et al. 2009). Long-lines and gillnets are difficult to position over the reefs and traps are selective for a certain species and size. These issues mean that the above methods are not ideal for determination of the abundance of all (fish) species and the species composition of the community living on the reefs (Costello et al. 2005).

Video footage may therefore be the best option for studying abundance and composition of animal species in the deep-sea. The accuracy of the video surveys is influenced by animal conspicuousness, animal activity, water clarity, and attraction and/or avoidance behaviour of the animal. The observer's speed and skill in identification of animal species also influences the accuracy of the study (Costello et al. 2005). A second observer can also analyse the videos and photographs of the sea floor to decrease this inter-observer effect and make the video surveys more accurate.

There are many research institutes working with video footage, e.g. IFREMER (France) and Institute of Marine Research (Norway). However, the different research institutes use different survey designs, which makes it difficult to compare the data and results between institutes. In this report, the several survey designs and data analysis described in previous literature are reviewed.

2 A review of the current state-of-the-art

2.1 Survey designs

2.1.1 Survey gear: vehicles and cameras

The first difference between survey designs is with the gear that is used. Although all gear (ROVs, submersibles, towed cameras, baited cameras) makes video or photographic images of the substrate of the sea floor, and the animals living in, on or above the bottom, the way this video footage is made differs. ROVs and submersibles are similar: most of the survey designs are based on (pre-determined) transects and the cameras are recording while the ROV or submersible is flying a few metres above the sea floor. The towed camera is operated in a similar way as a (mostly downward-facing) camera in a frame or on a platform is towed behind the ship while recording the bottom. The difference between the ROVs/submersibles and the towed camera is that the towed camera does not have its own drive. Baited cameras are somewhat different, as this video footage is recorded while the gear is stationary on the sea floor and bait is released. During these experiments, landers – a frame with floating devices and a weight release system – are used. The fact that animals, mostly scavenging fish and benthic animals (e.g. echinoids), are attracted by bait makes this way of video recording different than the survey designs of ROVs or submersibles. This report will not discuss the baited cameras.

2.1.2 Transect locations

Most survey designs are based on transects that are pre-determined, i.e. the locations of the transects are decided before the cruise starts. However, the number of transects done and therefore the amount of data collected are affected by the weather (Roberts et al. 2006, Stone 2006, Jan et al. 2007, Smith et al. 2007). If the weather does not permit a deployment of the ROV or submersible, then the numbers of transects decrease. Towed camera systems are especially affected by the weather, since the lack of an own drive means that they can only be controlled with a winch (up and down) or with the movement of the ship.

The data discussed in this section were collected between 1996 and 2007. Several areas are dealt with e.g. Bay of Biscay (Uiblein et al. 2002, 2003, Trenkel et al. 2004b), Mid-Atlantic Ridge (Felley et al. 2008, Mortensen et al. 2008), Rockall plateau (Wienberg et al. 2008, Guinan et al. 2009b), and Norwegian waters (Fossa et al. 2002, Costello et al. 2005, Jerosch et al. 2006, Mortensen et al. 2009). There has also been some work done in the northwest Atlantic Ocean (Sulak 2007, Ross & Quattrini 2009), Pacific Ocean (Chave & Mundy 1994, Lundsten et al. 2009) and polar waters (Soltwedel et al. 2003, Stone 2006, Sumida et al. 2008). Depths of surveys ranged between 39m (Norway) and 4500m (Charlie-Gibbs Fracture Zone; Mid-Atlantic Ridge).

A few studies designed their surveys – locations of transects and the way to record video or photographic material – before the cruise started. Trenkel et al. (2004a; 2004b) defined their transect lines before the ROV survey started at three locations in the Bay of Biscay. At each site, the depth range that was surveyed was between 1100m and 1500m depth. The survey design of this study consisted of perpendicular lines with nominal length of 300m along depth gradient and 60m across the gradient. A total length of 24km (1 site) or 20km (2 sites) were surveyed in this way. The authors recorded the actual strip length from ROV speed records every 5 seconds, and the start and end time of the transect. The strip width was calibrated by using a plastic chain of a certain known length and was 5m at around

1.5m ahead from the ROV. Hereafter the survey parameters kept constant (constant survey speed $0.25ms^{-1}$, fixed settings of the camera and an altitude – the distance between the ROV and seafloor – of approximately 0.8m. The seafloor was visible until the altitude reached 2.5m or above. The fish seen along the transects were counted in real time when they passed a virtual line on the video monitor. The fish were identified to the lowest possible taxonomic level when the videos were replayed later (Trenkel et al. 2004a, Trenkel et al. 2004b). Lorance & Trenkel (2006) used the same survey design, using the data of Trenkel et al. (2004a; 2004b).

Another method used to pre-define locations of transects is determined by the bathymetry. Dolan et al. (2009) examined multibeam data of their study area and positioned transects of approximately 1km long across the study area. Using this survey design the authors were able to acquire data over a range of topographic features and seabed acoustic signatures that might be of ecological importance. They were also able to spread the sampling stations evenly on a geographical level among the area. In this study the survey parameters – camera settings, speed (of the vessel, because it involves a towed camera) and altitude (1.5m above the seafloor) – were kept constant (Dolan et al. 2009).

Some studies use georeferenced topographic maps to choose the locations for their survey design (Uiblein et al. 2002, 2003, Stone 2006, Tissot et al. 2006, Sulak et al. 2007). These maps could be made by acoustic echosounder data (Sulak 2007), multibeam bathymetry (Tissot et al. 2006, Roberts et al. 2008) or backscatter data (Howell et al. 2010). Other information, such as navigation and temperature data (Uiblein et al. 2002, 2003), previous literature and surveys (Costello et al. 2005, Tissot et al. 2006, Ross & Quattrini 2007) fish abundance in the study area (Stone 2006), or side-scan sonar and seismic reflection (Tissot et al. 2006), can also be used to determine locations of transects.

The goal of the study can also help to decide the location of transects. For example, Tissot et al. (2006) focussed on sea floors with rocky substrate in their study area. Other studies designed their survey to incorporate many different habitat types (Stone 2006, Ross & Quattrini 2007, Howell et al. 2010), a certain depth range, or certain geomorphologic features (Howell 2010, Howell et al. 2010). Another goal of the video survey might be to determine the amount of fishery impact in an area, such as trawling in Heraklion Bay, Crete (Smith et al. 2007). In this case the survey design was based on the fishing lanes in this area. The camera system was towed in a zigzag pattern across the fishing lane from the un-fished areas to its north and south (Smith et al. 2007).

Many authors mention the locations of transects within the study area, but they do not mention the survey design in terms of the way the transects were chosen (Chave & Mundy 1994, Soltwedel et al. 2003, Jerosch et al. 2006, Staudigel et al. 2006, Leujak & Ormond 2007, Felley et al. 2008, Mortensen et al. 2008, Sumida et al. 2008, Wienberg et al. 2008, Lundsten et al. 2009).

2.1.3 Survey parameters

In most referenced literature the survey parameters (fixed camera settings, altitude and speed of the ROV/submersible/vessel) are mentioned and an attempt was made to keep them as constant as possible. However, they are influenced by currents, weather conditions and swell.

Even though the parameters within a survey were kept constant, there are many differences between surveys. The field of view of the camera differed between studies, due to the angle the camera was set at, or the make or model of the camera. The width of the camera view ranged from 0.97m to 8.17m (Lundsten et al. 2009) and the view ahead of the ROV/submersible with a front-ward facing camera ranged from 1.5m (Trenkel et al. 2004a, Trenkel et al. 2004b, Lorance & Trenkel 2006) to 15m (Uiblein et al. 2002, 2003). In many papers the field of view was not mentioned (e.g. Jerosch et al., 2006, Guinan et al., 2009b).

The same is true in the case of the speed of the ROV/submersible or vessel (in case of a towed camera) and the altitude. The speed ranged from 0.2 knots (Mortensen et al. 2008) to 1 knots (Sumida et al. 2008), or the speed is not mentioned (e.g. Fossa et al. 2002, Tissot et al. 2006). The distance between the camera system (towed, ROV or submersible) and the bottom varied from 0.8m(Trenkel et al. 2004a, Trenkel et al. 2004b) to 3m (Jerosch et al. 2006, Guinan et al. 2009b). Some studies do not mention the altitude (e.g. Mortensen et al. 2008, Wienberg et al. 2008, Ross & Quattrini 2009). In some studies the altitude was highly variable due to the seafloor terrain (Stone 2006).

Transect lengths differed between studies, ranging from 45m to 17.5km (Soltwedel et al. 2003, Lundsten et al. 2009). However, in some papers a total transect length is given (Trenkel et al. 2004a, Trenkel et al. 2004b, Jerosch et al. 2006, Lorance & Trenkel 2006) or not given at all (e.g. Costello et al. 2005, Sulak 2007, Felley et al. 2008, Guinan et al. 2009b).

2.1.4 Standardisation of survey designs

One simple way to standardise survey design is to base transects on vertical lines, grids or radial lines (Figure 1a-c). The vertical line transects can be used to obtain an assessment about large biological features, such as coral mounds and seamounts. The start point will be at the base of the feature. The grid transect covers a large area systematically and the length of transect is usually predetermined. This survey design is very powerful when it is combined with a sampling methodology to verify video identification. However, it is time consuming. The radial transect will start from an arbitrary or random selected centre. This transect design is most suitable for smaller features or low relief mounds. It helps to determine the limits of a particular community when the size of that community in unknown (Kutti et al. 2009).

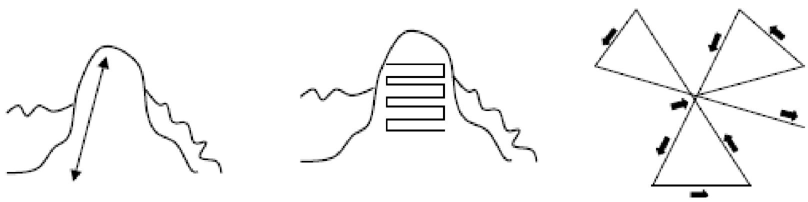

Figure 1: Common types of transect surveys. A) vertical line transect, B) grid transects and C) radial transect (Etnoyer et al. 2006, Kutti et al. 2009)

The survey parameters can be standardised as well, although this is more difficult due to different gear, bathymetric features (e.g. altitude is easier to maintain constant at flat areas than in areas with mounds, sand waves or vertical rock formations), and weather conditions.

2.1.5 Summary and conclusions

It is necessary to have a survey design to make a cruise as efficient as possible and make the data comparable between study areas, cruises and institutes. However, it is possible this survey design is not practical for several reasons, of which weather conditions is likely to be the most important. A standardised survey design (e.g. based on one of the three survey designs in Figure 1) might increase the amount of data and results that are available for comparing between transects, study areas and research institutes.

However, one problem that still exists is that cruises collect data with different goals, such as determining benthic invertebrate abundances (Sumida et al. 2008, Howell et al. 2010), fishing intensities (Stone 2006, Smith et al. 2007), or coral habitat use of fish (Trenkel et al.

2004b, Ross & Quattrini 2009). The survey design for investigating fishing intensities is looking for different areas (fished and un-fished, but with similar substrate) compared to one investigating the coral habitat use of fish (that might take areas with and without corals).

So, even with similar survey designs the data cannot be compared between transects, study areas and research institutes. if the analysis of the video footage is (completely) different.

2.2 Video analysis

During video surveys the data output are video or photographic footage. Most studies count and identify – if possible – animal species in real time and during playback of the material in the lab.

The analysis of the data after the identification and counting of the animal species is dependent on the research questions of the authors. Sumida et al. (2008) and Howell et al. (2010) excluded fish from their analysis, because these authors were interested in habitat use by benthic faunal communities. In contrast, Trenkel et al. (2004b) and Uiblein et al. (2003) were investigating the fish abundance and composition in the study areas.

The way the video footage was analysed differed. In some studies the video was divided into sequences based on time, e.g. 30 seconds (Dolan et al. 2009, Mortensen et al. 2009) and 1 minute (Felley et al. 2008, Mortensen et al. 2008) or based on depth, e.g. 50m (Lundsten et al. 2009). In these studies, every individual animal was counted and identified during these sequences. The number of sequences is used during further analysis. Other studies take frame grabs at several different intervals, including approximately 1 second (Sulak 2007, Dolan et al. 2008), 5 seconds (Guinan et al. 2009b) or 2 minutes (Roberts et al. 2008). Sumida et al. (2008) used every image when the area seen on the camera was between $1m^2$ and $4m^2$, and selected 50 frame grabs randomly for further analysis.

In almost all studies described in this report the first analysis involved counting and identifying the animal species to the lowest possible taxonomic level . The exceptions were three papers that analysed substrate cover rather than animals (Jerosch et al. 2006, Wienberg et al. 2008, Guinan et al. 2009b).

The goal of Jerosch et al. (2006) was to use geostatistical techniques and GIS for georeferenced video mosaics. These georeferenced video mosaics can be used for the computation of spatial distributions of ecological (morphological, geological and biological) features at the seafloor. A mosaicing program (MATISSE) was used to analyse the video images. See Jerosch et al. (2006) for a detailed description of mosaicing.

Although Wienberg et al. (2008) focussed on substrate cover, their goal was to make a classification of substrate cover that can be easily used in GIS programs (e.g. ArcGIS®). Therefore the different facies and biocoenosis types were recorded on each image of the camera sledge (OFOS).

Guinan et al. (2009b) used video frame grabs with intervals of 5 seconds to determine the substrate with Coral Point Count with Excel extension (Kohler & Gill 2006). This program allows creation of a standard window (quadrant) containing random points on every frame grab. In this study the authors used 9 random points to analyse the substrate of every frame grab after they tested that there was no significant difference in the recording of substrate cover when using 9, 12, 21 and 36 points. The (coral) cover was expressed as a percentage and used in a Genetic Algorithm for Rule-set Prediction (GARP) model. This model predicts single and multiple species distribution across diverse regions and taxa. The details about this model are beyond the scope of this report and can be found in Guinan et al. (2009b).

As mentioned already, the video analysis of most studies started with counting and identifying animals (Table 1). The focus of most of these studies was on fish. Some studies included fish associations with elevated invertebrates, such as sponges, black coral, gorgonians and scleractinian corals (Stone 2006; Tissot et al. 2006). Other studies included fish behaviour, e.g. position in the water column, locomotion type, activity level, reaction type to the ROV, the distance this reaction took place and foraging behaviour (Trenkel et al. 2004a,b; Uiblein et al. 2002, 2003; Costello et al. 1995; Stone 2006).

Although authors use some standardisation in the video analysis method it is difficult or impossible to compare the data across studies. A standardisation of the video analysis might be to analyse a certain area (Leujak & Ormond 2007, Guinan et al. 2009a), such as $1m^2$ (Sulak et al. 2007, Kutti et al. 2009). Another possibility would be to measure the area covered by the camera and express the abundance of animals as number per m^2 by dividing the number of animals seen at a certain transect by the total area covered by the camera (Uiblein et al. 2002, 2003, Tissot et al. 2006, Dolan et al. 2009, Mortensen et al. 2009, Howell et al. 2010). Another standardisation of count data on species level might be to calculate the percentage of individuals of a certain species from all individuals seen (Ross & Quattrini 2007, 2009). However, as seen, there are several methods used in standardisation which makes it hard to compare data between studies.

Table 1: The outcome of video analysis of several references. All these studies counted and identified animal species. This table shows how they used the animal counts in further analysis. The way of normalisation/standardisation is shown in the fifth column. Some studies investigated species composition, community structure, fish association with invertebrates (e.g. sponges, black corals, gorgonians and scleractinian corals) and fish behaviour. This last aspect includes e.g. the location of the fish towards the bottom or invertebrates, the locomotion of fish and reaction behaviour to the ROV/submersible. * Presence/absence data, so no real numbers. ** Relative abundance (percentage of individuals of a certain species in a habitat from the total individuals in that habitat) and absolute density (the absolute number of individuals) ***Relative abundance (percentage of individuals of a certain species in a habitat from the total individuals in that habitat)

Reference	**Count animals**	**Identify animals**	**Abundance/ density**	**Normalised/ standardised**	**Species composition**	**Community structure**	**Fish association**	**Fish behaviour**
(Chave & Mundy 1994)	x	x						x
(Costello et al. 2005)	x	x	X	effort (count/minutes surveyed)		x		
(Dolan et al. 2009)	x	x	X	area (# individuals m^{-2})				
(Felley et al. 2008)	x	x						
(Howell et al. 2010)	x	x	X	area (# individuals m^{-2})				
(Lorance & Trenkel 2006)		x						x
(Lundsten et al. 2009)	x	x	X	total time spent in certain depth bin of 50 m				
(Mortensen et al. 2008)	x	x	X	% (total # of video sequences)				
(Mortensen et al. 2009)	x	x	X	area (# individuals m-2)				
(Roberts et al. 2008)	pres/abs*	x		No				
(Ross & Quattrini 2007)	x	x	x (rel)***		X			
(Ross & Quattrini 2009)	x	x	x (rel)***		X			
(Stone 2006)	x	x					x	x
(Sulak 2007)	x	x						
(Sumida et al. 2008)	x	x	X					
(Tissot et al. 2006)	x	x	X	area			x	
(Trenkel et al. 2004a)	x	x						
(Trenkel et al. 2004b)	x	x						
(Uiblein et al. 2002)	x	x	x (rel and abs)**	?				x
(Uiblein et al. 2003)	x	x	x (rel and abs)**	?				x
(Wienberg et al. 2008)	x	x	X		x			

2.2.1 Post-processing tools

In a few studies the videos were analysed with the programs ADELIE (IFREMER, France) or VARS (Video Annotation & Reference System; Monterey Bay Aquarium Research Institute (MBARI), California, USA). These programs can be used for real-time- or post-processing of the video data acquired by ROVs, submersibles or towed camera systems, and are a tool for displaying, manipulating and describing the video footage. Another analysis program is OFOP (Ocean Floor Observation Protocol; Scientific Abyss Mapping Services (SAMS); Texel, the Netherlands). OFOP and ADELIE have similar functions. The author of this report has no experience with VARS.

<u>ADELIE</u>

ADELIE is a tool that helps to display and manipulate data, images and video recordings from submersibles and ROVs. The program works with a video input (DVD, tape recorder, hard disk, etc.) and allows the user to play, fast-forward, rewind, replay and pause (etc.) the video, or to go to a certain time in the dive. It can make so-called mini-films, where the program takes a frame grab every *n* seconds, for example every 5s, that are saved in a chosen directory. These frame grabs are georeferenced and can be combined with the dive track in ArcGIS® with the extension ADELIE-GIS. This extension can also import all the dive data and represent this geographically on a map in GIS.

<u>OFOP</u>

Ocean Floor Observation Protocol is similar to ADELIE. This program allows location of the gear on the seafloor, saves the ROV operations and writes protocols that can be imported into GIS. Within the seafloor observation window, the substrate type and animal species (annotations) can be clicked and will record the correspondent information in a text file. This text file contains georeferenced data and can therefore be imported into GIS, which makes it possible to show the substrate types and/or animal species on a georeferenced map. This might be of an advantage when sampling a certain animal species or on a certain substrate for example. The annotation window can be customised by the user depending on their research questions.

OFOP has a function that smooths and splines the transect navigation data every second. This is a good method to get rid of the effect of outliers in the data set and to get a measurement every second, even when the navigation (or any other measurement) is measured at a longer interval. The video can also be linked to the navigation file while post-processing the data in the lab, which makes it possible to show the location of a certain video image on the map of the seafloor.

OFOP can also be used to extract frame grabs every *n* seconds. Although the frame grabs are not georeferenced (as with ADELIE), OFOP displays a time code that can be combined with the navigation file in GIS, making it possible to link frame grabs to locations on transects.

<u>VARS</u>

Video Annotation & Reference System (VARS) can be used for describing, cataloguing, retrieving and viewing the visual, descriptive and quantitative data obtained by ROVs, submersibles and towed camera systems. With this program, frame grabs can be taken during the dives. It also allows the user to enter annotations about substrate type and animal species. The annotations can be added and removed by the user, depending on the importance of substrate type and animal species in their research (e.g. 'fish' is enough for a person investigating echinoderms; however, fish needs to be split into species for a person working on (a certain species of) fish).

2.2.2 Summary and conclusion

It is apparent that the methods of analysing video (or photographic) data are different, and depend mainly on the research questions. Some studies focussed on substrate cover to use that in other models, or in programs for mosaicing or making georeferenced maps showing the substrate type in a certain area. Other studies focussed on a certain type of substrate or on animals in a certain area. The animals encountered during these surveys are counted and identified and their abundances are calculated. The association of fish and the behaviour of fish have also been investigated by several scientists. However, one problem about these data is that they are not easily comparable – even if the survey design is similar – because most data are not standardised or the data are standardised in a different way. This makes it impossible to compare the data. A standardised protocol of video analysing should help to increase the ability to compare data (e.g. abundance data) among transects and areas, but also between research institutes. Certain programs, such as ADELIE, OFOP and VARS, might make it easier to analyse video footage retrieved from ROVs, submersibles or towed camera systems. Methods using a certain window (e.g. $1m^2$) for frame grabs or abundances expressed by the total area that was covered on the camera can be used to standardise video outputs.

2.3 Annotation

Annotation will vary from study to study, depending on the questions raised by the research. . For scientists interested in the way the substrate type in a certain area changes, the annotation used for substrate will be expanded compared to that used by a scientist interested in a certain type of substrate, for example corals. The same is true for scientists working on animal species; a person working on echinoderms will have a different annotation list to one working on fish or coral species. Table 2 gives several examples of annotation lists, including both substrate types and animal species, from different studies. Differences in annotation lists will also arise due to the location and depth of the area under investigation e.g. different animal species will be encountered in different parts of the world, and the species composition at a depth of 300m might be different to the species composition at a depth of 4500m.

Another consideration is to whether or not to record the behaviour of animal species in the annotation list . It might be favourable for scientists to use two different annotation lists; one for real-time observation and one for post-processing. During real-time observation not everything that is seen can be recorded because of the speed of the animals and ROV. The animals seen at a certain moment can disappear from the screen within a few seconds. Especially when there are many animals (and substrate types) to record it is hard to record everything on the screen before it moves on to the next scene. During post-processing the video footage can be paused, rewound, and replayed as many times as needed to record everything at a certain moment. It might be that the post-processing annotation list is larger than the real-time annotation list.

Howell (2010; Tables 2 and 3) gives a summary of several annotation lists used in previous literature of both substrate type and animal species.

Table 2 Annotation lists of several studies. This table gives a few examples of annotation lists of studies investigating substrate type and/or animal species. It is clear that every study has its own list. The red words mean similarities in annotation lists.

Reference	(Tissot et al. 2006)	(Wienberg et al. 2008)	(Trenkel et al. 2004a, Trenkel et al. 2004b)	(Costello et al. 2005)	(Lorance & Trenkel 2006)	(Stone 2006)
Substrate	x	x				
Animals			x	x		
Behaviour					x	x
Annotation list	Mud	Hard ground	Alepocephalidae	Cottidae	Position in water column	Resting, including hovering
	Sand	Soft sediment	*Bathypterois dubius*	Zoarchidae	Locomotion type	Searching (i.e. slow swimming)
	Gravel	Soft sediment with current ripples	Dogfish shark	Anarhichadidae	Activity level	Directed movements (i.e. fast swimming)
	Pebble	Discrete live coral colonies	*Trachyscorpia c. echinata*	Sebastidae	Reaction on ROV	
	Cobble	Dense coral framework cover	Chimaeridae	Chimaeridae	Reaction distance	
	Boulder	Abundant coral debris	*Coryphaenoides rupestris*	Macrouridae		
	Continuous flat rock	Scattered coral debris	Moridae	Moridae		
	Rock ridge	Soft sediment faunal community	*Neocyttus helgae*	Oreosomatidae		
	Pinnacles		Cat sharks	Scylorhinidae		
			Synaphobranchus kaupii	Synaphobranchidae		
				Noatocanthidae		
				Lotidae		
				Phycidae		
				Unidentified fish		
				Rajidae		
				Gadidae		
				Lophiidae		
				Pleuronectidae		

2.4 Statistical analysis

The statistical analysis used is, like many of the subjects discussed in this report, dependent on the research questions. Table 3 shows a sample of the statistical analysis used by the different papers reviewed here. The most common statistical analysis is a cluster analysis using the Bray-Curtis similarity coefficient that is used to see whether species richness is similar on two or more transects. Multivariate analyses are used too, however these are not further explained in this section (for further information see the references). Other statistics, such as ANOVA, Kruskal-Wallis tests or generalised linear models (GLM), are also used (Table 3

Table 3 A schematic presentation of the statistical analysis used in different research groups. GLM = generalised linear model; MCA = multi correspondence analysis; MSA = multivariate statistical analysis.

	Statistical method							
Reference	**Unknown**	**G-test of independency**	**GLM**	**MCA**	**MSA**	**Cluster analysis**	**Bray-Curtis similarity**	**Other statistics**
Chave & Mundy, 1994	x							
Costello et al., 2005					x	x	x	Univariate analysis
Dolan et al., 2009					x			
Felley et al., 2008								χ^2 and Bonferroni correction
Howell et al., 2010						x	x	
Jerosch et al., 2006								Mosaic program MATISSE
Leujak & Ormond, 2007								ANOVA with post hoc Tukey test
Lorance et al. 2006				x				
Lundsten et al., 2009						x	x	
Mortensen et al., 2008	x							
Mortensen et al., 2009					x			
Roberts et al., 2008					x			ANOVA with Bonferroni corrections
Ross & Quattrini (2007)					x			
Ross & Quattrini (2009)					x			
Stone, 2006	x							
Sulak et al., 2007	x							
Sumida et al., 2008								Kruskal-Wallis/ANOVA
Tissot et al., 2006						x		Chi-square (assoc)
Trenkel et al. 2004a			X					
Trenkel et al. 2004b			X					
Uiblein et al., 2002		x						
Uiblein et al., 2003		x						
Wienberg et al., 2008	x							

2.5 Data management

Most research data discussed in this report are not located in a database (or the authors do not mention data storage). In only a few papers is database storage mentioned. Wienberg et al. (2006) use the database program Filemaker to store the data, mainly video images. They recommend the creation of a comprehensive database in which all information about cold-water corals and their ecosystems from various regions of the world's oceans can be found: in this way a better understanding of the development and formation of these ecosystems can be realised (Wienberg et al. 2008). Howell et al. (2010) put the image data, both raw and standardised, into an access database. All information gathered by Jerosch et al. (2006) was stored in a relational geodatabase system which gives information about cruise name, station and dive numbers etc.

Existing databases can be used in studies that involve video footage, but also in studies that use information in another way, e.g. model suitability modelling. In databases scientist can find information about: taxons seen in previous literature including the latitude and longitude (Reveillaud et al. 2008); fisheries (Haedrich et al. 2001, Sulak et al. 2007); cold-water corals for developing habitat suitability models (Davies et al. 2008); deep-water demersal fish families (Bergstad et al. 2008).

3 Case Study: Arc Mounds video analysis

3.1 Survey design

The survey design was determined before the cruise started. Based on high resolution bathymetry data and literature studies, 2km x 2km experimental blocks were digitized onto bathymetry maps and classified into on-mound(coral habitat)and off-mound/non-coral habitat. The non-coral habitat was used to make a good comparison between the animal (mainly fish) abundance in coral and non-coral habitat. Fish and/or other animals seen only in the coral areas might be specialised in or depend on the coral in these areas. Of these boxes, three were randomly chosen within each class. In these chosen boxes, 2km transects were then planned along the gradient with most varying terrain morphology (i.e. habitat type). In Arc Mounds, three transects were done in coral habitat and three transect in non-coral habitat (Figure 2). All transects were performed between 600 and 800m depth. The mounds of this region are very small (base is approximately 2 or 3km long) and the transects were planned to cross the top of the mound.

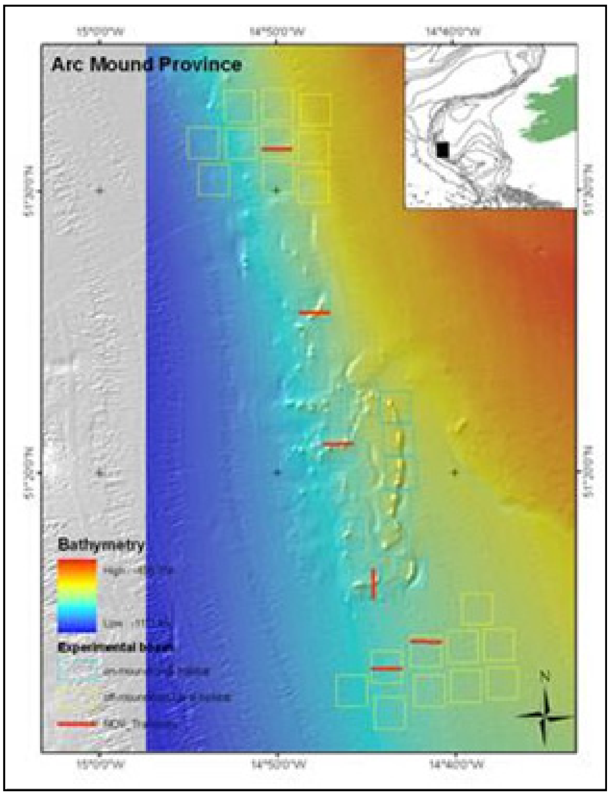

Figure 2 An overview of the 2km x 2km boxes in the Arc Mound provinces. The blue boxes represent the boxes in the coral habitat (mounds) and the yellow boxes represent the non-coral habitat (control area). In each habitat three boxes are randomly selected. In these boxes a 2km ROV transect is plotted (red lines) based on bathymetry data.

The parameters of the ROV were kept constant as possible, with speeds of approximately 0.6 knots and an altitude between approximately 1.5m–2.5m. The angle of the HD camera was kept constant at approximately 45º while the HD camera was zoomed out completely at all times.

3.2 Data Acquisition

Data were collected during the April/May 2010 CE10014 cruise with the Celtic Explorer (Marine Institute, Ireland). During this cruise three regions in the northeastern Atlantic Ocean – the Logachev mound (Southern Rockall Bank), Arc mound (Southern Porcupine Bank), and Belgica mound (Porcupine Seabight) provinces – were visited. This case study involves the Arc Mound province, which was visited from April 28th to May 2nd 2010. A total of 8 ROV dives were carried out, of which 7 were used in further analysis (the dive that is not used in the analysis was a sample dive). Two dives were combined (#11 and #17), because they involved the same transect. The transect locations can be seen in Figure 3. Previous observations (unpublished data) showed that coral is centred on the top of the mound. The transects in this region were planned in such a way that they would cross the top of the mound. A random system could have been used to plan the locations of each transect, however, this would have meant a high chance that the transect would have missed the coral habitat..

The video footage was recorded by the ROV Holland I (Marine Institute, Ireland). The vehicle is equipped with a high level of auto-control features, including auto-hold which proved valuable during standardized video transects. The ROV is also equipped with one photographic camera and four video cameras: a HD forward-looking oblique camera, a digital downward-looking camera (vertical), a digital forward-looking camera and a digital aft-looking camera. All the cameras are Kongsberg (specifications of the cameras and lights can be found in Appendix 1). The video footage of the digital cameras was stored on hard drives incorporated into DVD recorders and were copied on DVDs after the transects were done. These DVDs were labelled (cruise number, dive number, date, location, DVD number and total number of DVDs per dive) and stored for later use. The HD camera was recorded on JVC and Sony tapes. The tapes were labelled (cruise number, dive number, date, location, tape number and total number of tapes per dive) and stored for later use. In the lab these tapes were digitalised and stored on a RAID. More details about this storage can be found in Chapter 4.4. A live stream from the HD-camera was set up in one of the labs on the ship. This live-stream was used to record observations about substrate and animal species seen on the HD camera. An annotation program called Ocean Floor Observation Protocol (OFOP; SAMS) was used for this. More details about this program can be found in the next chapter.

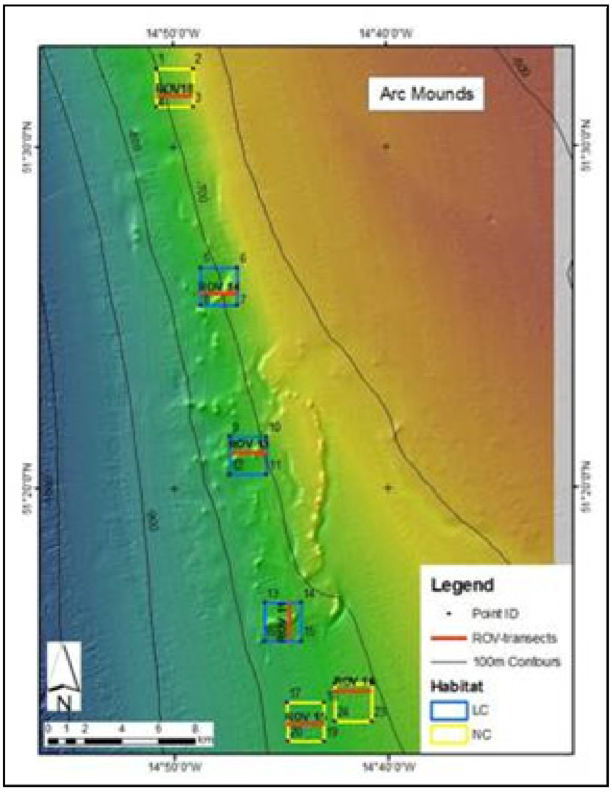

Figure 3. An overview of the locations of the ROV dives in the Arc Mound province. The blue boxes represent coral habitat and the yellow boxes the non-coral or control transects. The red lines represent the transects. Transects were planned along the gradient with the most varying terrain morphology. In coral areas the transects were located to go over the summit of the mound.

A Photonic Internal Navigation System (PHINS, IXSEA) was used for navigation purposes which gave position and speed of the ROV as well as other parameters, such as heading and altitude of the vehicle. The PHINS system was connected to an external USBL sensor (GAPS, IXSEA) and this resulted in a more accurate positioning (by several orders of magnitude) compared to traditional navigation (e.g. GAPS alone). The positioning data was fed directly into PDS2000 (RESON) navigation software which enabled a remote presentation of ROV and ship positioning to the bridge as well. PHINS data was exported from PDS2000 and merged with the seafloor observation log derived by OFOP. This program was also used to clean the navigation data. Although the navigation data is very accurate it can have some outliers. OFOP has a function to get rid of these outliers and smooth the track. This can be done by selecting “Processing and Observation” in the “Tool” menu of the title page of OFOP (Figure 7, next chapter). A window with four tabs appears. The smoothing of the navigation data can be done by selecting the ‘Edit & Smooth data’-tab (green in Figure 4), browsing for the correct *_posi file (red; Figure 3), and clicking on the button “Plot raw data” (blue). The data can be zoomed by selecting data with the mouse and clicking on “plot raw data” again.

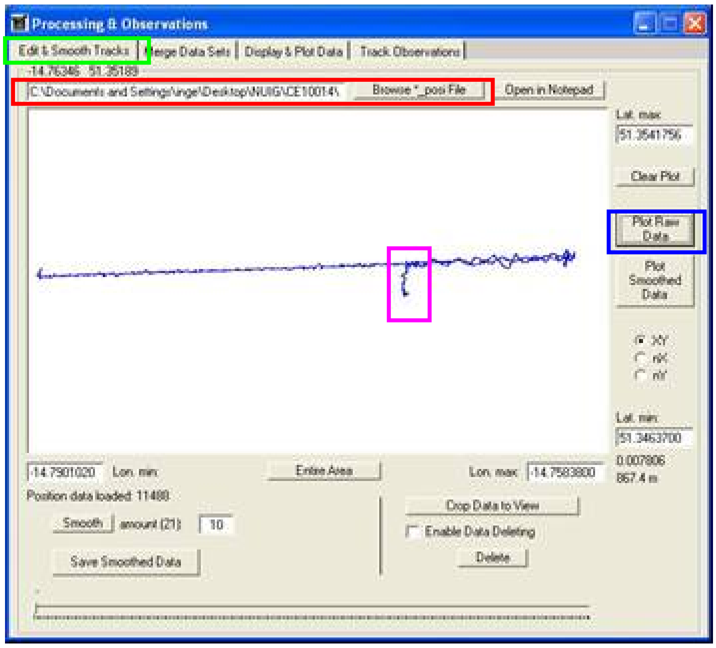

Figure 4. The OFOP window to smooth the navigation data. After selecting a *_posi file and clicking on “plot raw data” –the red and blue square respectively – the track appears on the screen. Part of this track is not part of the analysis, because of an exploration on a different part of the mound (indicated by a pink square). This can be removed from the navigation data.

The pink square in Figure 4 indicates an exploration to the surroundings of the track. This is not part of the analysis and can be removed (Figure 5). This is done by clicking on “Enable Data Deleting” (green in Figure 5) and selecting the part to be deleted by dragging a square on the track by the mouse (red in Figure 5). After each deleted part, the “plot raw data” should be clicked again: be careful – uncheck “Enable Data Deleting”. Repeat the steps until all data that needs to be removed is deleted.

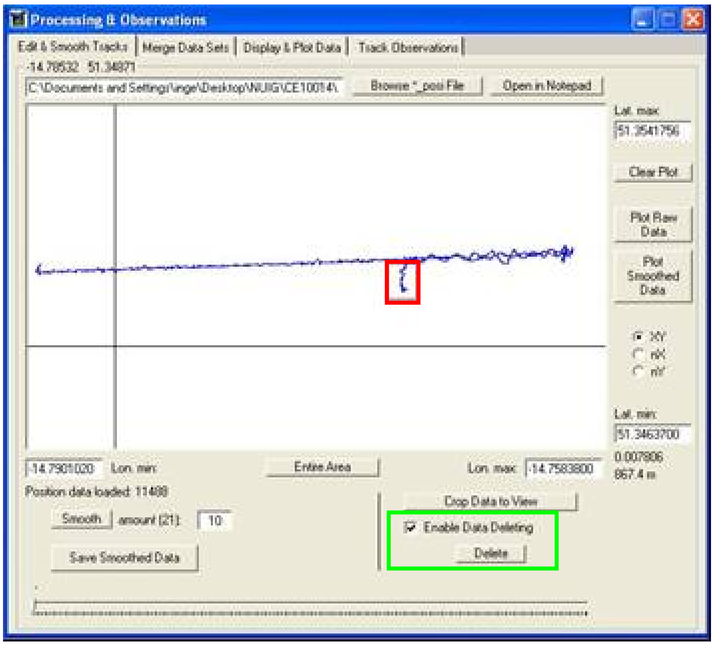

Figure 5. Deleting outliers or data that is not part of the track to make the navigation more accurate. Check "enable Data deleting" (green square) and select the data by dragging a red square over the data that needs to be deleted. Press "delete" and click on "plot raw data" to plot the data again without the deleted part. Be careful: uncheck "enable data deleting" before plotting the new raw data.

The next step is smoothing the data. This function calculates the position of the ROV every second, while the original navigation is recorded at larger time intervals. This makes it possible to merge other data, such as the observations, to the clean navigation track, even when the position at that time was not originally recorded. To smooth the data the smooth amount can be filled in on the same tab as deleting the outliers (red in Figure 6). In this study a smooth amount of 20 is used; this is the number of data points that are averaged to smooth the track. The smooth track can be plotted by clicking on "plot smoothed data" (green in Figure 6). Save the smoothed track by clicking "save smoothed data (red in Figure 6).

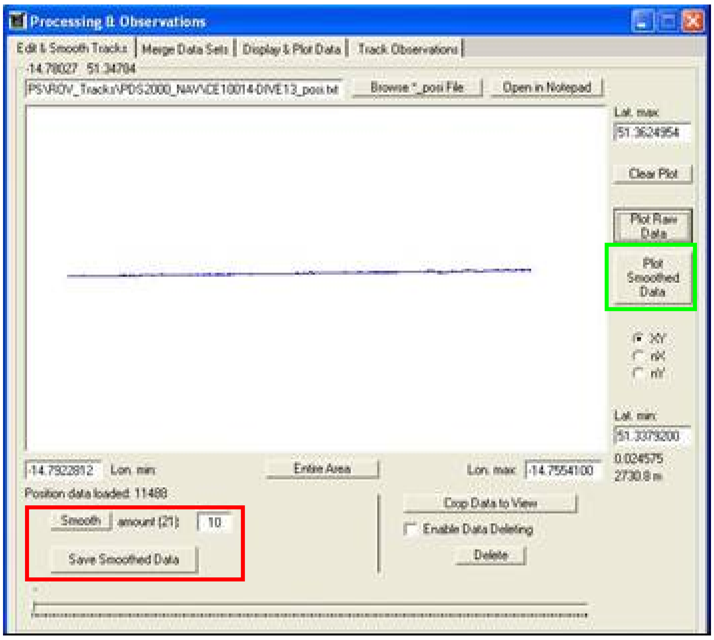

Figure 6. A window to smooth the track. The size of data points that needs to be average can be selected (red square), the data can be plot (green square) and the smoothed data can be saved (red square).

This smoothed data file can be used for further analysis and is used in the preliminary results given in Section 3.3.2.

3.3 Real-time annotation of video using OFOP

3.3.1 How does OFOP work?

There are several steps in using OFOP for observation of videos in real-time: making an observation window; calibrating maps; connecting to navigation; making a new protocol; and opening map calibration, deployment and observation windows. The substrate and animal species can then be recorded from the video. These recordings are automatically stored with time, date and position into a text-file which can be used for post-processing.

<u>Before the cruise</u>

After opening the program, the title page and the window with the command menu will be visible (Figure 7).

Figure 7. Title page of OFOP. The tool bar (file, GPS & Logging, Protocol, Tools, Map, Window and About) can be used to give several commands and open other windows necessary for recording substrate and animal species on the video footage.

Before the cruise, the first thing that should be made is an observation window that suits the needs of the cruise. This observation window is used for recording the substrate and animal species on the video. It is coupled to a text file that has three TAB separated columns; one for the button and list names, a second for an entry ID, and a third for a button ID. The manual of OFOP explains how to change these buttons and lists in more detail (http://ofop.texel.com/). Figure 8 shows the observation window used during the CE10014 cruise. Since the focus of that cruise was on substrate and fish species, these aspects (buttons and lists) give more detail than the list with other animal species, e.g. Echinodermata and Porifera. When an animal species, substrate or any other interesting object is seen on the video, the button or list entry can be clicked. This makes a record in a text file, containing time, date and navigation and marked with *_obser.txt.

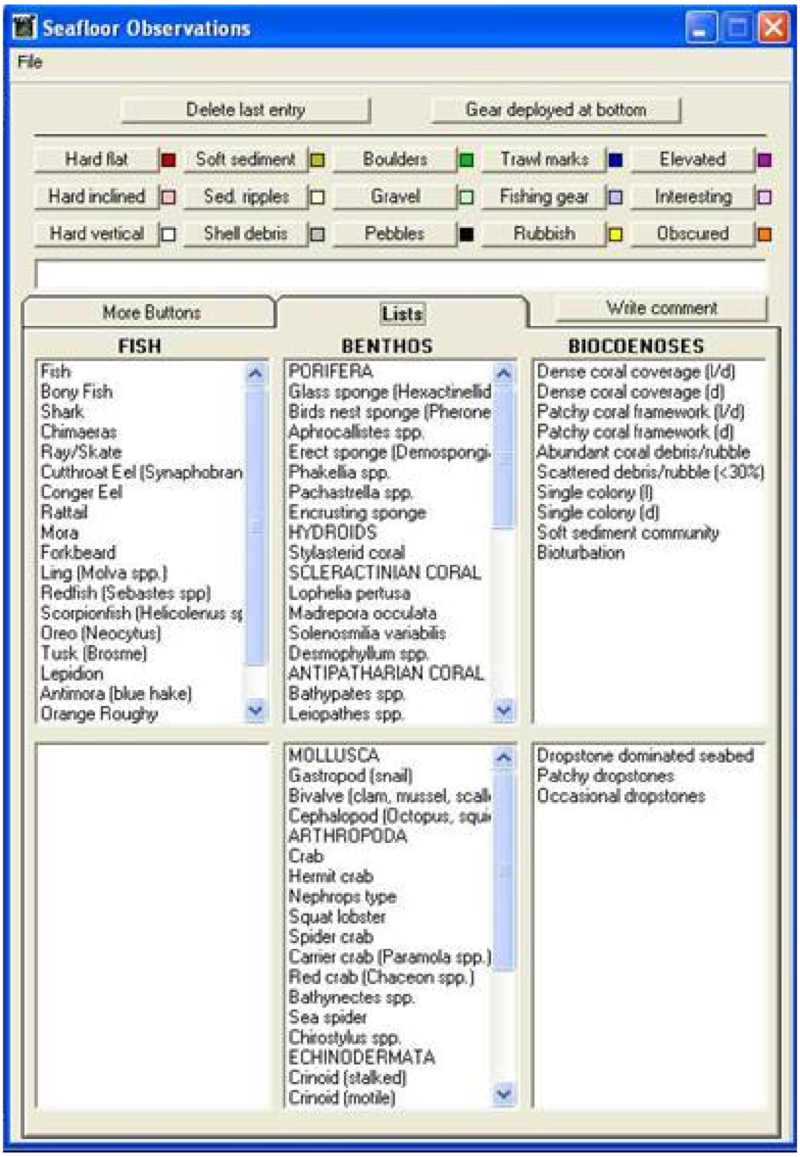

Figure 8. The observation window used during the cruise CE10014. The buttons contain the substrate , such as hard ground and soft sediment, and the anthropogenic impact, such as trawl marks. The lists contain other information, mainly animal species. However, one list is dedicated to biocoenoses (e.g. coral coverage) and one states the amount of dropstones on the seafloor.

This observation window needs to be made before the cruise, but can be changed on the cruise if the buttons and lists do not fulfil the needs of the observer. It is possible that some animal species are forgotten or that one animal species is seen very frequently on the video but is not listed in the observation window.

The creation of the observation window is not the only thing that can be done before the cruise. OFOP uses maps to follow the position of the ROV. These maps can be made before the cruise with ArcGIS. The following map is made to use in OFOP. The bathymetry, the depth contours, a geographical reference and the track can be seen (Figure 9; left). Because the map is a .jpg file, it needs to be calibrated so the ROV can be plotted on the map. This can be done in OFOP using “calibrate a map” in the “file” menu of the title page after loading a map file (in the same menu). A calibration window appears (Figure 9; right).

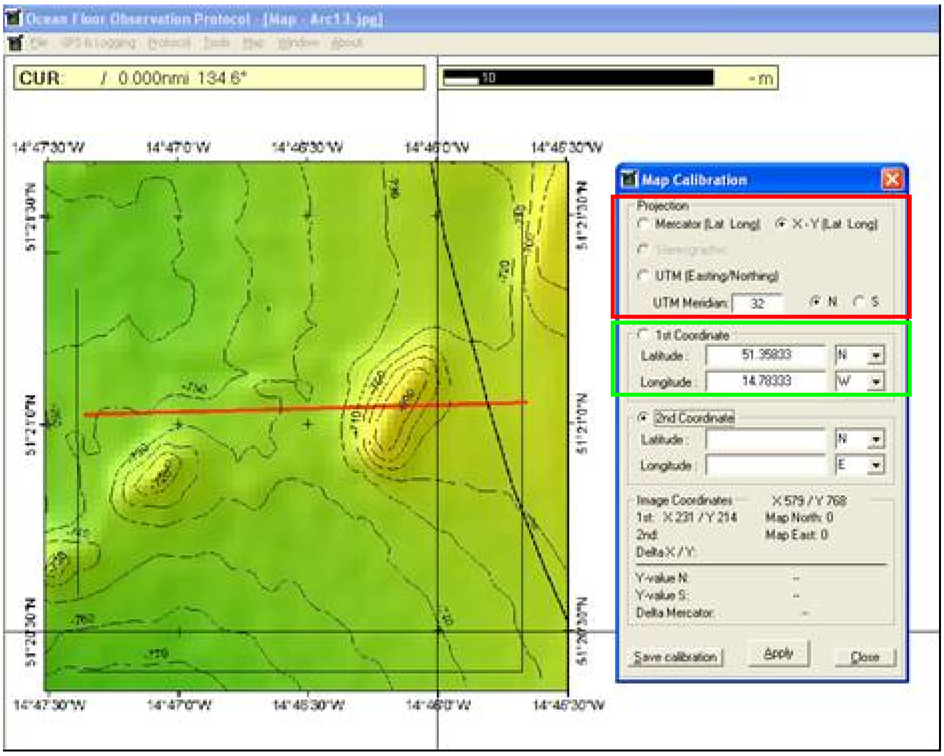

Figure 9. The map calibration window. A map can be calibrated using this window. The maps used in this study were .jpg files exported from ArcGIS®. The references on the site of the map can be used to calibrate the map. Select the X-Y (lat long) in the projection window (red square). Type the longitude and latitude of the first coordinate in the green square and click on a point in the map that corresponds to those longitude and latitude. Do the same for a second point (select 2nd coordinate as this is done in this figure). Click on "apply" and check if the map is calibrated correctly. If this is correct, save the calibration by clicking "save calibration".

<u>During the cruise</u>

Calibration of maps and creation of the observation windows can be done before the cruise. The following steps need to be taken while preparing a dive during the cruise.

First the navigation needs to be connected to the program. This can be done by opening the "Ship and Sub selection – Data connection" window (Figure 10; left) that can be found in the menu "GPS and data logging". COM port settings of the navigation from both ROV and ship need to be set using the lists in the red square in Figure 10. The first position is used for the ship's navigation and the second position for the ROV navigation. Be aware that the 1st and 2nd position needs to be set separately and the position that is changed is ticked. In Figure 10 the 2nd position is ticked (green).

Another step needs to be taken to connect the ROV navigation to the program. This can be done by selecting "ROV- Data connection" in the "GPS & Logging" menu. The ROV data connection window opens (Figure 10; right). Tick "connect to the ROV" (pink square) and fill in the right COM port settings. In the white block below these settings – indicated by a blue square – navigation data will appear (not shown in this figure). Press "apply" and close the window. To check if the navigation data from both the ship and the ROV is connected to the program, select "Show Received COM port data" in the "GPS & Logging"-menu. The numbers in the window that appears should be changing.

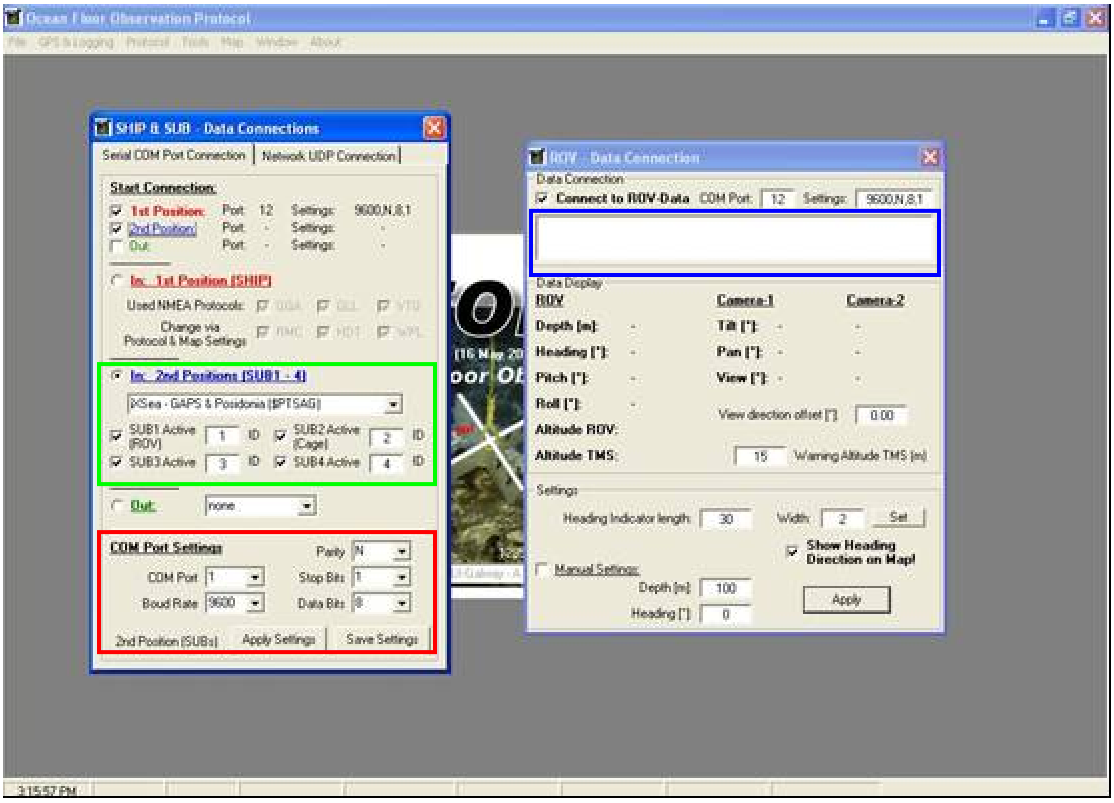

Figure 10. Connecting the ship and ROV navigation data to the program. In the left window the COM port settings (red square) of both the ship (1st position) and ROV (2nd position) is applied. The ROV navigation needs to be connected by the ROV-Data connection window (right). Tick "connect to ROV-data" and changing numbers should appear in the window indicated by a blue square

If the navigation is connected, the next step is to open a calibrated map by selecting "Load calibrated map" in the "File" menu. The calibrated map appears and the ship and ROV are indicated by a blue circle and orange square. The heading is also shown by a line.

The previous described steps are everything that needs to be done to prepare a dive. The next step is to start a "New protocol" in the "File" menu. The protocol records everything that is recorded during the dive. After clicking this, a window appears that allow you to select a folder and type a name for this protocol/dive. All the different files made by OFOP are named the same way. OFOP makes a protocol file *_prot.txt), a position file (*_posi.txt) and an observation file (*_obser.txt). Sometimes OFOP also creates a so-called cherokee file (*_cherokee.txt). Together these files contain the date, time, position and the observations of the dive. Press "ok" if you selected the correct folder and typed the correct name.

After this, open the "deployment window" and the "seafloor observation window" in the "protocol"menu. The deployment window (Figure 11) records the time when the ROV is in the water and at the bottom. To record this, the "now" button (red) needs to be clicked. A time appears (green) and the next line is selected (in this case "at the bottom"). The program only records the logging of the observation window when the ROV is "at the bottom". When the transect is done and the ROV is being recovered, press "now" when "off the bottom" and "on deck" are selected. The ROV dive is ready then and nothing can be added anymore. OFOP can be closed or being prepared for the next dive.

Figure 11. The deployment window that records the times that the ROV is in the water, at the bottom, off the bottom and on deck. It can also be used as a reminder when tapes need to be exchanged because the tape is full. However, this function cannot be used if tapes of other than 2 or 4 hours duration are used.

After the cruise

The data recorded by OFOP can be clean (e.g. navigation data) and merged with other data (e.g. CTD data). Merging data is done by the same window as the window used for cleaning and smoothing the navigation data. Select "Processing and Observation" in the "tools" menu of OFOP. Select the tab "Merge data sets" (green in Figure 12). Load the track data and make a data array (red square), load the observation file (pink square) and if desirable other data, e.g. CTD data (blue). Add the data to array. The data will appear in the white block on the bottom right of the window (orange). Tick the information that is desired in the merged file. Before saving the merged data ("Save merged data array"), spline the data (black) to fill each of the 1 second intervals of the smoothed navigation data.

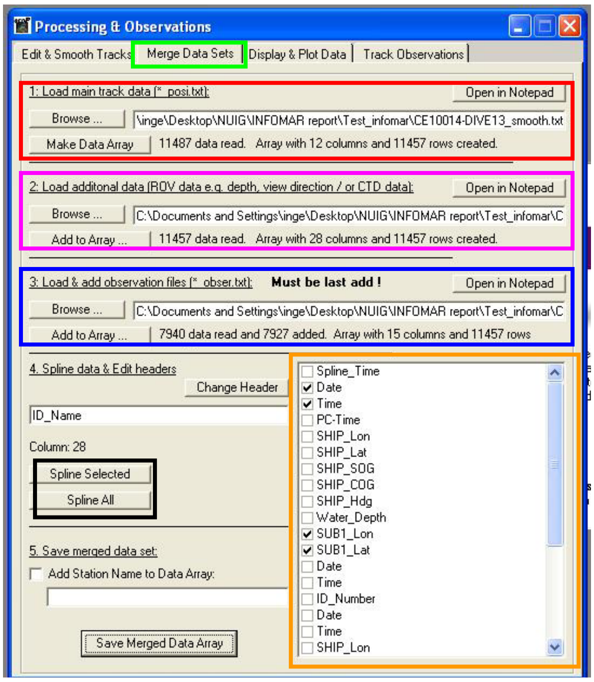

Figure 12. The window used to merge several data sets. The smoothed track data (red square) and the observation data (blue square) can be merged. Other data sets, e.g. CTD data, can be merged with the other datasets as well (pink). After adding the data set to the array the columns appear in the block on the right bottom (orange). After ticking the desired information, the data will be splined (black) and saved.

These merged data can be used for further analysis, e.g. used to plot the different substrates on maps using ArcGIS®, while the observation file is used to analyse the fish abundance on the different habitats in the Arc Mound province.

3.3.2 Preliminary results

The preliminary results are based on substrate and fish data recorded real-time by OFOP. The vertical camera was used to analyse the substrate and the fish were mostly recorded from the HD camera. In Figure 13 and Figure 14snapshots are seen from the vertical camera at the different habitats and Figure 15 shows snapshots of the HD camera in both habitat types.

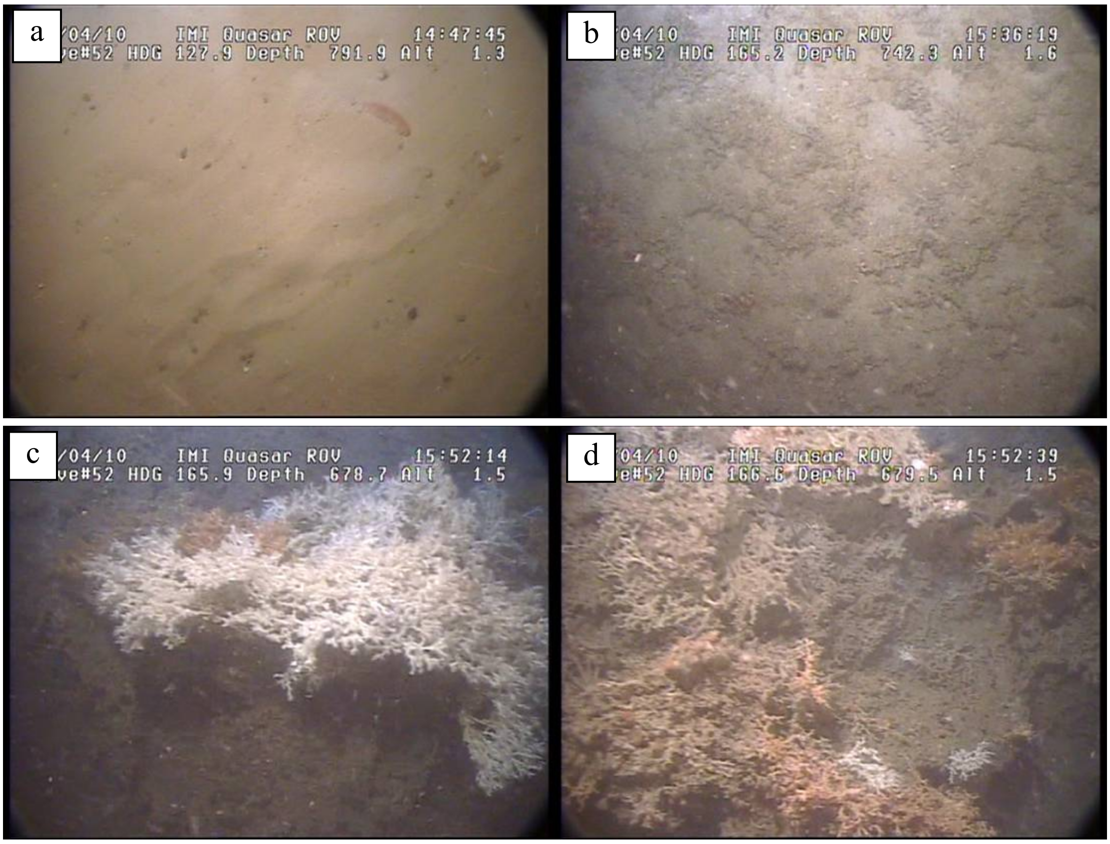

Figure 13. Snapshots of the vertical camera (dive 14) in the coral habitat. The substrate of the first and end part of the dive are covered by soft sediment (a). Closer to the mound some coral rubble (b) can be found. On the summit of the mound several coral frameworks (c and d), both dead and alive, can be found.

Figure 14. Snapshots of the vertical camera (a, b: dive 16; c: dive 18) in the control habitat. Most dives were covered by soft sediment with bioturbation (a). Several fish species, such as monkfish (b), were seen. Sporadically a dropstone was seen (c).

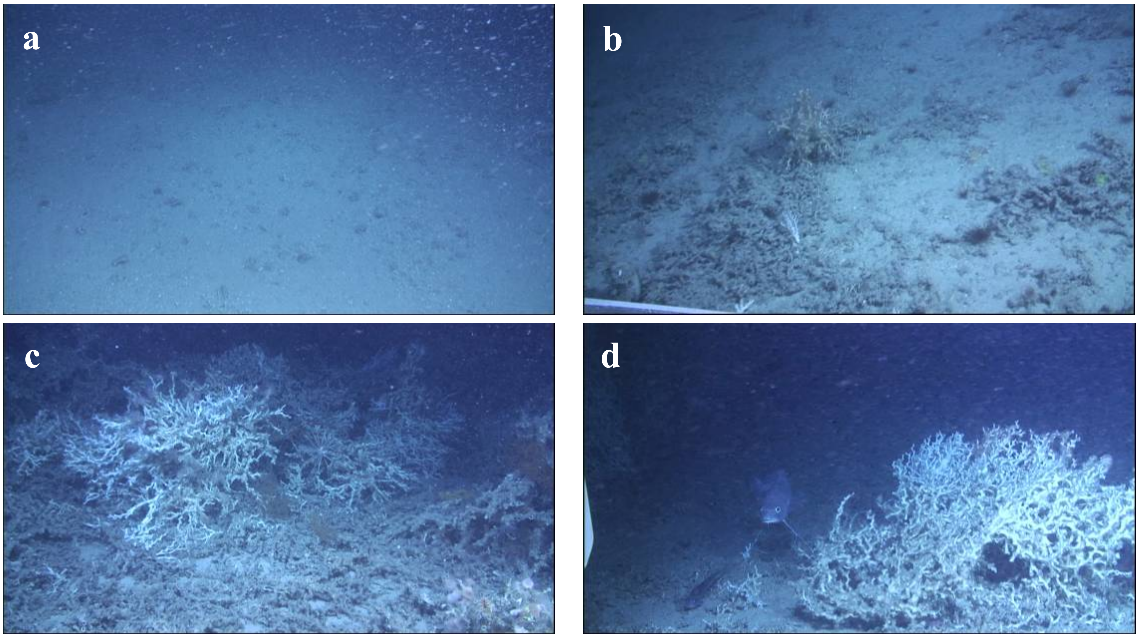

Figure 15. Snapshots of the HD camera of the coral habitat. a) soft sediments surrounded the mound, followed by coral rubble closer to the mound (b). The top was covered by coral frameworks (c and d). A greater forkbeard (*Phycis blennoides*) and grenadier (*Macrouridae*) are seen on d.

<u>Substrate</u>

During the real-time recording of the video footage, substrate was recorded andclassified into soft sediment, sediment ripples, hard ground (flat, inclined and vertical), coral (single colony, patchy framework and dense framework) and coral rubble (scattered or dense). The different substrates are plotted on a map with depth contours of the Arc Mounds (Figure 16).

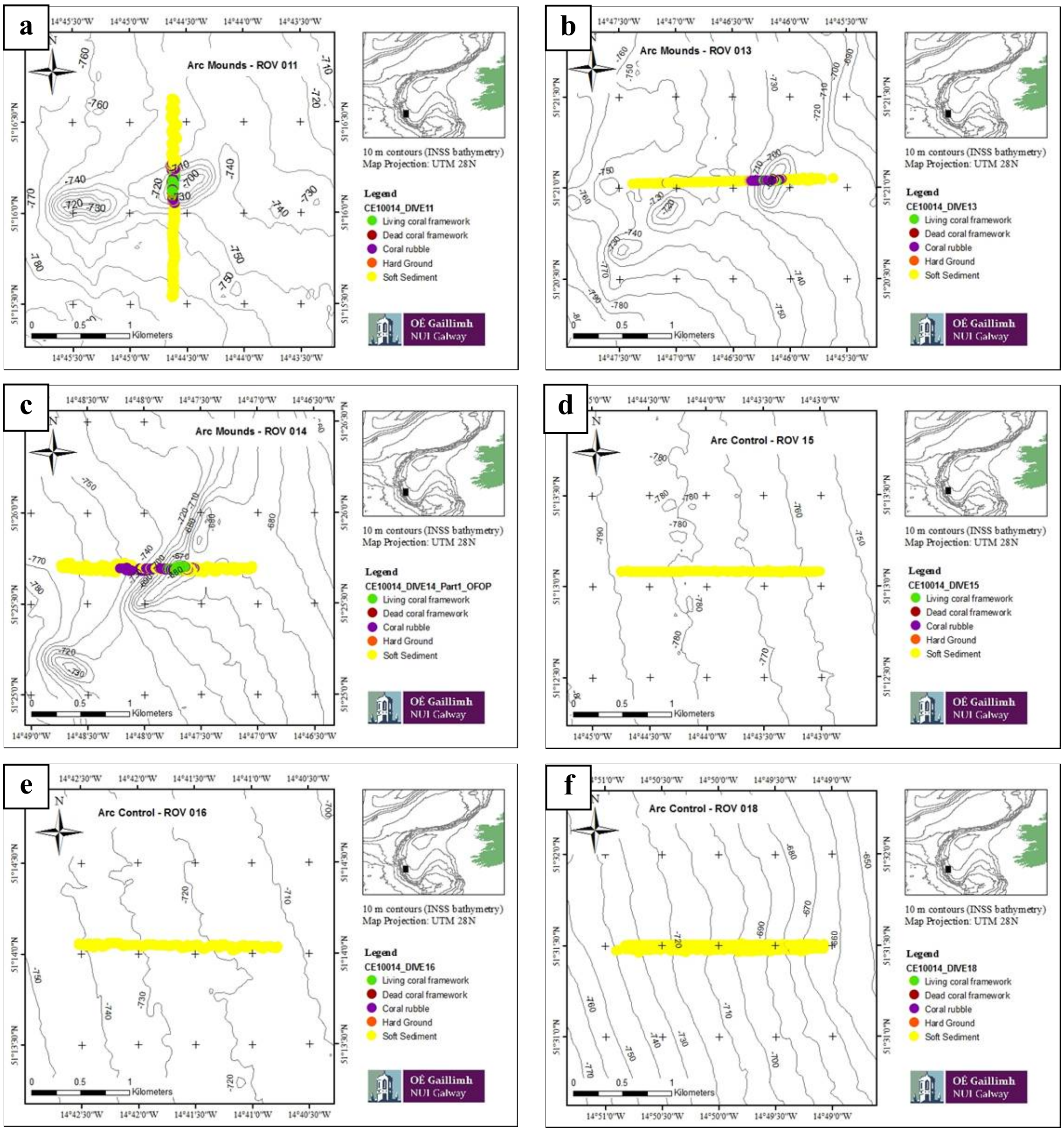

Figure 16. Preliminary results of the substrate of the different transects in the Arc Mounds province. a-c) The transect in the coral habitat; d-f) the transects of the non-coral/control habitat. The yellow colour indicates soft substrate; green indicates living coral framework; red the dead coral framework; purple represent coral rubble and the orange colour indicates hard ground.

The seafloor of the control transect (Figure 16d, e, f) are covered with soft sediment. The main part of the transects in the coral habitat was soft sediment as well. The coral (framework) is concentrated on the summit of the mounds (Figure 16a, b, c).

Fish

The fish seen on the videos during the different dives were counted per dive. The total number of fish are averaged over the transects in each habitat (3 dives in the coral habitat and 3 dives in the control habitat). Comparisons between the fish abundance in the coral habitat is compared with the fish abundance in the control habitat. These results are based on the counts of fish seen during the real-time observation of the video. The HD camera is analysed in most of the dives. However, sometimes the visibility was bad because of much marine snow. In this case the vertical camera was analysed. The results can change after post-processing. It is possible – even though the video observers were very careful – that fish are counted twice. Features that look like fish initially, but turn out to be, for example, shadows, decrease the number of fish in the post-processing. The total number of fish can also increase, because some fish that are caught on camera were not seen in real-time, but are seen in post-processing when the video can be paused, rewound and played again. Most fish are still unidentified, so the results shown here are based on all fish. Table 4 shows the total numbers of fish found at the different dives. Frame grabs from the HD camera can be seen in Figure 15.

Table 4. The total number of fish counted at the different transects during real-time analysing the HD camera. The first column shows the dive number, the second column the habitat, the third column gives the total number of fish and the last column shows the average of fish numbers and the standard deviation of the two habitats.

Dive number	Habitat	Number of fish	Average (± st.dev.)
11/17	Coral	191	146 (± 47)
13	Coral	98	
14	Coral	150	
15	Control	172	140 (± 34)
16	Control	142	
18	Control	105	

Figure 17 is a schematic presentation of Table 4. It shows the average number of fish seen on the transects in coral habitat and the average number seen on the transects in the control habitat. There was no significant difference in number of fish between the two habitat types (t-test: $t = 0.20105$; $df = 4$, $p = 0.85$).

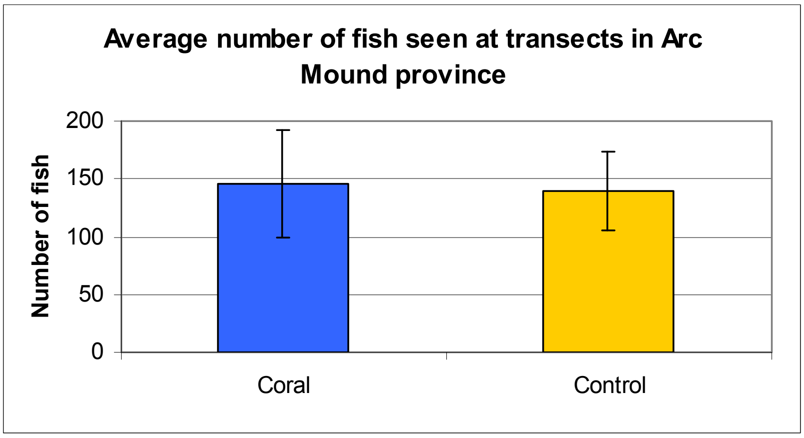

Figure 17. The average number of fish seen at the coral and control transects in Arc Mounds. On the y-axis the average number of fish can be seen. The colours of the bars and the x-axis show the habitat; blue is the coral habitat and the yellow bar shows the results of the control habitat. The error-bars represent the standard deviation. There was no significant difference between the numbers of fish seen in the two habitats (t-test: $t = 0.20105$; $df = 4$, $p = 0.85$).

Similar number of fish were found in the coral habitat and at the transects in the control habitat. Figure 16 shows that the transects in the coral habitat were mainly covered by soft sediment and that the coral (framework) was concentrated on the top of the mound. Therefore, it is interesting to see whether the number of fish seen on the soft sediment part of the coral transects differ from the number of fish found on the coral framework part. The distance of the soft sediment and the distance of the coral framework were measured. The numbers of fish seen on the corresponding substrate were divided by the distance of that substrate to standardise the fish abundance and to be able to compare the numbers. It appeared that similar numbers of fish were found on the framework and on the flat sediment of the coral habitat transects (t-test: t = -0.667; df = 4; p = 0.54; Figure 18).

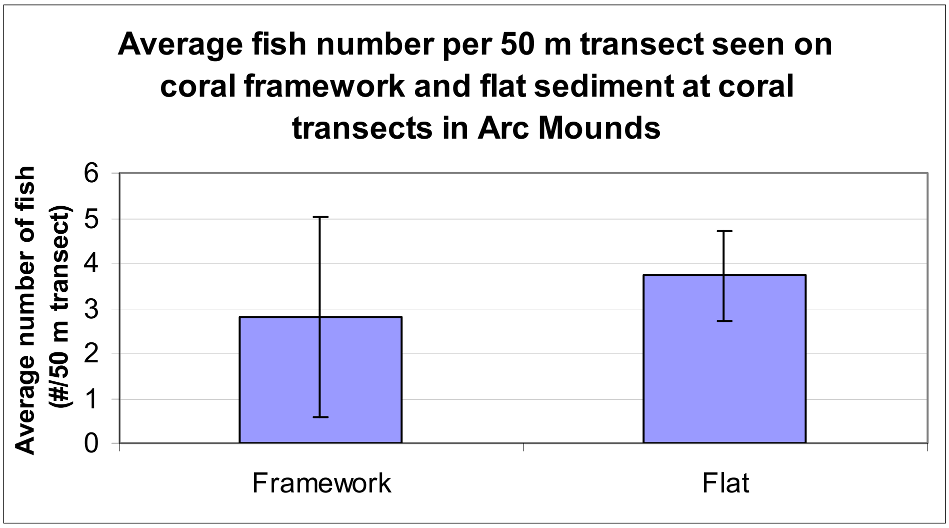

Figure 18. The average fish numbers (per 50m transect) seen on framework and flat sediment of the transects in the coral habitat. Similar numbers were found on the different parts of the coral transects (t-test: t = -0.667; df = 4; p = 0.54).

<u>Preliminary results: Conclusions</u>

The substrate of Arc Mounds is mainly soft sediment along both the coral and the control transects. Bioturbation was common along the transects of the control habitat. Some (live) coral framework was found in this region, but it is concentrated on the summit of the mounds. The fish abundance found in the coral habitat was similar to the abundance in the control transects. This might be to do with the fact that the largest part of the coral transect was covered with soft sediment. However, there was no significant difference in the number of fish in the coral frameworks on the top of the mound in the coral transects than in the surrounding flat sediment. It is possible that the coral on the summit influences the fish species on the flat sediment, but it is not known over what distance the presence of coral might influence the fish . Fish are highly mobile animals –they can cover a large distance in relatively short time – and it is possible that the approximately 1 km on each site of the mound does not have an effect on the fish.

Although the numbers of fish are not different between the control and the coral habitat, it is possible that the fish species composition differs between the two habitats. Since most of the fish are still unidentified at species level, this cannot be checked. Some species have already been identified, although these may change during post-processing. More grenadiers (*Macrouridae*) were seen on the control areas than on the coral areas (115 vs. 37), suggesting that they are more specialised to soft sediment or flat sediment than to coral habitat or sediment with a 3-dimensional structure. However, this is not tested and it may change when all fish are identified during post-processing.

3.3.3 Conclusions real-time data acquisition

OFOP is a good product to use for analysing video in real-time, i.e. onboard the ship. It can give an idea about the substrate and animal species in the different habitats. It can also be used for post-processing, although it is limited in some abilities. It is possible to make frame grabs at a certain time interval, but it is not possible to do this at certain distance intervals, e.g. every 1m of transect. Another aspect that is not possible with OFOP is calibration of the image. One way of standardisation is to analyse the substrate and animal species (except fish) within a certain area, e.g. 1m x 1m (Sulak 2007, Kutti et al. 2009), and it is not possible to plot this certain area on the images to make the analysis easier and more efficient.

4 Standard operating procedures (SOPs)

4.1 Image analysis

After the navigation is cleaned and smoothed (see section 3.2) and the data is splined to get a record every second, all the preparatory work is done, and the video is ready for analysis. OFOP's image generator takes a frame grab at a certain time interval, it is these frame grabs which can be analysed.

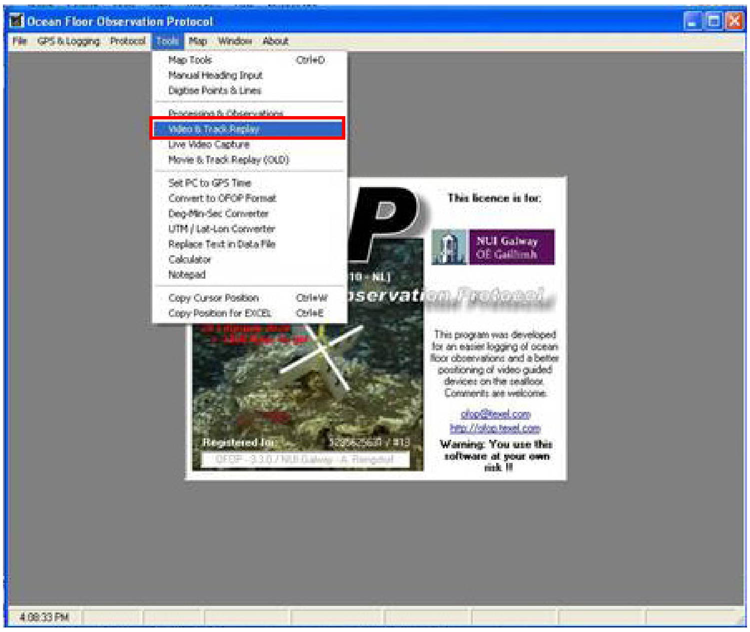

Figure 19. The 'Video & Track Replay' window can be found in the Tools menu.

The following outlines the method for making these frame grabs . After loading OFOP, choose the option 'Video & Track Replay' in the Tools menu (Figure 19).

The Video & Track Replay window opens (Figure 20). This window has four tabs. One for regulating the video, one for regulating the track navigation, one to make the frame grabs and one to select the navigation file and video file.

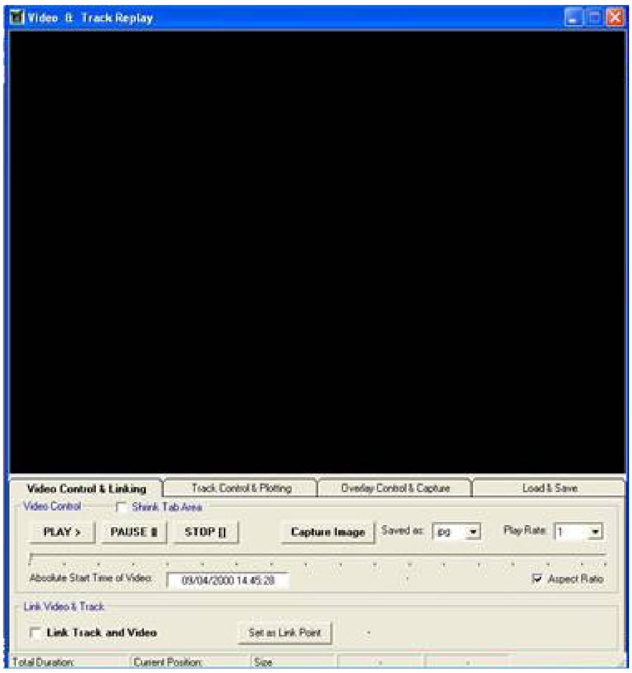

Figure 20. The 'Video & Track Replay' window

The first step is to select the navigation and video files that can be found on the 'Load & Save' tab (Figure 21). Select the navigation file (.txt) by clicking the 'Browse' button in the first line (red). Select the video file in the second line (green). The last line is the directory where the image files should be saved (pink).

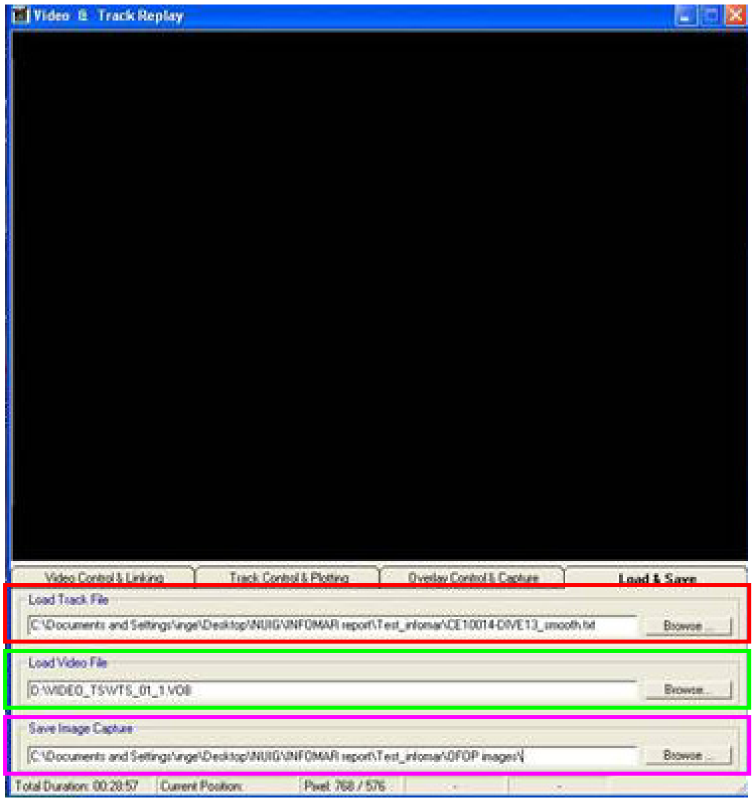

Figure 21. Load a navigation file, the video and select a directory to save images in.

Figure 22. Load the video.

After this, load and start the video. This is done at the 'Video Control & Linking' tab (Figure 22). Press 'play' (red). The video will show on the screen. Pause the video and fill in the absolute start time of the video (green) and press play again. The time behind this line should change in the correct time. Pause the video again.

The next step is to synchronise the navigation and link the navigation to the video (Figure 23). To do this, the navigation must be set to the same time as the video. It is easiest to move the video to the beginning of the file (absolute start). Fill in that time in the line that is highlighted with red in Figure 23. It can be found on the 'Track Control & Plotting' tab. Click on 'Go to this time'. The track time should be the same as the time of the video (green). If this is not the case, the time can be adjusted by the slide (pink).

Figure 23. The ‘Track Control & Plotting’-tab.

When the correct time is selected, it is necessary to link the navigation to the video, so the annotations will have the correct position. This can be done at the ‘Video Control & Linking’ tab (Figure 24). First the button ‘Set as Link Point’ needs to be clicked (red). After this button a number behind track and video appears (in this case: 172 and 0). Check if the time of both the video and the track is still correct and the same! If this is correct, tick ‘Link Track & Video’ (green).

Figure 24. Link the video and track to each other.

Check if the link is correct by playing the video for a few seconds and pause it. Go back to the ‘Track Control & Plotting’-tab and check if the time on the track is the same as the time on the video.

Frame grabs are made using the ‘Overlay Control & Capture’ tab (red; Figure 25). There are two options: i) automatic capture while playing the video and ii) automatic capture by jumping to the next time interval. The first option means that a frame grab is taken while the video is played. The second option means that the video will not play, but will jump to the next time a frame grab should be taken. The time-interval can be set by filling the number of seconds after each option. The number of frame grabs taken is counted and showed in the last line (red). Let the video play to take frame grabs (both options). When the capture function is running ‘Capture: on’ will appear at the bottom of the screen (green).

Figure 25. Image generator.

The data, both video and images, can be analysed using the same protocol as the analyses of a dive in real-time, using the video-replay window . A new observation file will be created that contains the time, position and the identified species.

4.2 GIS integration

The data from OFOP can be integrated into ArcGIS®. The major data files needed for this integration are the shapefiles from bathymetry of the area, navigation, and the video observations. The first step is to add the bathymetry data by clicking on the 'add data' button (Figure 26). Browse for the right shapefile and click 'ok'. This data shows the depth in colours. The colours can be easily changed.

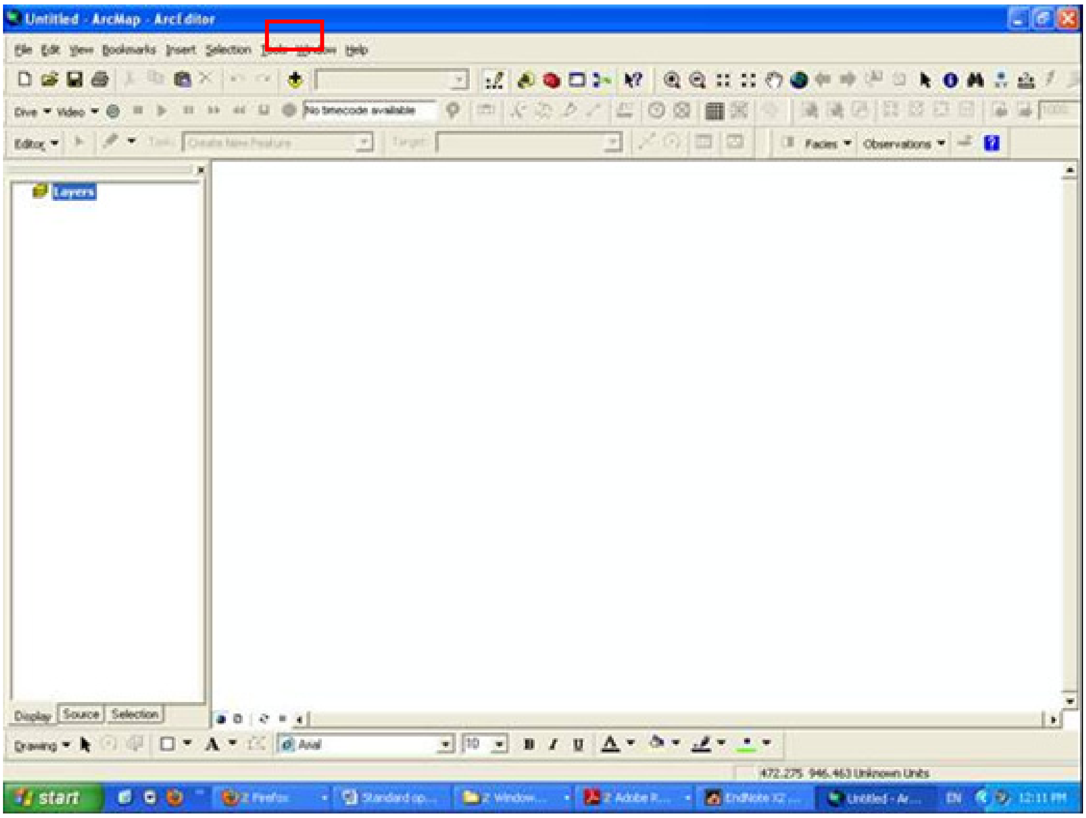

Figure 26. Add data.

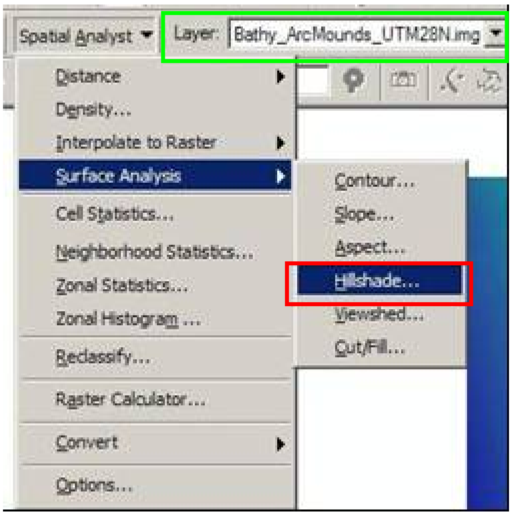

Figure 27. The 'hillshade'-function can be found in the 'Surface Analysis'-menu in the 'Spatial Analyst'-extension.

The mounds are easier to see when the 'Hillshade' function is used. This function displays elevation rasters and calculates the surface light and shadows based on a sun position. The 'Hillshade' function can be found in the 'Surface Analysis' menu in the 'Spatial analyst' extension (Figure 27; red). The layer involved in the manipulation can be seen next to the 'Spatial Analysis' extension in Figure 27 (indicated by green). However, the extension toolbars can be placed anywhere, so this does not have to be the same in each ArcGIS® program.

Figure 28. The window necessary to make a Hillshade of a layer in ArcGIS®.

A new window appears (Figure 28). The input surface can be changed, as well as other values, such as the Z factor and the output cell size.

Figure 29 shows the effect of using Hillshade. The mounds do not show up very well with bathymetry only, but are more visible in the Hillshade image(Figure 29b). The colour of the Hillshade can be manipulated. Overlapping a partly transparent bathymetry over the Hillshade gives a depth range in the same colour, but the mounds are better visible (Figure 29c).

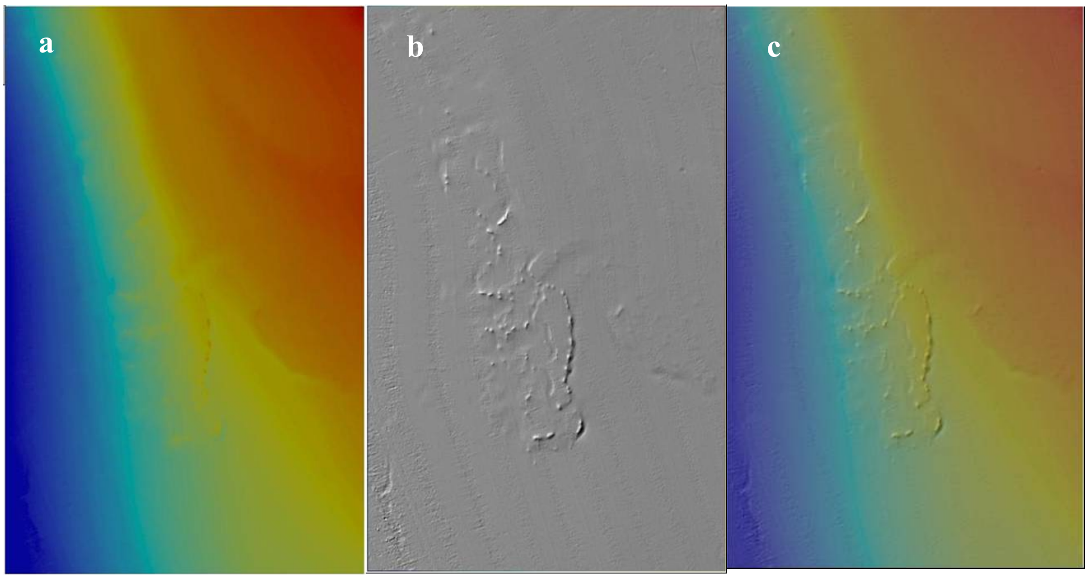

Figure 29. a) the bathymetry of Arc Mounds in ArcGIS®. The colours show the depth (shallow-deep: red-blue). b) the Hillshade of the bathymetry. The mounds are better to see than on the bathymetry. C) the combination of the bathymetry and Hillshade.

The shapefiles of the navigation can be added on the map as well. This can be done by clicking on the 'add data'-button and browse for the relevant shapefiles.

The observation file (text file) can be added by selecting 'add XY data' in the Tools menu (Figure 30).

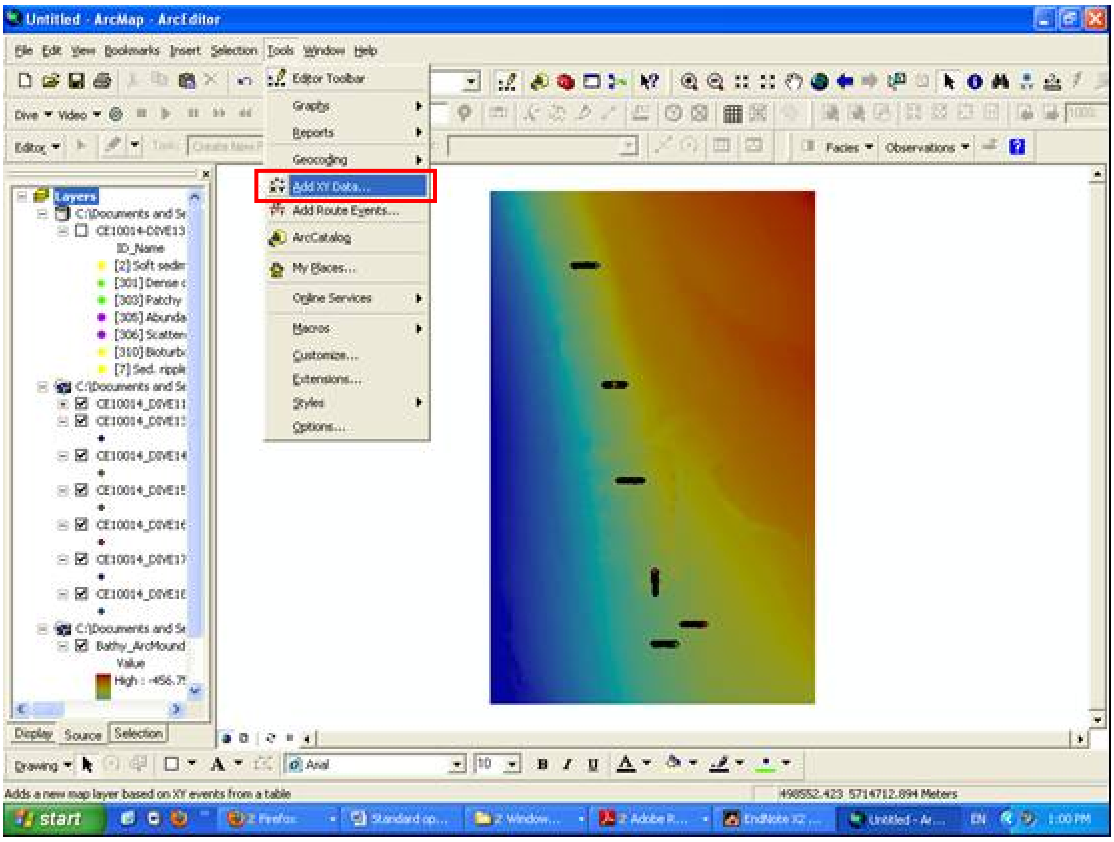

Figure 30. Add XY-data can be found in the Tools-menu.

Select the shape-file, select the correct X and Y values (longitude and latitude) and select the correct coordinate system by clicking on ‘Edit’. In this example, the GCS_WGS_1984 coordinate system is being used. Click ‘ok’.

After this the observation file is added as a layer. To change the symbology of this file to show the substrate or the fish for example, double click on the layer. A new window called ‘Layer properties’ opens (Figure 31). Select the tab ‘Symbology’. On the left a menu is seen (green) and contains the aspects that can be shown on the map (Features, categories, quantities, charts and multiple attributes). Select the categories-aspect.

In the value field (pink) the headers of the columns in the observation file can be found. Select the desired headers; in this case ID_Name. After selecting the header click on ‘add all values’.

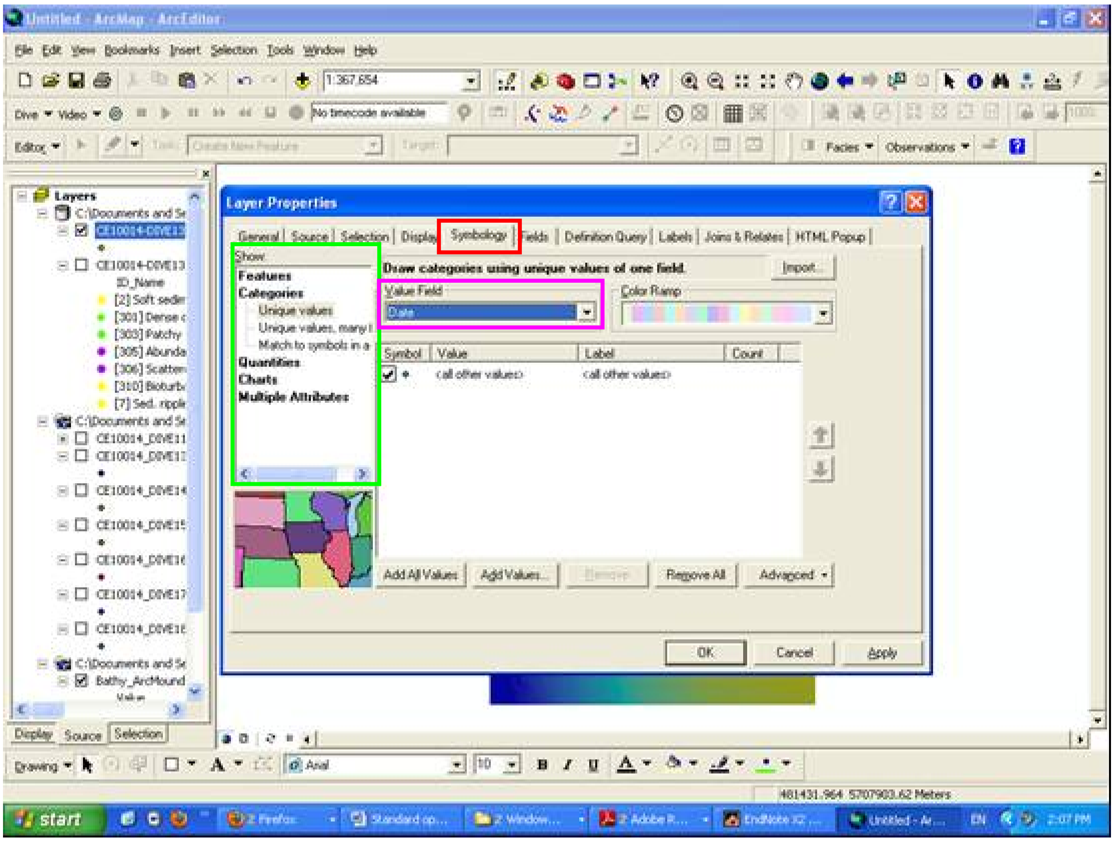

Figure 31. The Layer properties window to change the symbology.

All the values appear in the window in Figure 32 (red) with the label and the total number that that particular label/value was found in the file. In the figure below, it records that during this dive 37 fish and 22 bony fish were seen.

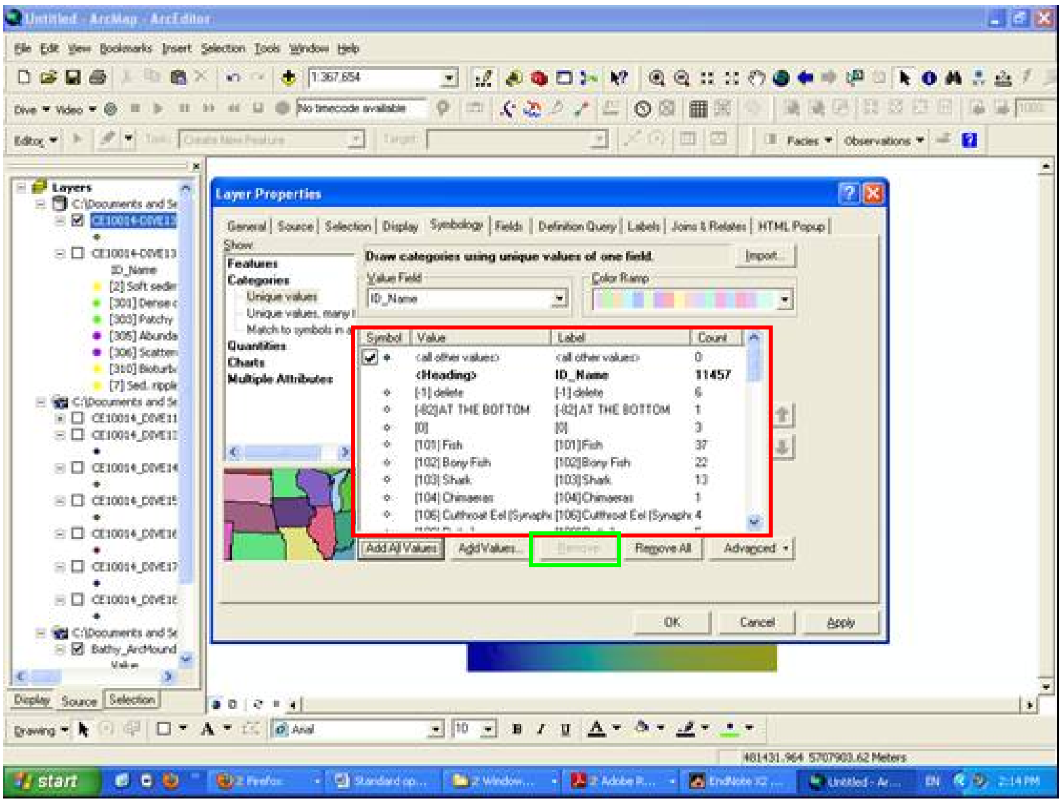

Figure 32. The values of the table.

Depending on what is desired to show on the map (e.g. substrate, fish, anthropogenic impact etc.) the unwanted values can be removed by selecting that value and click on 'remove' (green in Figure 32).

The symbol of the value can be changed by double clicking on the value. A new window 'Symbol Selector' appears. Select the correct symbol, colour and size of the symbol. In this window a blue circle with size 9 mm is selected (Figure 33). Click ok.

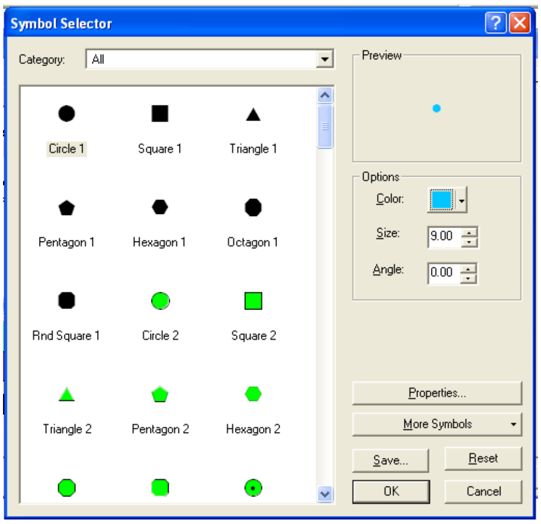

Figure 33. The window to change the symbol of a value.

The symbol of 'fish' is changed into the blue circle with a size 9. Do this for all values (Figure 34).

After changing the symbology of all values, click 'apply' and 'ok'. The track will show the selected values in certain symbology. In this example, it will show the different fish species – from unidentified to family name – along the track (Figure 35). The colours correspond to what fish can be seen on the left (red).

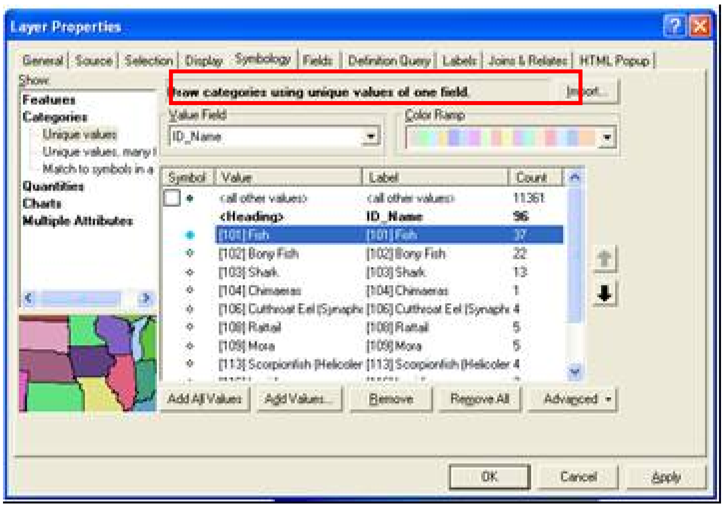

Figure 34. The symbol of 'fish' has changed.

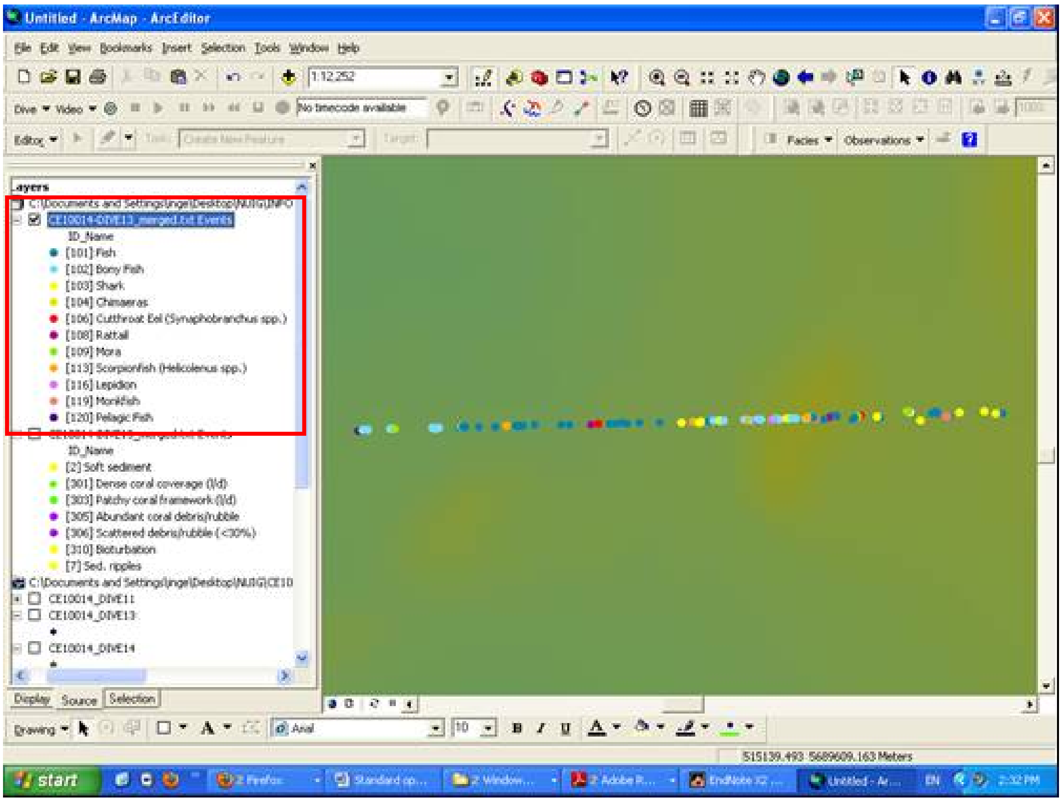

Figure 35. The fish seen along the track. A legend can be seen on the left (red).

A second example is the substrate (Figure 36). The legend is seen on the left of the figure. This map shows every time a certain value is in the observation file. This can be manipulated by selecting only the values every 10 or 50m.

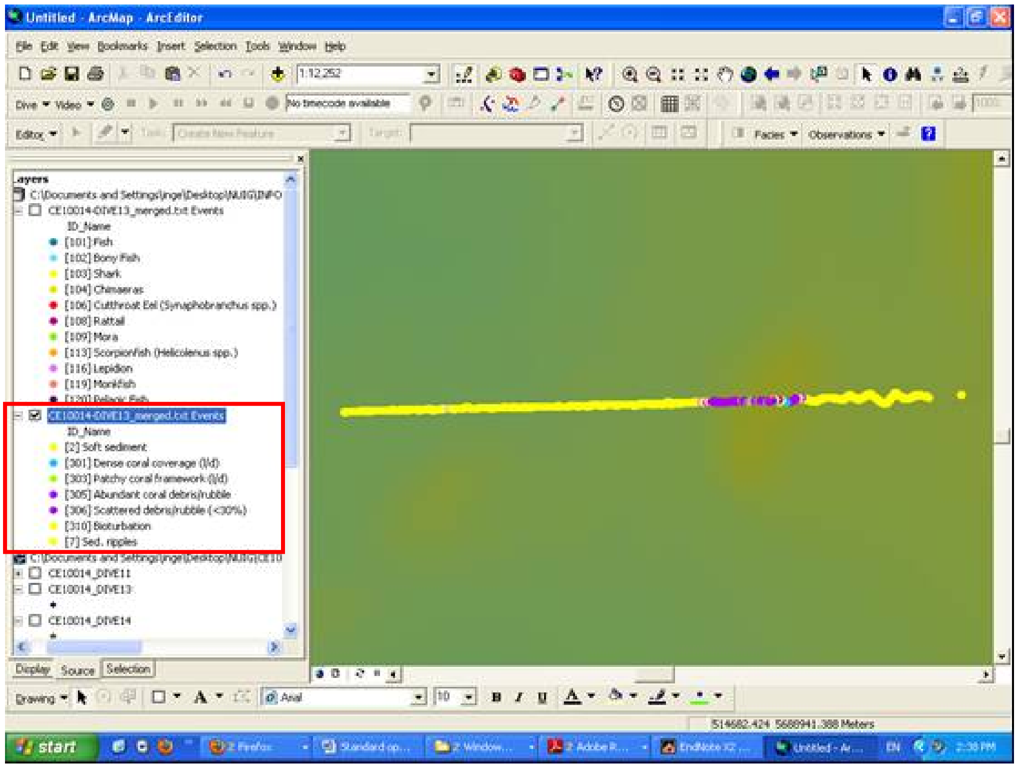

Figure 36. The substrate seen along the track. The legend can be seen on the left (red).

In this way all the different observations can be plotted on the map. Combinations can also be made, for example substrate and fish.

4.3 Classification

Closing deep-sea areas, e.g. to fishing activity, in order to protect habitat is increasingly being used worldwide. Marine protected areas (MPAs) are established by International, European and national initiatives. However, setting an MPA is not that easy. There are several criteria, e.g. ecological and economic importance, that need to be investigated before designating an area in the ocean an MPA. It is important to know what to protect. The use of indicators, such as biodiversity, is very important in this case. However, given that the distribution and function of deep-sea biodiversity is not well known, representative patterns in biodiversity at different scales need to be established. The ability to create an MPA that is properly representative of the area is largely dependent on the ability of scientists to classify the environment into defined units that represent the biodiversity of the deep-sea at a variety of scales (Howell 2010). Classification systems have been developed to aid mapping the biodiversity of the deep-sea. The maps created this way can, in their turn, help to design MPA networks. Several classification systems already exist for different regions in the world, ranging from the USA to New Zealand and from the north to the south of the world (Howell 2010). However, most of these classifications do not specialise in the deep-sea. Two frequently used classification systems that are specialised for the deep-sea are 'Global Open Oceans and Deep Seabed' (GOODS; UNESCO 2009), and the 'European Nature Information System' (EUNIS; Davies et al. 2004), both of which are based on other classification schemes. Almost all classification systems that have substrate as a category follow the divisions of the Wentworth scale (1922), with the addition of various generalised terms such as 'mixed substrate'.

The EUNIS system was developed between 1996 and 2001. Although this system has a classification that fits the purpose of mapping representatives of a certain habitat, the deep-sea section of this system cannot provide a classification system that can be used in MPA design and wider spatial planning (Howell 2010). The EUNIS classification is built up in several levels. Level 1 includes 'Marine habitats', and the deep-sea bed is a subdivision within this (Level 2) which suggests that the whole of the deep-sea is one homogenous unit with regard to depth zonation and substrate type. The Level 3 divides the classification by detailed substrate type, but leaves out depth. If the maps that are required for MPA design are based on the EUNIS classification system (Davies et al., 2004) they will not fit the purpose of the MPA (Howell 2010). A useful classification system for deep-waters to aid in the designation of MPAs has not yet been developed, but Howell's (2010) classification system is at least biologically meaningful for this purpose.

Understanding the principal factors that influence the distribution of species within the deep-sea forms the basis for the development of a classification system. Once these factors and their importance are established, relevant surrogates of biodiversity – the different features that form the division, e.g. depth, geomorphologic features and substratum type – can be identified and organised in an hierarchical classification to provide an increasingly detailed representation of biodiversity in the deep-sea (Howell 2010). It is important that these surrogates can be easily mapped. Since the availability of fine-scale data in the deep-sea is limited, or the data that is available has been modelled, Howell (2010) reviewed previous classifications, and used these to develop the current classification (Howell 2010, Table 2). Depth, biogeographical province, geomorphology, substrate type and biology are the common and most frequently used divisions in previous classification systems. It is accepted that most deep-sea species have a restricted depth range (Howell et al. 2002, Carney 2005) and it has also been shown in previous literature that biogeography is important to fish, given e.g. a widely recognised division between Arctic and Atlantic deep-sea fauna (Howell 2010). Within the marine research field several seabed features are distinguished: hydrothermal vents, cold seeps, canyons, seamounts and continental slope. Substrate type has an important influence on fauna and certain substrates house specific faunal assemblages. Although the details of biological assemblages are rarely known in the deep-sea, they can provide more detailed information about the deep-sea and are useful to integrate into a classification system. Since there is limited understanding of the link between geomorphology and biological assemblages, Howell (2010) has chosen to leave geomorphology out of their classification scheme with the intention of integrating this surrogate later when there is a better understanding of this link. The classification system suggested by Howell (2010), therefore, has 4 hierarchical levels: biogeography, depth, substrate and biology (Table 5). Within those levels, the following classes are defined (Howell 2010):

1. Biogeography: Arctic and Atlantic
2. Depth: 200-750m, 750-1100m, 1100-1800m, 1800-2700m, 2700-5000m
3. Substrate: Mud, sand, mixed, coarse and rock
4. Biology: 40 benthic megafaunal assemblages which serve as ‘units’ for fine scale mapping. These ‘units’ can be found in Appendix 1 of Howell (2010).

The proposed system roughly follows the hierarchical structure suggested in many existing classification systems that use common surrogates. The difference between this classification (Howell 2010) and other classification systems is that the classes defined at each level of the classification are based on known changes in faunal composition.

Table 5. The proposed classification system of Howell (2010) with four levels: biogeography, depth, substrate and biology. Table taken from Howell (2010).

Level 1 Biogeography	Level 2 Depth	Level 3 Substratum	Level 4 Biology
Arctic	Upper slope, 200–750 m	Mud	
		Sand	
		Mixed	
		Coarse	Cyclostomes, ophiuroids and white encrusting sponges on coarse sediments
		Hard	
	Upper bathyal, 750–1100 m	Mud	
		Sand	Halcampid anemones in rippled sand
		Mixed	Sabellids, white encrusting sponges and ophiuroids on mixed sediment.
		Coarse	Coarse sediment assemblages of the Faroe–Shetland Channel
		Hard	Zoanthids, *Ophiactis abyssicola* and sabellids on hard substratum
	Mid bathyal, 1100–1800 m	Mud	Fine sediment assemblages of the Faroe–Shetland Channel
		Sand	
		Mixed	
		Coarse	
		Hard	
Atlantic	Upper slope, 200–750 m	Mud	Assemblages of amphiurid ophiuroids
			Kophobelemnon stelliferum and cerianthid anemones
		Sand	*Cidaris cidaris* – *Stichopus tremulus* assemblage
			Ophiuroids on rippled sediment
			Lanice beds
		Mixed	Sabellids, white encrusting sponges and ophiuroids on mixed sediment
		Coarse	Crinoid (Leptometra celtica) assemblages at the shelf edge
			Ophiactis abyssicola and white encrusting sponges on coarse sediments
			Munida and Caryophillids on coarse sediments
			Halcamid anemones and white encrusting sponges on coarse sediment
			Brachiopods on coarse sediment
			Serpulid polychaetes and Munida on coarse sediment
			White encrusting sponges and serpulids on coarse sediment
			Ophiactis balli and *Munida rugosa* on coarse sediment
		Hard	*Bathylasma hirsutum* – *Dallina septigera* – *Macandrevia cranium* assemblage
			Discrete coral (*Lophelia pertusa*) colonies on hard substratum
			Psolus squamatus, serpulid polychaetes and Munida on hard substratum
			Ophiactis balli and Munida rugosa in vesicular rock
	Upper bathyal, 750–1100 m	Mud	*Kophobelemnon stelliferum* and cerianthid anemones
			Echinus acutus norvegicus assemblage
			Sagartiid anemones and juvenile pennatulids
		Sand	Ophiuroids on rippled sediment
			Lanice beds
		Mixed	Sabellids, white encrusting sponges and ophiuroids on mixed sediment
		Coarse	Halcamid anemones and white encrusting sponges on coarse sediment
			White and blue encrusting sponges, ophiuroids and majids on coarse sediment
		Hard	*Bathylasma hirsutum* – *Dallina septigera* – *Macandrevia cranium* assemblage
			Hydroid turf and cerianthid anemones on sediment draped rock ledges
	Mid bathyal, 1100–1800 m	Mud	*Echinus alexandri* – Psilaster – Plinthaster assemblage
			Xenophyophore fields
		Sand	
		Mixed	
		Coarse	
		Hard	
	Lower bathyal, 1800–2700	Mud	*Acanella arbuscula* and *Ophiomuseum lymani* assemblage
			Hygrosoma petersii-Benthothuria funebris and Oneirophanta assemblage
		Sand	
		Mixed	
		Coarse	
		Hard	Rock outcrop with Anthomastus
	Abyssal, 2700–5000 m	Mud	*Psycropotes longicauda-Oneirophanta mutabilis* assemblage
			Thaumatocrinus jungerseni assemblage
		Sand	
		Mixed	
		Coarse	
		Hard	
Bioherms	Upper slope, 200–750 m	Lophelia pertusa reefs	Live summit
			Dead framework slopes
			Rubble apron
			Highly sediment draped scattered framework
		Sponge communities	Boreal Ostur
			Cold water Ostur
	Upper bathyal, 750–1100 m		
	Mid bathyal 1100–1800 m	Sponge communities	*Pheronema carpenteri* fields

This classification system (Howell 2010) has been modified in such a way that it can be used within the FP7-funded European project CoralFISH. The goal of this project is to establish ecosystem based management of corals, fish and fisheries in the European and other deep-waters of the world. Although Howell's (2010) classification is useful to CoralFISH, it needs some modification to fulfil the needs of the project. This modification is mainly with regard to the substrate types, since in CoralFISH more substrate types are recognised, such as coral reefs and coral rubble. It is also important that the classification used by all the institutes in the project can be applied on all the different regions of the Atlantic Ocean (Iceland and Norway to the

Azores) and Mediterranean. The classification of Howell (2010) will be used as well as the EUNIS classification (Davies et al., 2004).

Another European project involving the mapping of seabed habitat is EUSeaMap (http://www.jncc.gov.uk/page-5020). One of the objectives of this project is to develop a common methodology for seabed mapping on a broad scale across Europe, specifically for the Baltic, North Sea, Celtic Seas and western Mediterranean. The project assesses the benefits and constraints of using the EUNIS classification system and compares this with the use of other regional variations. EUSeaMap will address the shortcomings by more accuracy and higher resolution. The project uses a WebGIS to make maps with different layers. These layers can be based on e.g. seabed substrates and depth (Joint Nature Conservation Committee 2010).

4.4 Data archiving

Data archiving is a very important aspect of research. It not only involves the administration of the data collected during several cruises, but also the storage – for both short- and long-term – of the data.

4.4.1 Administration

The administration of the data involves the collection of DVD's, tapes and other data, e.g. navigation data. It is important to have several copies for back-up of all the data. Be sure to renew the back-up data if the data is manipulated and changes are made.

Another point of administration, which is not necessary but useful, is to make an inventory of all the data and where they are stored. This can be a list of DVD's with the file name, cruise number, dive number, camera type, start time of the file, end time of the file, remarks etc. It can also be a log where the data is stored, e.g. DVD's on the shelf in room 1, HD tapes in box in room 2 etc.

The storage on external devices and computers can be structured by using folders and subfolders. This can be done by cruise numbers, by data type (CTD, HD footage, etc.) or by any other structure that suits the scientist.

4.4.2 Storage

NUIG is setting-up a long-term structured database storage of all the data collected during several cruises, which at the moment is stored in different formats at different locations. It would be beneficial to have (at least) one station that stores all the available data, ranging from navigation data to photographic images and video footage.

One important aspect of data storage is the digitalising of the HD tapes. Although the HD tapes have a back-up recorded on VEGAS software, the files in this software are very small, as a new file was made every time the HD camera flickered and lost a frame, and analysis of these tiny files is not easy. The HD tapes themselves are digitalised one per tape. This is the file that is used for analysis, as well as being stored, as repeated playback and rewinding of the tapes can cause damage to them. It is possible to record the time stamp on the digitalised file. Figure 37 shows the set-up that is used to digitalise the HD tapes.

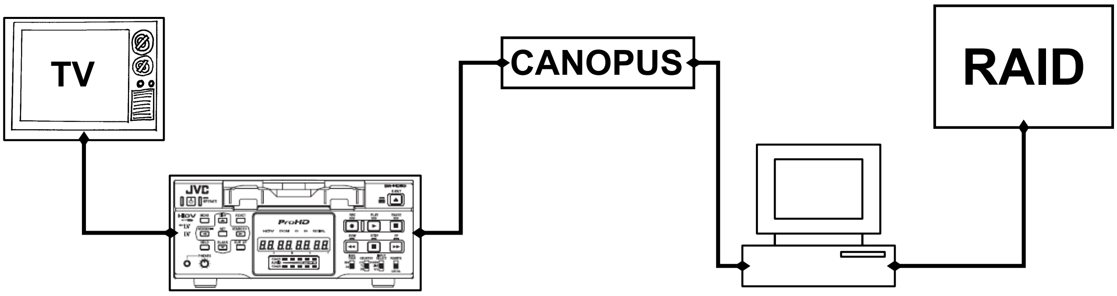

Figure 37. The set-up used for digitalising HD tapes. In this figure a picture of the JVC tape recorder is used. The set-up does not change when the Sony tape recorder is used. The JVC is than replaced by the Sony deck.

A JVC (BR-HD50E) or Sony (HVR-1500A) recorder (Marine Institute; Ireland) is connected to a computer (Apple Mac Pro 3.1) or the CANOPUS (advc100) by a fire wire. A CANOPUS is a device that converts analogue signals to digital ones. It is necessary to be able to see the time stamp that was recorded on the tapes on the cruise. It is not possible to show the time stamp on the screen when the tape recorder is directly connected to the computer. The time code is only visible while recording DV video and not HDV. The CANOPUS converts the HDV signal into a DV signal and displays the time stamp. One disadvantage of using the CANOPUS is that the video footage is compressed to DV signal which has a lower resolution (720 x 480) and frame rate (~30f/s) than the HDV (res: 1280 x 720; frame rate: ~120f/s). The loss of resolution is an especially unwanted aspect. Because of this problem – where the time stamp is recorded on lower resolution file but there is no time stamp on the correct resolution files – it has been decided to record all tapes twice: once compressed, but with time stamp; and once as the raw stream, without the time stamp. The procedure will be explained later in this section. The computer is also connected to a storage device. NUIG uses a RAID (NTFS file system; 4.77 TB). This RAID will store all the data that is available for each cruise, such as navigation data, maps, video data, CTD-data, acoustic echo sounder data etc. NUIG is the only institute that will provide and make a long-term database of all cruise data.

4.5 Digitalising HD tapes

4.5.1 Formats and codecs

Before describing the method to digitalise tapes, a short explanation of file format, containers and codec is necessary.

A file format is a particular way that information is encoded for storage in a computer file. There are different formats for different kinds of information. More information about file formats can be found on http://en.wikipedia.org/wiki/File_format. Examples of file formats are MPEG-1, MPEG-2 and MPEG-4.

A codec is a device or computer program that is able to encode and/or decode a digital data stream or signal. Codec is short for **co**der-**dec**oder and encodes and decodes data streams or signals. Simplified: a codec is a manual for your computer which tells the computer how to use/decode the movie. More information about codecs can be found at http://en.wikipedia.org/wiki/Codec.

A container (or wrapper-format) is a meta-file format whose specifications describe how data and metadata is stored. More information about this can be found on http://en.wikipedia.org/wiki/Container_format_%28digital%29. Simpler containers might contain different types of audio files, while more complex container formats contains multiple audio and video streams. It can be used to make only one file from different audio and video streams with many different algorithms. A few examples of containers are AVI, MPEG program stream, and MPEG-2 transport stream (MPEG-PS and MPEG-TS respectively). Simplified: a container gives the computer extra information, such as subtitles, menu-options and metadata.

Table 6 shows some examples of containers and matching video and audio containers. Figure 38 shows a schematic summary of Table 6.

Table 6. Examples of containers and matching video and audio codecs. Source: http://www.tvjoost.nl/codecs-en-containers-voor-altijd-duidelijk.

Container	**Name**	**Video codec**	**Audio codec**
AVI	Audio Video Interleave	MPEG-4, DV, MJPEG	MP3, MP2
DIVX	DivX Media Format	DivX	MP3
M2TS/MTS	MPEG-2 Transport Stream	H.264, VC-1, MPEG-2	(E)AC3, DTS(HD), PCM
MP4	MPEG-4	H.264, MPEG-4	AAC
MPG	MPEG Program Stream	MPEG-1, MPEG-2	MP2
MOV	QuickTime Movie	H.264, MPEG-4, MPEG-1	MP3, AC3, PCM
VOB	Video object	MPEG-2	AC3, DTS, MP2

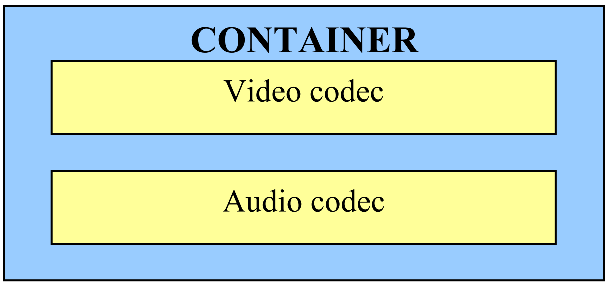

Figure 38. A schematic presentation about containers and video and audio codecs. A container can contain several codecs.

4.5.2 Methods of digitalising tapes

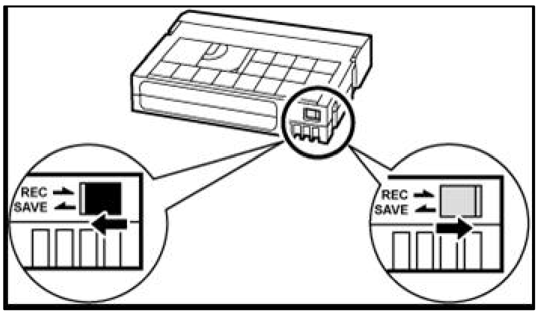

Figure 39. The different positions of a DV tape. During digitalising of the tapes, the slide should be in the save position (left). This prevents the data from being erased. During recording the slide should be in the recording position (right). http://www.canon.fr/Images/G0014421_tcm79-604459.gif.

The DV tapes have a safety slide on the back which can be in the ‘record’ position (allowing data to be recorded on the tape), or in the ‘save’ position (making it impossible to record on the tape) (Figure 39). Before digitalising HD tapes, the safety slide should be set to the ‘save’ position to prevent accidental erasure of the data on the tapes. This should be checked at all times before you put the tape into the video recorder.

Two different programs are used to digitalise the HD tapes: VirtualDub and HDVSplit. They are free-source programs and easy to use. VirtualDub can be downloaded at http://sourceforge.net/projects/virtualdub/files/virtualdub-win/1.9.10.32839/VirtualDub-1.9.10.zip/download and HDVSplit at http://www.free-codecs.com/download/HDVSplit.htm.

4.5.2.1 VirtualDub

VirtualDub is used to digitalise the HD tapes. It displays the time code that is recorded on the tape. The following steps need to be followed.

1) Make sure the time code is displayed by the (JVC) tape recorder. This can be set in the menu of the tape recorder (Figure 40).

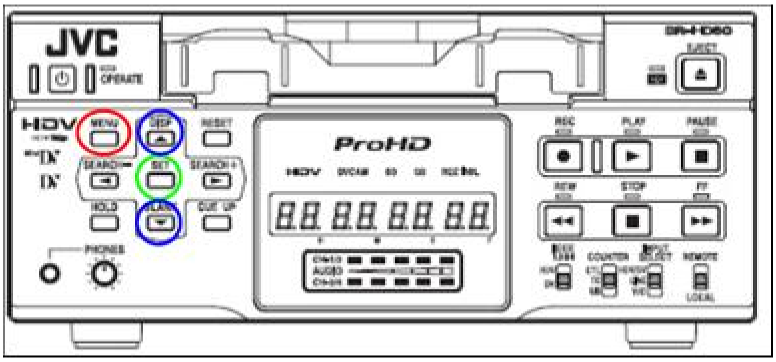

Figure 40. The front of the JVC tape recorder. To go to the menu, press 'menu' (red circle). For navigating in the menu the arrows (bleu circles) can be used and to select an option the 'set'-button can be used.

When the menu opens, you see several settings. Choose 'display settings' by moving the arrows on the front of the VCR (blue circles in Figure 40) and press 'set' to select the option (green circle in previous figure). After selecting the 'display settings', the menu will look like Figure 41.

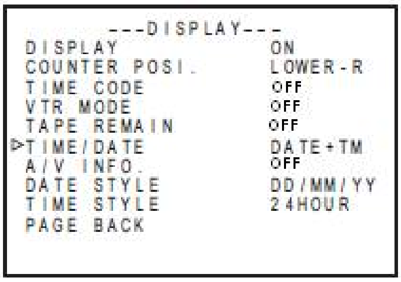

Figure 41. The display menu should like this as the time code is recorded on the HD tapes during the cruise.

There are two options depending on whether or not the tape was recorded using a time code.

i) Time code recorded on the tape during survey

Select 'Date+Tm' in the 'Time/date'option as seen in Figure 41. All other options should be 'off', except for the option 'display' which makes the time code show up on the screen.

ii) No time code recorded on the tape during survey.

In this case the time code of the VCR itself needs to be used. Figure 42 shows how the display menu should look like when there is no time code recorded during the cruise.

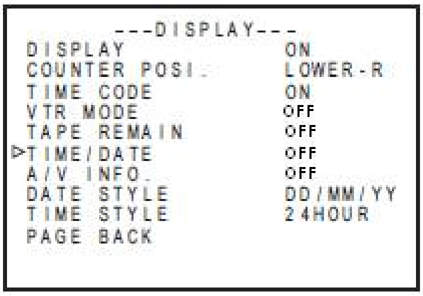

Figure 42. The display menu when there is no time code recorded during the survey.

All options are 'off' except for 'display' (displays the time code in the screen) and 'time code'. This time code is the time code of the tape, starting with 00:00:00:00. Be careful: in this case, the start time of recording on the tape should be noted! It can be corrected for this. For example: the recording started at 09:05:12 (real time). This point is 00:00:00 at the VCR time code. If the VCR time code is at 00:12:52 then the time during the survey this tape was recorded is 09:18:04.

The options 'VTR mode' and 'Tape remain' are not necessary during this part of the study. It shows the command of the VCR (e.g. play, fast forward etc.) and the time that is remaining on the tape, respectively. The position of the time code of the VCR (Not the time code that is recorded on the tape) can be changed by the option 'counter position'.

2) Launch the VirtualDub software. The main window (Figure 43) opens.

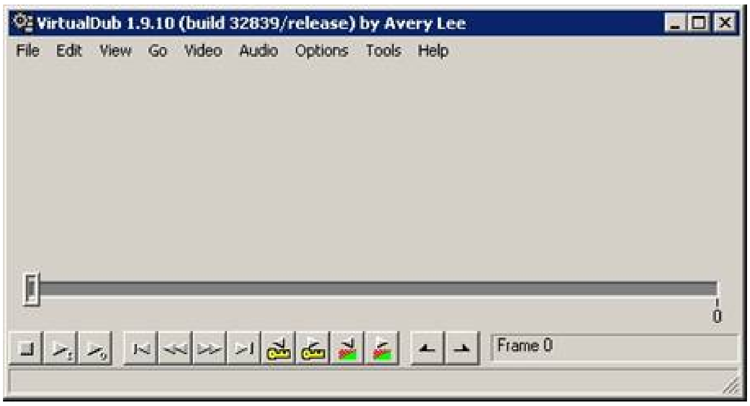

Figure 43. The VirtualDub software main window.

3) Open the capture mode by selecting ‘Capture AVI’ in the File-menu (Figure 44).

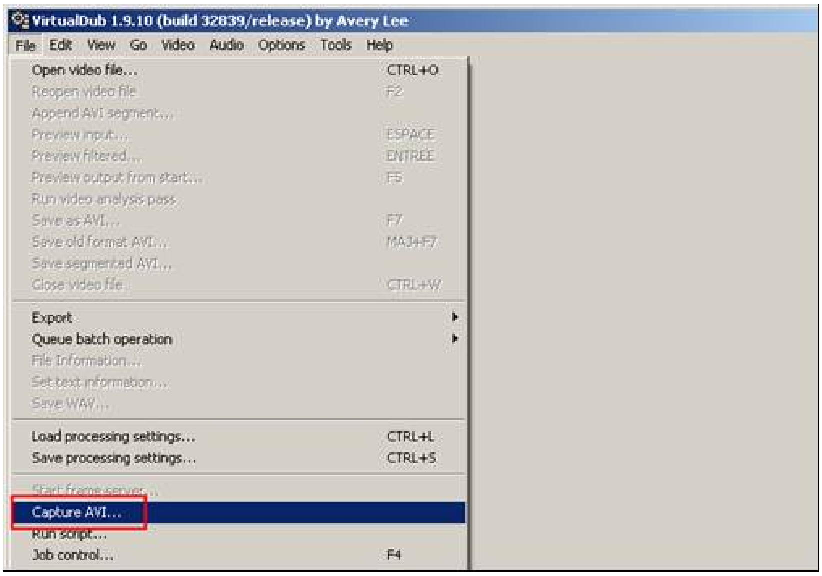

Figure 44. The Capture AVI module can be found in the ‘File’ menu.

4) Select the input device in the capture window (Figure 45). Select the name of the device in the Device menu. In this window it is number 1 Microsoft DV Camera and VCR (Directshow).

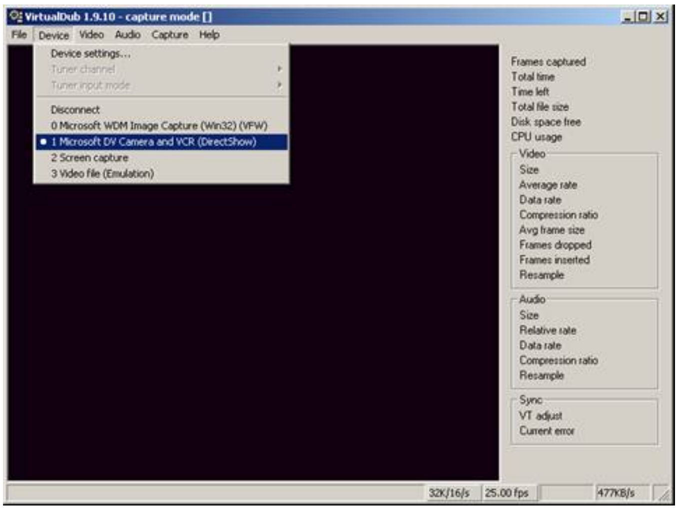

Figure 45. Select the device in the capture window.

5) Check the codecs and the video format. The parameters should be correct by default. There should be no compression. This can be checked by selecting ‘Set custom format’ in the Video-menu (Figure 46).

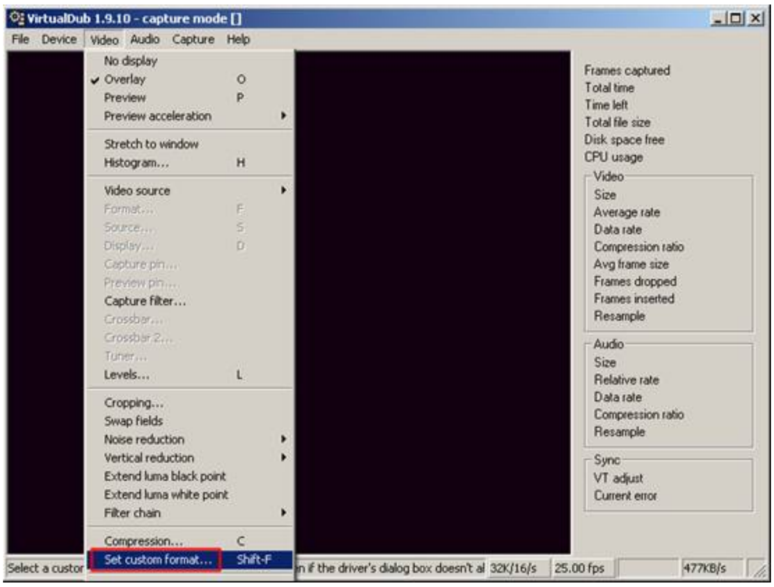

Figure 46. Check the format of the video.

The set custom window opens (Figure 47). The data format selected is “dvsd”. This corresponds to the stream that is provided by the Canopus. There is no need to change the other settings, since the raw stream is recorded. Press ‘OK’.

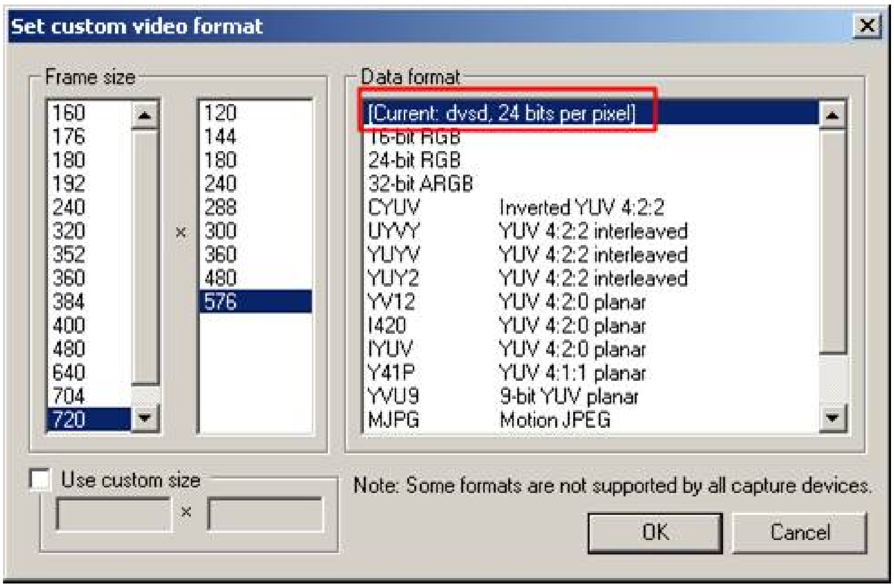

Figure 47. The ‘set customs video format’-window.

A second check can be done by selecting ‘Compression’ in the Video-menu (Figure 48).

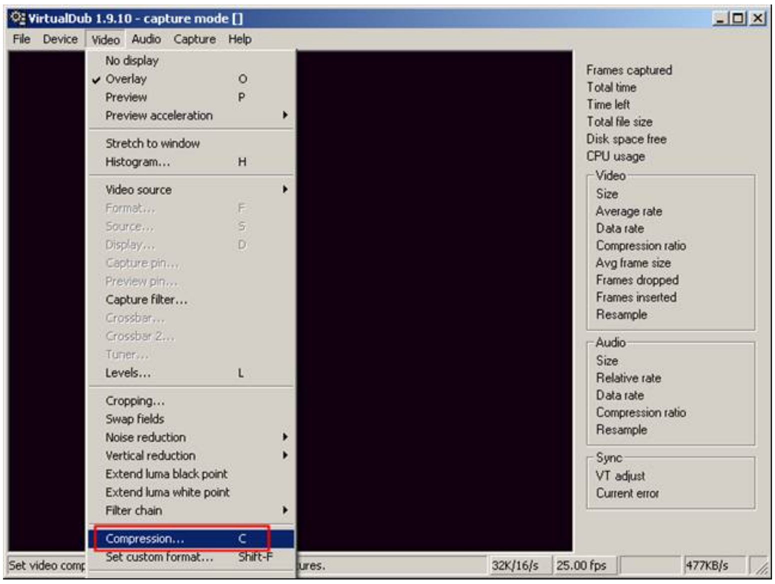

Figure 48. A second check can be done.

Figure 49 appears. ‘No compression’ should be selected. If not, select this and press ‘ok’.

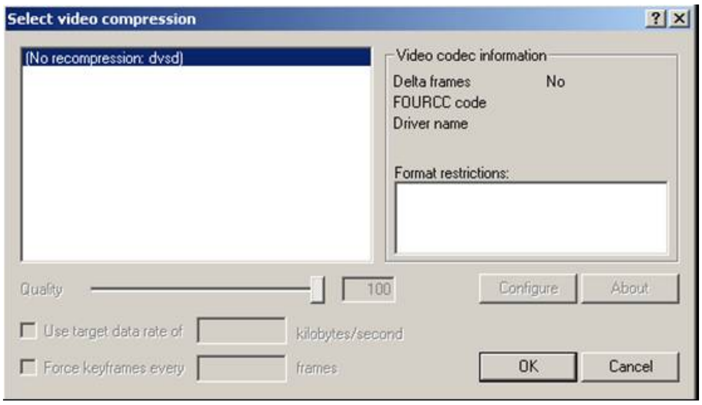

Figure 49. ‘Select video compression’-window.

6) Select the ‘timing’ option in the Capture-window (Figure 50).

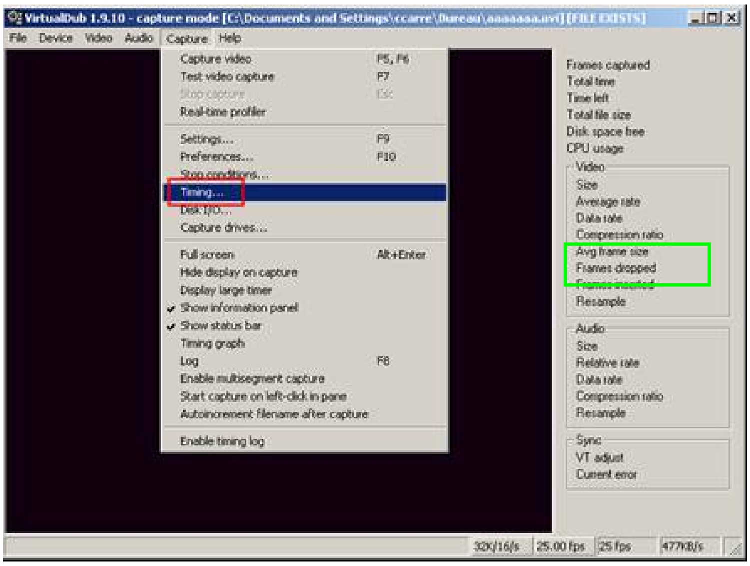

Figure 50. Select Timing in the Capture-menu.

The capture timing options window appears (Figure 51). The original parameters are shown in the next figure. These should be OK. If there are dropped frames at the end of the capture, increase the Null Frame Burst Limit. The amount of dropped and inserted frames can be seen in Figure 50 (green).

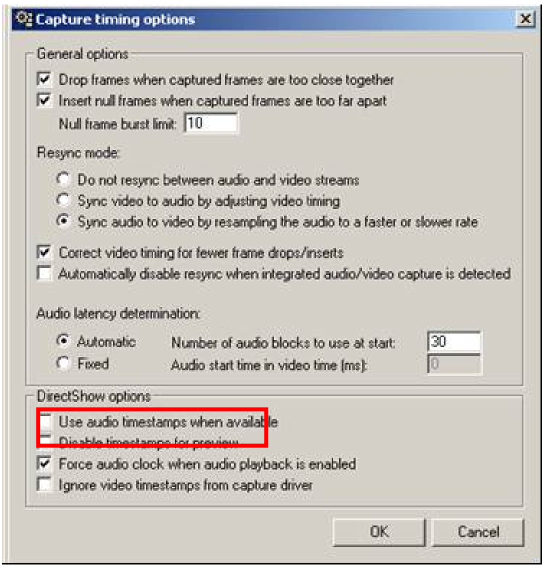

Figure 51. The ‘Capture timing options’-window.

7) Select a directory and a file name by using ‘Set capture file’ in the file menu (Figure 52).

Figure 52. ‘Set capture file’ can be found in the File-menu.

8) Start the recording by selecting ‘Capture video’ in the Capture menu (Figure 53). Press play on the tape recorder. The video should appear on the screen.

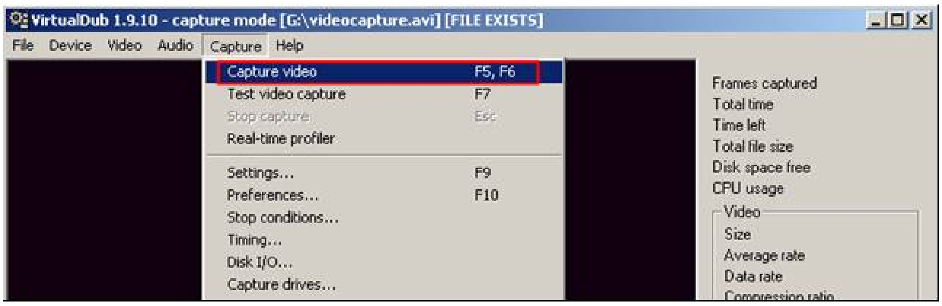

Figure 53. The ‘Capture Video’-window can be found in the Capture menu.

9) Stop the recording after the tape is finished by selecting ‘Stop capture’ in the Capture menu or by pressing the Escape button on the computer keyboard (Figure 54).

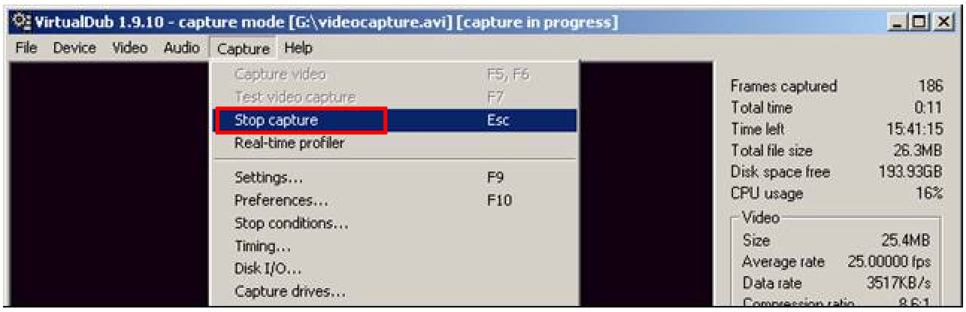

Figure 54. Stop the capture of a video by clicking on ‘Stop capture’ in the Capture menu.

The files are .avi and take a lot of space. They can be converted into DIVX using a Divx-converter program that can be downloaded from the internet.

This is the method to record HD tapes with the time stamp on the video. Snapshots of the digitalised files can be seen in the next section (Figure 60). They will be shown with snapshots on the digitalised files done with HDVSplit.

4.5.2.2 HDVSplit

This program is used when the raw stream of the HD tape is recorded. This means that there is no compression at all. The stream is recorded in the highest possible resolution (1280 x 720) and with a frame rate of approximately 120 frames per second.

Follow the following steps for digitalising the HD tapes using HDVSplit.

1. Open the program. The main window will be seen (Figure 55). When the tape recorder is not connected it will be displayed in the red.

If a tape recorder is connected then the brand of the tape recorder will appear in the red square. In Figure 56 it is the JVC tape recorder that is recognized by the program.

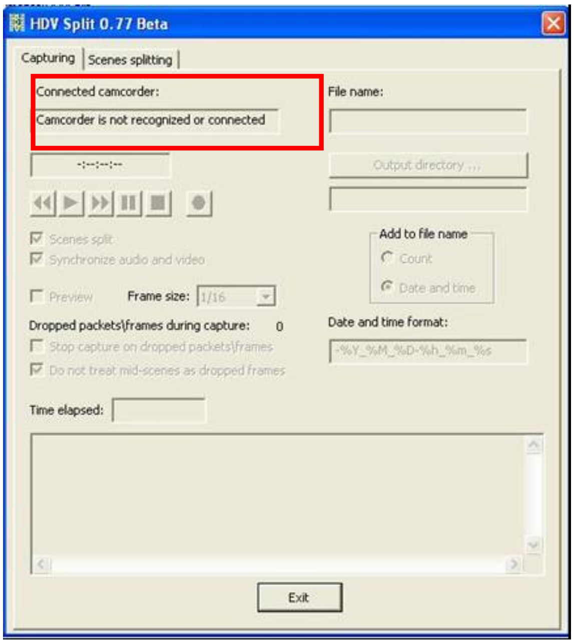

Figure 55. The main window of HDVSplit. The camera is not connected or recognized

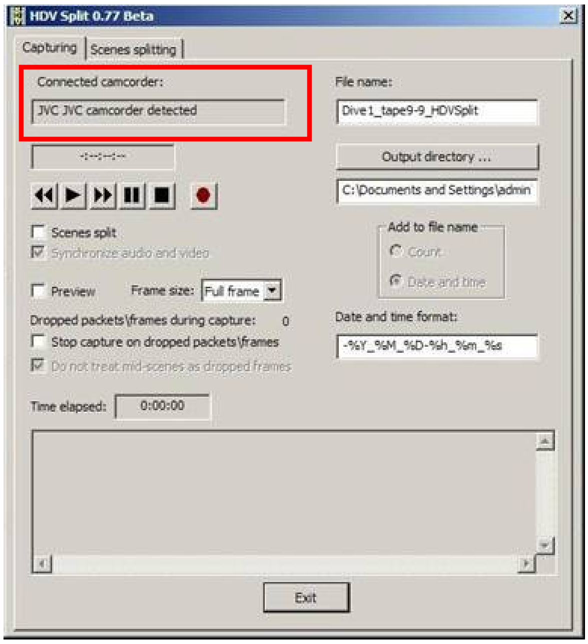

Figure 56. A JVC recorder is detected by the program.

2. An output directory should be selected by pressing the button ‘Output directory …’ and the name of the file can be filled in (Figure 57; red).

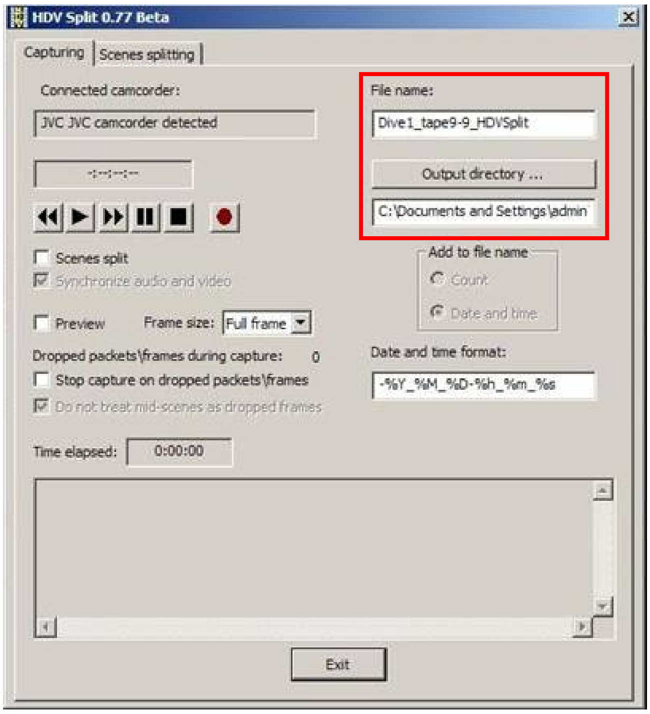

Figure 57. Select a directory and give the file a name.

3. Deselect ‘Scenes split’ and change the Frame size to ‘Full frame’ (Figure 58; red).

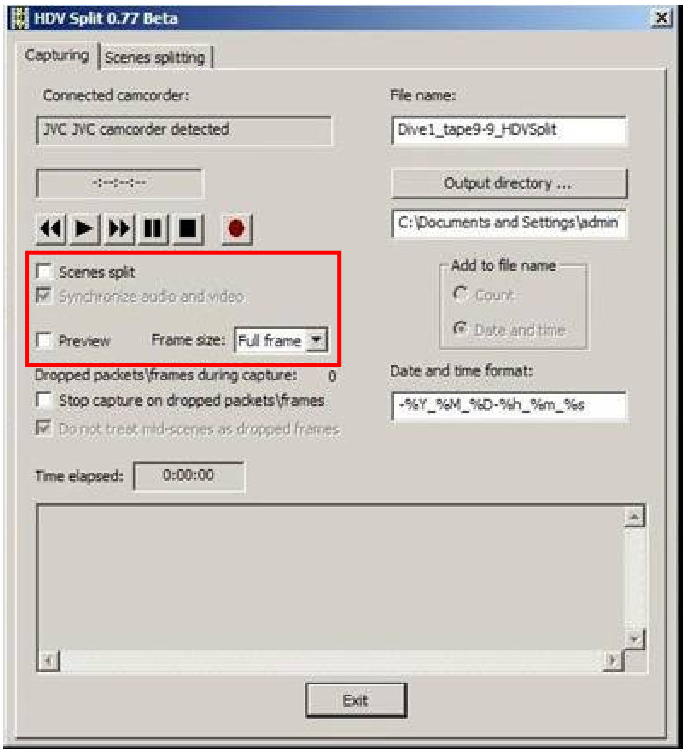

Figure 58. Prevent the program from splitting and select the full frame size.

4. Press the record button on the HDVSplit window. Information about the process – record mode, packages that are lost, tape reached the end, file is made, etc. – appear in the window (green square, Figure 59).

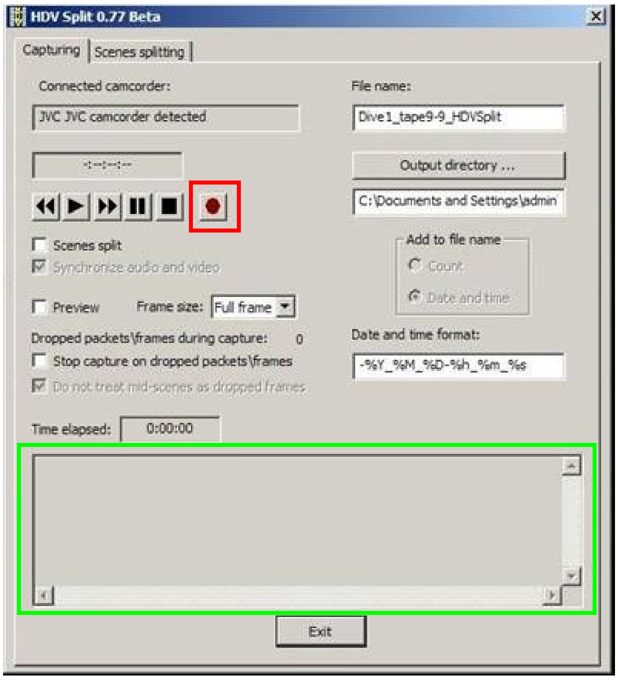

Figure 59. Recording information display in the green square.

5. Press the play button on the tape recorder to start the tape.

6. After the digitalising is done, the program will give a notice that the recording has stopped, because the end of the tape is reached. Press 'ok' and close the program. It is possible to stop the recording yourself by pressing the stop-button on the main window. The outputs of HDVSplit are .m2t-files.

Figure 60 shows some snapshots of the digitalised files recorded with both VirtualDub (a; b) and HDVSplit (c; d). The snapshots are roughly at the same places. Three fish of the family *Helicolenus* (left) and *Molva* (right) can be seen.

The video-formats, AVI (VirtualDub) and m2t (HDVSplit), can be played by VLC media player, that can be downloaded from the internet for free. This program plays most files. AVI can also be played by other programs, such as Windows Media Player and QuickTime.

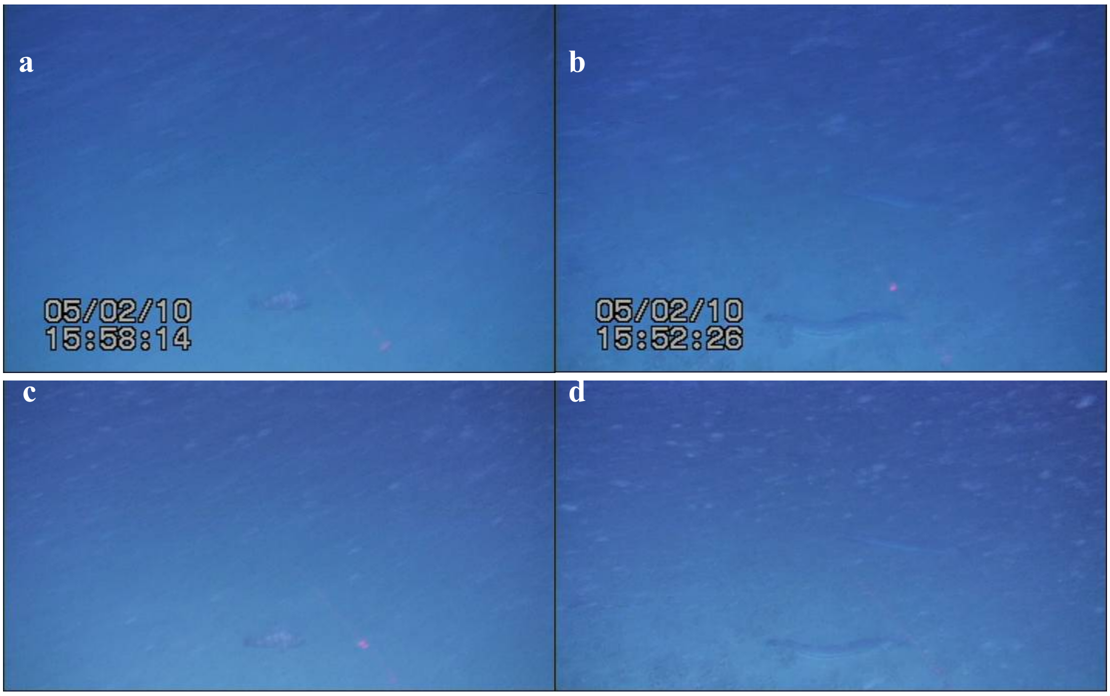

Figure 60. Snapshots of the HD tape (dive 18) recorded with VirtualDub (a; b) and with HDVSplit (c; d). The top snapshots show the time stamp in the screen, but they are in a lower resolution. The bottom snapshots have no time stamp, but the highest possible resolution. Three fish are seen in these pictures; on the left *Helicolenus* (*dactylopterus*?) and on the right two individuals of the *Molva* family.

4.6 Difficulties with archiving

One major aspect of archiving is the time that it requires. It takes time to digitalise all the video material. All the HD tapes need to be recorded twice as explained above. A HD tape of 2 hours takes 2 hours to digitalise – therefore it takes 4 hours to digitalise one tape using the two above described methods (VirtualDub and HDVSplit). The video material on the DVD's should also be copied onto the RAID. The time this will take depends on the number of dives during a cruise and how long the dives were. It is not as simple as connecting a tape recorder to a computer and digitalising the tapes. It is important to have the correct programs, and the correct cables to connect the tape recorder to the CANOPUS and/or computer. Every tape recorder can be different. The JVC and the Sony tape recorders have different plugs. This means that the Sony recorder cannot be connected the same way as the JVC recorder. This may mean that the computer programs (VirtualDub and HDVSplit) used to digitalise the JVC tapes cannot be used for the Sony tapes. It might take time to find the correct settings for the tape recorder/program or a different solution to digitalise the tapes. All the other available data relating to the cruise should also be collected and copied.

Another difficult but very important aspect of archiving t is the way the data is stored (the administration). The easiest way, since it is used for storage (of the DVDs etc), is to archive the data per cruise number. Then the data can be divided in investigation method: ROV, echo-sounder, CTD, ADCP, grabs, boxcores, etc. An additional folder can contain the navigation data, since this might be linked to all other files in the different directories, such as the ROV data. Maps, logbooks of the cruise, etc. are also additional information that can be stored in an additional folder. The ROV folder can exist with subfolders, such as HD tapes, vertical camera, aft camera, digital forward looking camera (pilot camera), observations files, dive summaries etc (Figure 61a), or structured by dive number (Figure 61b). (The cruise numbers are fictitious in Figure 61) It is important to ensure that the file names of the different data files contain the cruise number and the dive number. Date and time can also be used in the filename, but is not necessary. In that way the date and time of that particular file can be established by using the logbook (the file that contains everything that was done on the cruise, with date, (start/end) time, location, methods (ROV/grabs/etc.) and any remarks, such as aborted dives.

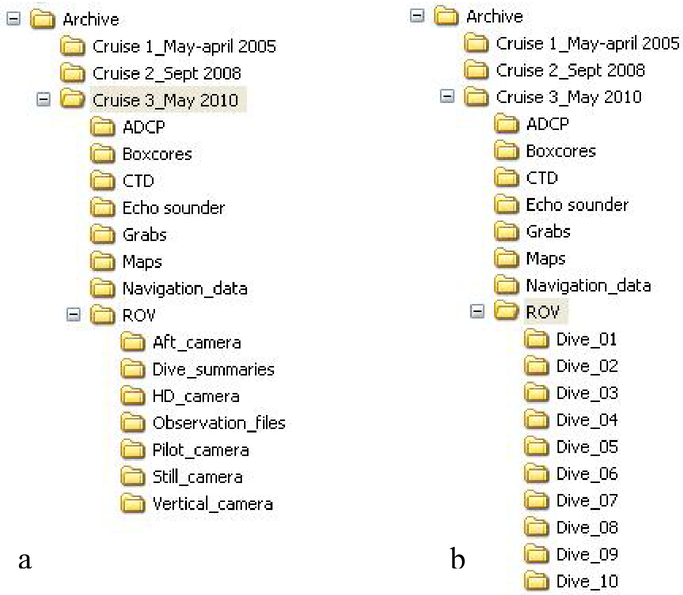

Figure 61. A way of structuring the data. The data will be stored according to cruise number and to the investigation method. Then the data can be structured into subfolders, such as on sort of data (a) or on dive number (b). The structure in the left figure can be used to subfolder the dives.

All data that involve the same type of records should be in similar formats. For example, the navigation data should be in similar formats, such as a comma-separated value file (.csv.) or dBase file (.dbf). The columns in the files should be similar as well. If the columns of one file are names ‘date’, ‘time’, ‘longitude’ and ‘latitude’, then all the columns in all the navigation files should be the same. Check for the formats of the cells; if date in one file is 'dd/mm/yyyy' it should be the same in each file.

5 Further Work

The described standard operating procedures can be used by several institutes and (European) projects. The European project CoralFISH will use these SOPs for their work. However, these SOPs need to be updated to fulfil the needs of CoralFISH, in both annotation (classification system) and in annotation software. The annotation, specialised for CoralFISH work, is in the final state. The classification is almost done and should be shared with all the partners of the project within the next few months. The partners will test the classification to see whether the categories in the annotation are correct and can be applied to all different research areas (Norway, Iceland to Mediterranean). The CoralFISH annotation will be based on several classification systems, such as CMECS (Coastal and Marine Ecological Classification Standard;(Federal Geographic Data Committee 2010) and the classification described by Howell (2010). CMECS is a classification system developed by NOAA and NatureServe. It can be used to classify all the ecological aspects in estuaries, wetlands, rivers, shorelines, islands, the intertidal zone, the entire benthic zone and the entire water column. It can be applied to coastal waters and the deep-sea and everything in between, except for freshwater habitat, except for the Great Lake. It is based on a hierarchical system and can be used to specify biological assemblages on small scales.

The hierarchical structure of this classification system consists of several components, such as the benthic and the water column component. These components consist of categories involving class, subclass and biotic group (Figure 62). Standard knowledge and attribute tables are made. These tables show the different categories and annotations.

The benthic component:

- **Class: Rock substrate**
  - Subclass: Bedrock
  - Subclass: Pavement
- **Class: Unconsolidated Mineral**
  - Subclass: Shells/Coral
  - Subclass: Fragments
  - Subclass: Sand
  - Subclass: Mixes
    - *Group: Coarse Mixes*
    - *Group: Fine Mixes*

Figure 62. An example of the hierarchical structure of CMECS. This classification system is used to develop a classification for CoralFISH.

The annotation software is the second major aspect that needs to be changed before it could be used in CoralFISH. Although OFOP can be used for the real-time analysis, it did not meet the needs of CoralFISH. Several options, such as calibrating an image for analyses, are not possible in the program. New annotation software was developed. The experience that the project has with OFOP and other software were used to develop COVER (Customizable Observation Video image Record; Cyril Carré; IFREMER, France). This software program has similar functions as OFOP, but it has some additional functions as well. The annotation of COVER is based on the knowledge tables of the classification system. An example of a knowledge table can be seen in Figure 63.

Phylum	Class	Order	Family	Genus	Species	ScientificName
Cnidaria	Anthozoa	Scleractinia				Scleractinia
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	Lophelia	pertusa	Lophelia pertusa
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	Desmophyllum	dianthus	Desmophyllum dianthus
Cnidaria	Anthozoa	Scleractinia	Oculinidae	Madrepora	oculata	Madrepora oculata

Figure 63. An example of a knowledge table used for the annotation of COVER. This example shows a hierarchical table of cold water coral. Source: manual of COVER (Carré, 2010).

The software is able to play and replay videos (in different formats, since VLC media player is the player that is integrated in the program), make annotations, generate images at certain time and distance intervals, and show the navigation of the ROV. A function build in COVER that is not available in OFOP is the option to calibrate an image by plotting a certain area on top of it. The standardisation of the analysis used in CoralFISH is a 1m square plot on an image. In this square 25 points are randomly plotted and these points are used for the substrate determination. This analysis is based on the software Coral Point Count (Kohler & Gill 2006). The program lays a matrix of points on an image and the benthic substrate or community are visually identified. The calibration of the image can be done by the field of view, by the distance between two laser points or by a known distance of an object.

Another new function is measuring the length of certain animal species, such as sea urchins and asteroids. The function to measure the surface of animals and objects (e.g. stones, weights etc.) is under development.

All the files necessary for COVER can be added in ArcGIS® as well, although COVER is not integrated into ArcGIS® itself. How the data can be integrated in ArcGIS® can be seen in section 4.2.

More details about COVER can be read in the manual that can be downloaded on https://sourceforge.net/projects/cover/files.

6 Acknowledgements

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Appendix 1: Specifications of ROV's cameras and lights

The camera systems used during the cruise are all Kongsberg. Table 1 shows type number and object size of the cameras.

Table A1: The specifications of the cameras of the ROV. The first column shows the camera name, the second column shows the model number, the third column shows the field of view, and the last column shows the object size at 1 metre.

Camera	Camera model	Field of view	Object size at 1m
HD camera	Kongsberg 14-502	45 deg. x 29 deg.	0.83 x 0.52 m
Vertical camera	Kongsberg 15-100	71 deg. x 54 deg.	1.43 x 1.0 m
Pilot camera	Kongsberg 14-366	48 deg. x 34 deg.	0.89 x 0.6 m
Still camera	Kongsberg 14-208	50.5 deg. x 38 deg.	0.94 x 0.69 m

TableA2: The specification of the lights of the ROV. The first column shows the lights type, the second column the light model, the third column the specifications such as voltage and depth ranting.

Light type	Light model	Specifications
HMI lights	Deep Multi-Sealite	60° Widefloor beam
		4,750 lumens
		6000 m depth rating
Normal lights	DeepSea Power	250 W
		120 V