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THE USE OF BRUVs AS A TOOL FOR ASSESSING MARINE FISHERIES AND ECOSYSTEMS: A REVIEW OF THE HURDLES AND POTENTIAL

- 2011 NATIONAL WORKSHOP -

Harvey ES, McLean D, Frusher S, Haywood MDE, Newman SJ, Williams A

PROJECT NO. 2010/002

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

Title: The use of BRUVs as a tool for assessing marine fisheries and ecosystems: a review of the hurdles and potential

Authors: E. S. Harvey, D. L. McLean, S. Frusher, M. D. D. Haywood, S. J. Newman, A. Williams

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TABLE OF CONTENTS

1. NON TECHNICAL SUMMARY

2010/002	The use of BRUVs as a tool for assessing marine fisheries and ecosystems: a review of the hurdles and potential

PRINCIPAL INVESTIGATOR: Euan S Harvey

ADDRESS: The UWA Oceans Institute & School of Plant Biology
The University of Western Australia
35 Stirling Hwy (M470),
Crawley, W.A. 6009
Telephone: 08 6488 2416 Fax: 08 6488 7278

OBJECTIVES

1. To critically evaluate the strengths and limitations of data collected with BRUVs for detecting changes in the relative abundance, length frequency and community composition of scalefish and sharks.
2. To identify potential solutions to limitations.
3. To develop a nationally agreed to protocol for the deployment of BRUVs and the analysis and storage of the resulting imagery.

NON-TECHNICAL SUMMARY

Baited remote underwater video systems (BRUVs) are a cost effective and robust sampling tool for scientists assessing the community composition, distribution, relative abundance and size of Australian marine fishes.

In July 2011, a two-day workshop was conducted at The University of Western Australia and attracted 30 participants by invitation from key research and industry organisations around Australia. The workshop focused on evaluating strengths and limitations of data collected with BRUVS for (1) detecting changes in the relative abundance; (2) length frequency; and (3) community composition of scalefishes and sharks. It also focused on identifying potential solutions to limitations; and the development of nationally agreed protocols for the deployment of BRUVs and the analysis of the resulting imagery.

The ultimate aim of the workshop was to improve the ways in which BRUVs and resulting data are used to provide essential information for understanding and managing Australian fishes and fisheries. The workshop format aimed to concentrate and share experience and expertise from a range of disciplines relevant to the field deployment and application of the BRUVs technique, image analysis, and use of BRUVs data in science and management.

Prior to the workshop, an online survey was constructed and distributed to fisheries scientists and managers and BRUVs users worldwide. Results of the survey were used to set priorities for, and facilitate, workshop discussions. The survey and workshop discussion identified the key strengths of the BRUVs technique as being:

- Able to sample depths beyond the limits of SCUBA, including the deep ocean.
- Fishery independent and non-extractive.
- Highly efficient and cost effective compared to more traditional methods of sampling fish communities.
- Suited to sampling a diverse array of fish assemblages, including those of relatively inaccessible rocky habitats.
- Statistically robust (efficient and powerful) for monitoring applications.
- Able to retain a permanent video record of species and habitats.
- Able to derive accurate length measurements of individuals.

Primary limitations of the BRUVs technique were identified as:

- A lack of a consistent protocol for BRUVs use.
- Bait-related biases, including quantifying the area of attraction and species attracted.
- The inability to use a large fraction of fish observation data, through use of MaxN or similar measure, that avoids repeated counts of the same individuals.
- Video processing time.
- Uncertainties surrounding the use of length frequency data, which often assume no size-related behavioural responses.

The workshop discussions focussed on these BRUVs limitations. Initiatives and potential solutions included:

- Identifying priority research areas to overcome the limitations.
- Developing a Standard Operating Procedure for BRUVs.
- Formulation of working groups and networks to advance important national initiatives through collaboration and sharing of knowledge and expertise.

KEYWORDS: Baited remote underwater video systems (BRUVs), relative abundance, length, length frequency, scalefish, sharks, detecting change, community composition

2. ACKNOWLEDGEMENTS

The project was funded by the Fisheries Research and Development Corporation (FRDC project 2010/002). We would like to acknowledge all the participants who attended the workshop. In particular we are grateful for input and guidance from Drs. Mike Cappo, Russell Babcock, Tim Langlois, Howard Choat and Peter Fairweather.

3. BACKGROUND

In September 2000, FRDC funded a workshop (FRDC 2000/187: *Direct sensing of the size and abundance of target and non-target fauna in Australian fisheries - a national workshop*), which was held on Rottnest Island, Western Australia. This workshop brought together 42 researchers from across Australia and culminated in a detailed review of the application of video in Australian fisheries. FRDC 2000/187 identified a number of limitations of the BRUVs technique that required further research including; 1) the cost of equipment; 2) overcoming bottlenecks in video analysis time; 3) requirement for a "Standard Operating Procedures", and; 4) a need for sharing of hardware/software/expertise via a national facility.

Since the 2000 national workshop, some very significant advances have been made that have addressed points 1) and 2) listed above but little work has specifically addressed points 3) and 4). Rapid advances in video technology, combined with cheaper prices have made the technique more affordable and accessible to researchers. Memory cards have replaced mini DV tapes, cameras have become digital and compact, and battery capacity has been vastly improved, as has the definition of the recorded video. Such advances have enabled longer BRUVs deployments and quicker and simpler capture and storage of imagery. The higher quality imagery has greatly improved the ability to identify, count and measure fish. Significant advances have also been made in the software used to analyse video imagery. Purpose-built programs such as 'EventMeasure Stereo' by SeaGIS Pty Ltd and the Australian Institute of Marine Science BRUVs database, have vastly reduced video analysis time and improved the accessibility and quality of data. All of these technological advances have meant that BRUVs have become a more cost effective sampling technique for scientists conducting baseline surveys and impact assessments of demersal fish assemblages.

In 2009, a special session on non-extractive fish sampling was held at the Indo Pacific Fish Conference (IPFC) in Perth. A consistent theme of discussions at the IPFC conference, and in subsequent email and phone conversations, was that many people were supportive of the use of BRUVs for collecting data on the composition, size frequency and relative abundance of fishes, and ideas on how improvements and significant gains could be made. Many people indicated that there was the need for a critical review of BRUVs as a tool for the assessment and monitoring of marine fishes and expressed a willingness to participate in a workshop. A concern that arose from the IPFC special session was the subtle, but differing approaches used to capture BRUVs data and analyse the imagery. Differences included the quantity and type of bait used in bait bags or the length of time over which video imagery was collected. This further highlighted the need for a nationally agreed upon set of Standard Operating Procedures as identified in the earlier FRDC 2000/187 workshop and highlighted in point 3 above. Discussions between researchers culminated in a proposal being developed for a second FRDC funded National workshop *"The use of BRUVs as a tool for assessing marine fisheries and ecosystems: a review of the hurdles and potential."*

4. NEED

FRDC Project 1995/055 "*Review and synthesis of Australian fisheries and habitat research"* identified the need for non-extractive, fishery-independent sampling and stock assessment techniques that are cost-effective, repeatable and robust across a range of habitats and depths. These methods are becoming increasingly important as Australian fisheries face the challenge of addressing Ecosystem-Based Fisheries Management (EBFM) and impacts from climate change including increased variability. A national workshop on the use of video for sensing the size and abundance of target and non-target fauna in Australian fisheries (FRDC 2000/187) highlighted the potential of BRUVs and a decade later there has been wide adoption of this technique. However, it is not understood how differences in protocols for deployment, analysis and interpretation affect spatial and temporal comparisons of BRUVs data. There remains the need (although significant steps are made here) to develop a robust set of Standard Operating Procedures to ensure that users are appropriately informed and trained through a comprehensive extension and capacity building program that ensures data standardisation, and also identifies key unresolved technical issues.

With the increased use of BRUVs, and their application to a greater variety of research questions, a number of independent developments have occurred. Future technological advances and more detailed statistical and modelling approaches will expand the use of BRUVs data for ecosystem assessment and management. Maximising the potential that these advances will provide to Australian fisheries will be best achieved by a coordinated and collaborative research strategy. The 2011 FRDC-funded national workshop was proposed to critically evaluate the use of BRUVs as a data collection tool for scalefish and sharks.

5. OBJECTIVES

1. To critically evaluate the strengths and limitations of data collected with BRUVs for detecting changes in the relative abundance, length frequency and community composition of scalefish and sharks.
2. To identify potential solutions to limitations.
3. To develop a nationally agreed protocol (Standard Operating Procedure) for the deployment of BRUVs and the analysis and storage of the resulting imagery.

6. METHODS

6.1. Online BRUVs survey

An online BRUVs survey was developed to capture information on how the BRUVs technique is used, its strengths and limitations, and potential solutions for these limitations.

6.2. National Workshop

A national workshop was held at The University of Western Australia's 'University Club' on Friday 8th and Saturday 9th July, 2011. The workshop addressed the objectives listed in Section 5.

6.2.1. Agenda

Day 1: Friday 8th July

Time	Agenda	Speaker/Facilitator
8:30 am	Registration; tea and coffee	
9 am	Welcome & presentation of workshop objectives	E Harvey
9:10 am	Results of the online BRUVs survey	D McLean
9:40 am	Software, BRUVs image analysis and future developments	E Harvey, D McLean, M Cappo
10:10 am	Using BRUVs data in science and management	T Langlois
10:30 am	Morning Tea	
10:50 am	MaxN and bait plumes	M Cappo
11:30 am	Open discussion on MaxN and bait plumes	M Cappo
12:30 pm	Lunch	
1:15 pm	Identifying priorities for afternoon discussion sessions	E Harvey
1:30 pm	Open discussion	E Harvey
3 pm	Afternoon Tea	
3:20 pm	Open discussion	E Harvey
5 pm	Day 1 summary	E Harvey
5:30 – 7:30 pm	Sundowner at the UWA Club. Drinks and dinner provided.	

Day 2: Saturday 9th July

Time	Agenda	Speaker/Facilitator
8:30 am	Introduction to workshop objectives for Day 2	E Harvey
9 am	Discussion session	D McLean
10:30 am	Morning Tea	
10:50 am	Discussion session	T Langlois
12:30 pm	Lunch	
1:15 pm	The future for BRUVs research	E Harvey
2 pm	An exploration of collaborative opportunities across Australia	E Harvey
3 pm	Afternoon Tea	
	Workshop Summary	E Harvey
3:30 pm	Close	

6.2.2. Workshop Proceedings

The first morning of the workshop consisted of a series of presentations that are provided in Section 13.2. These presentations led to discussions through the remainder of the two-day workshop that centered around four broad themes; 1) BRUVs in the field, 2) the use of bait, 3) video analysis and data management, and 4) BRUVs community extension.

BRUVs in the Field

- The way in which BRUVs are used in the field can vary quite dramatically between researchers depending on the questions they are seeking to address, the habitats and depths in which they operate, resources they have available, etc.
- ‘Field of view’ of cameras can vary dramatically and significantly affect measurements of fish diversity, relative abundance and length taken from video imagery.
- Field of view issues include: obstruction by habitat, BRUVs orientation, visibility, and fish saturation.
- Inter and intra-specific interactions – the presence of particular species or exceptionally large individuals may influence whether other individuals enter the camera’s field of view.

The Use of Bait

- There is variation in the types, quantities and consistencies of baits used, and in their method of deployment.
- The area sampled (area of attraction) when using bait is unknown.
- A number of techniques may assist efforts to determine the area sampled when using bait including: bait plume modeling, combining BRUVs with acoustic techniques, using fish behavioural and population data.
- The use of bait elicits complex behavioural responses in fish.

Video Analysis and Data Management

- MaxN (maximum number of individuals for a given species counted within the field of view at the same time) is a conservative measure, but remains the most simple and commonly used standard measure of relative abundance. Issues associated with its use were discussed.

- The use of MaxN may cause bias in assessments of population size structure where the lengths of individuals are only measured when the maximum numbers of fish are in the field of view.
- Measures of cumulative MaxN (each instance in which MaxN is updated for every species) may be used to better understand fish behaviour and the influence of fish behaviour on relative abundance and length measures obtained from video.
- Increased use of the statistical program 'R' in fish ecology should lead to the sharing of R scripts by scientists.
- Gigabytes of video data are being collected on a regular basis. There is an immediate need for speeding up processes used to convert videos into usable formats and for determining the most effective techniques for storing and archiving data.
- There needs to be a National approach to the storage of raw imagery, numerical data and metadata, and a mechanism for making that information discoverable and accessible by other researchers. Research projects funded by the Australian National Data Service (ANDS) and National eResearch Collaboration Tools and Resources (NeCTAR) coordinated by iVEC, Sydney University, and The University of Western Australia will start to address these issues and may provide some solutions during 2012/13.

BRUVs Community Outreach

- There is a great need and opportunity to use the video collected in community outreach programs. This may be achieved through Google maps/Google Earth, YouTube (eg http://www.youtube.com/watch?v=2d27m1ECzxA), social networking (Facebook, twitter), 3D TV (stereo BRUVs), media programs such as Catalyst, and print media such as National Geographic.
- There is a need to promote the importance of biodiversity to the community and BRUVs video imagery provides an engaging mode to facilitate this.

7. RESULTS

7.1. Online Survey

A total of 102 people contributed information to the 48-question survey with 75% of these answering all questions. The survey results provided a platform for discussion at the workshop and enabled discussions to focus on what were perceived as the most significant limitations of the BRUVs technique.

The complete results of the online survey are presented in Appendix 3, while key points are summarised below.

Of the 76 respondents who completed the survey, 78% were BRUVs users, referred to as 'BRUVers'. Fifty-six percent of those surveyed had between three and 10 years experience in using BRUVs and the vast majority considered themselves 'researchers'.

BRUVs sample data was being collected for a very broad range of applications including:

- Understanding human impacts (effects of fishing, coastal development, climate change, artificial reefs).
- Assessment of fish species of interest or assemblage structure including diversity, relative abundance and length.
- Exploration of fish behaviour.
- Deep-sea fish ecology.
- Examination of relationships between fish and habitats including sea surface temperature gradients.
- Examination of spatial and temporal patterns in fish distribution and methods for predicting these.
- Monitoring recruitment of fish.

The vast majority of BRUVers collect information on the diversity, relative abundance and length of fish and do so using Event Measure Stereo software developed by Jim Seager (SeaGIS Pty Ltd). However, there was some variation in the way in which the technique is used to collect this information. The majority (86%) of BRUVers use systems that film horizontally along the seafloor, while 17% use downward facing systems and 9% use systems on a downward angle to the seafloor. Most use high definition video (71%). Again, this highlights the need for, and current lack of, a nationally accepted set of Standard Operating Procedures.

One main finding of the online survey was the vast amount of variability surrounding the use of bait. Different researchers use different types, quantities and consistencies of bait. Each of these factors is known to have a strong influence on the diversity and relative abundance of fish viewed.

When asked to rank the strengths and advantages of BRUVs, the majority considered the most significant advantages to be:

- BRUVs ability to sample at depth (including deep continental slope depths).
- BRUVs are non-extractive and are fishery independent.
- High sampling efficiency in the field.

The most significant limitation identified was the time required for processing video in the lab and the most reported bias was the use of bait.

For bait, BRUVers considered the most significant bias of the technique to be the unknown area that is sampled by the bait plume. Solutions were suggested to help overcome these limitations and biases including the use of highly trained staff, the development of Standard Operating Procedures and investigating the potential for bait plume modelling with consideration of species responses to bait (e.g. behaviour, olfactory responses, etc). Suggested solutions were discussed in detail at the workshop and some significant outcomes were achieved, see Section 11.

7.2. National Workshop

Outcomes of the workshop are detailed below and specifically address the objectives listed in Section 5.

Primary limitations of the BRUVs technique discussed in detail at the workshop included:

- A lack of a consistent protocol for BRUVs use.
- Bait-related biases, including quantifying the area of attraction.
- The inability to use a large fraction of fish observation data, through use of MaxN or similar measure, that avoids repeated counts of the same individuals.
- Video processing time.
- Uncertainties surrounding the use of length frequency data which often assume no size-related behavioural responses.

A number of additional limitations were presented during discussions (Table 1). Many of these were also captured by the online survey (Appendix 3).

Absence of an agreed Standard Operating Procedure for BRUVs has led to a large variation in the way in which the technique is used. A call for a Standard Operating Procedure was also an outcome of the 2000 national workshop (FRDC2000/187). Without a standard, spatial and temporal comparisons of BRUVs data are subject to unknown or undetected biases. While experienced BRUVers have developed standards in using BRUVs in their research areas (or institutions), to enable broad comparisons of data across regions and larger spatial scales requires co-ordination which is best addressed by developing an Australia wide standard – the design of which could be draw from the experience of these aforementioned groups. These solutions need to be shared to maximise the value of BRUVs. Separate Standard Operating Procedures employed by AIMS, UWA and CSIRO are provided as Appendices to this report.

Biases associated with the use of bait are numerous (see Table 1) and, in some instances, are particularly difficult to address. Seemingly simple decisions such as what bait to use, how much to use, its consistency and how you attach or position it on your BRUVs, can have a large impact on the diversity and relative abundance of fish viewed. Through workshop discussion it was evident that there has been little research in Australia that has examined how bait should be used on BRUVs in shallow water to maximise measures of fish diversity and relative abundance. The use of bait also elicits complex behavioural responses in fish that are not understood and presently under-researched. The largest limitation of bait is the unknown area that is effectively sampled. Bait plumes will vary according to the bait that is used, how it is used (amount, consistency, contained), environmental conditions (depth, waves, currents, tides) and the amount of feeding activity on the bait. Discussion regarding the biases associated with bait led to the formulation of several priority research questions (Section 10).

Video processing time is considered to be a limitation of BRUVs because, compared to traditional underwater visual census where very little post-field processing is required, BRUVs video imagery requires detailed lab analysis to extract numerical data. Without advances to technology that streamline the analysis process, video processing will always be considered a limitation of BRUVs. Since the 2000 FRDC nationally funded workshop, some significant software advances have been made, aided by continually improving video technology (e.g. high definition video). Purpose-built video analysis software packages EventMeasure Stereo (SeaGIS Pty Ltd) and the AIMS BRUVs Database have been developed by software experts with the guidance of experienced BRUVs researchers. Both are now widely used. The result has been a significant reduction in video analysis time through fast playback capabilities and streamlined fish identification processes. These software packages have also significantly reduced observer error through the compulsory use of drop-down species lists and inbuilt reference libraries.

Further potential to reduce lab-processing time is discussed in Section 11.9.

Table 1 Current limitations of the BRUVs technique. Reference #'s are provided to link to research questions presented in Section 10.

Theme	Reference #	Limitation
BRUVs in the Field	1	Cost
	2	Vessel requirements
	3	Difficult to use in strong currents
	4	Difficult to use in poor visibility
	5	Biases vary according to field conditions
	6	Obstruction of the field of view
	7	Deployment can damage fragile habitats
	8	Fish saturation of field of view
	9	Other field logistics
The Use of Bait	10	Alters species behaviour
	11	Attraction of certain species over others
	12	Unknown area sampled (bait plume)
	13	Inconsistency in bait type/quantity/consistency/deployment methods used
	14	Translocation issues (e.g. use of temperate baitfish as bait in tropical waters
	15	Inability to sample cryptic species
Video Analysis & Data Management	16	Processing time
	17	Difficulties identifying fish from video
	18	Requirement for calibration
	19	Use of MaxN (relative abundance) or similar measure
	20	Use of length frequency measures
	21	Significant storage requirement
Other	22	Lack of consistent BRUVs protocol

Use of BRUVs for a wide variety of applications highlights the necessity for a set of Standard Operating Procedures to ensure that the technique is used in appropriate, consistent and reproducible ways. Workshop delegates discussed and agreed upon a number of protocols that should be implemented as 'standard' when using the BRUVs technique (

Table 2). These standards were agreed upon following significant discussion between delegates with extensive experience in the use of BRUVs. Although some of these standards may seem simple, deviation from them can result in very different measurements of fish diversity, relative abundance and length. For example, experience shows that if the bait is not crushed to disperse bait oil or the bait basket sits up off the seafloor far fewer species and individuals will be seen. It should be noted that these standards would not necessarily be appropriate for surveys conducted at great depths – but this is yet to be determined.

Table 2. Progress made towards developing a Standard Operating Procedure. Issues for which variation in the technique currently exists are presented alongside standards that should be implemented.

Issue	**Standard to be implemented**
Bait quantity, type and consistency	1 kg pilchards, crushed
Bait soak time	1 hour
Height of the bait off the seafloor	As close to the top of the benthos as possible
Method of bait deployment	Plastic-coated wire bait basket with 1 cm mesh
Field of view issues (e.g. visibility)	Acknowledge issue, do not use videos for analysis, or standardise field of view sampled (possible with stereo BRUVs)
Method of relative abundance measurement	MaxN and cumulative MaxN
Standard metrics from BRUVs	Species richness/diversity, frequency of occurrence, MaxN, fish length
Time of day for sampling	1st drop 1 hour after sunrise, retrieve 1 hour before sunset. More conservative at depths or on overcast days.
Habitat profile assessment from video	See Section 11.5
Value adding:	
Knowledge of current direction	Measurement of current over BRUVs using current meters
Operating depths	Add a depth gauge to BRUVs
Temperature	Add a temperate logger to BRUVs (e.g. sensis logger)

A whole range of additional variability exists in the way in which BRUVs are used that could not be covered in the workshop (insufficient time) or where a standard protocol could not be decided upon without additional research (see Section 10). Examples include; BRUVs configuration and orientation to ambient current, distance between neighbouring BRUVs, fork *vs* total length fish measurements, duration of BRUVs deployment, how many replicate BRUVs you need, and so forth.

8. DISCUSSION

The online survey and workshop were successful in addressing the first two objectives. There was 1) critical evaluation of the strengths and limitations of data collected with BRUVs for detecting changes in the relative abundance, length frequency and community composition of scalefish and sharks; and 2) identification of potential solutions to these limitations. In achieving these two objectives it became clear that it was not yet possible to finalise a nationally agreed upon set of Standard Operating Procedures for the deployment of BRUVs and the analysis and storage of the resulting imagery (objective 3). This is due to the fact that there is a number of 'unknowns' surrounding their use that still need to be addressed with targeted research (see Section 10). Despite this, real progress was made (see **Table** 2) in setting a number of standards. These agreed upon standards are important as each was recognised to have a potentially significant effect on the species surveyed and their abundance. For example, a bait basket resting on the seafloor will survey a far superior number of species and individuals than one raised above it. Dissemination of knowledge surrounding the use of BRUVs has also recently been improved with the development of an online BRUV (and DOV – diver operated video) forum.

9. BENEFITS AND ADOPTION

The beneficiaries of the workshop outcomes can be divided into two broad groups:

1. Those organisations or groups currently *conducting* research using BRUVs and those who might into the future. These include, but are not limited to Universities, state and federal Government agencies and NGOs and peak body groups (eg RECFISHWEST and WAFIC).
2. Those utilising the *results of BRUVs research*, i.e. Universities, Government agencies (i.e. management), Industry, stakeholders, community groups.

The online survey and workshop discussions provided an up-to-date understanding of the limitations and advantages of BRUVs and where targeted research and collaboration is required to further improve the technique. Progress towards developing a set of Standard Operating Procedures was achieved in addition to the identification of a number of useful initiatives (see Section 11). Greater standardisation will facilitate spatial and temporal comparisons of data sets and allow end users of the data greater confidence in the outcomes.

An online discussion (BRUV google group) has been established where new users can seek advice and ask questions to facilitate further standardisation.

10. FURTHER DEVELOPMENT

Potential solutions to BRUVs limitations were provided in the online survey (Appendix 3) and discussed by workshop delegates. Discussion focussed on finding solutions to the principal limitations of the technique namely: inconsistency in the way in which the technique is used, bait-related biases and video analysis time. In addition, delegates identified some priority research questions that would enable potential solutions to be found for many of the bait-related biases of the BRUVs technique that, to date, have received little attention. These priority research questions are listed here with a reference number specific to the limitation(s) presented in Table 1.

Q1: Is there an optimum deployment time for BRUVs? (#10, 16, 21)

Q2: What is the optimal bait soak time for different species of interest? (#10, 13, 22)

These questions could be addressed by a desktop study using existing data. The study would examine species accumulation curves with time across different locations (and with different tides, time of day, moon phase etc) around Australia – standardised by bait used and depth.

Q3: What is the relationship between depth and bait soak time? (#13, 22)

Q4: Can an acoustic array be combined with BRUVs and multibeam to track the movement of fish in relation to the bait plume? (#12)

Q5: Can acoustics be used in deep water to track the movement of fish up to and around a BRUVs system? (#12)

Q6: How does fish feeding behaviour influence measures of MaxN? (#10)

Using existing data, examine the time at which a species first feeds in combination with cumulative MaxN measures. This could be done across species/functional groups or temperate/tropical gradient to provide additional information.

Q7: Do fish in protected and fished locations respond differently to bait? (#10)

Most studies examining the effects of fishing compare surveys inside and outside protected areas (e.g. MPAs) and assume the same response of fish to bait in each of these areas.

Q8: What is the optimal distance between neighbouring BRUVs? (#5, 9, 10, 11, 21)

Q9: Does the swimming speed of species differ across different areas? (#10)

These questions may be addressed by using stereo-video systems to measure the time it takes species to move from one point to another across the field of view. This swimming speed may be used to hypothesise about bait plume dispersal and the likelihood of species visiting multiple BRUVs.

Q10: Can time of first arrival be a useful index of abundance? (#10, 11, 12, 21)

This can be achieved by comparing time of first arrival against other BRUV generated metrics (MaxN etc) and perhaps validated in an aquarium where abundance is known.

Q11: Do fish learn to associate BRUVs with food and how quickly does this happen? (#10)

Q12: How does the behaviour of fish change in highly bait-saturated places? (#10, 11)

Q13: How does the following influence fish behaviour and as a consequence, measurements obtained: (#5, 10, 22)

- *Storms, tides, weather*
- *Time of day*
- *Season*
- *Location*

Q14: At what distance from the cameras are measurements of MaxN typically made? (#22)

Is it possible to implement a maximum distance for MaxN measurements as a standard protocol such that data may be comparable across locations?

Q15: Does measurement of fish length at 'Time MaxN' bias your assessment of size class? (#19, 20)

This question may be answered by measuring the length of individuals at each cumulative MaxN recording such that changes in the size structure may be detected through the course of a deployment. Alternatively, MaxN could be measured for defined periods of a video, e.g. 10-minute blocks.

Q16: Can measuring 'snapshots' of footage shorten video analysis time? How do these snapshots compare to MaxN measures? (#16, 9)

Q17: Can examination of 'clusters of times of first arrival' improve our understanding of species associations and co-occurrence? (#11, 19)

Q18: How should power analyses be conducted to accurately assess whether there has been a change in a population or species?

It was acknowledged that no solution currently exists for determining the area sampled when using bait, but the use of current measurement sensors, e.g. Acoustic Current Doppler Profilers (ADCP), in conjunction with bait plume modelling, provide options for future developments of BRUVs techniques.

11. PLANNED OUTCOMES

The increasing popularity of BRUVs across Australia as a tool for surveying fish and fisheries means there are now many opportunities for sharing knowledge, expertise, equipment, protocols, data, and so forth. There are researchers that have used BRUVs for >10 years whose knowledge of the technique, its advantages and disadvantages, are invaluable to those using BRUVs irregularly or for the first time. Workshop discussions highlighted a number of ways in which knowledge and expertise may be accessed and maximised that included developing:

- A set of Standard Operating Procedures.
- An updated literature review.
- A BRUVers list.
- A national fish image reference library.
- A national habitat classification tool and reference library.
- A national BRUVs specific facility.
- A national BRUVs program.

11.1. Standard Operating Procedures

Further contribution to a set of Standard Operating Procedures should occur following additional discussions and the results of targeted research (see Section 10). Examples include protocols regarding; BRUVs configuration and orientation to ambient current, distance between neighbouring BRUVs, fork *vs* total length fish measurements, duration of BRUVs deployment, how many replicate BRUVs you need, and so forth.

11.2. Literature Review

A detailed literature review on the use of BRUVs has not been completed since the 2000 FRDC funded National workshop. Building on this review to include BRUV research conducted since the review would produce a very valuable resource for present and future BRUVs users. The review document and resulting library database would allow researchers to remain up-to-date in the use of BRUVs and BRUV technology, identify how other scientists have tackled specific problems, look for ways to improve upon the technique and promote collaboration between researchers.

11.3. BRUVers List

Euan Harvey and Dianne McLean will develop a contact list of all researchers that are currently using the BRUVs technique. The BRUVers list (name, organisation, email address) will enable more effective collaboration between researchers and promote sharing of information. For example, many researchers are using the statistical program 'R' in which complex and long scripts can be generated. The BRUVers list would enable sharing of this R script in a simple and effective manner. Tim Langlois has built upon this idea whereby he has started an online BRUVs (and DOVs) forum. Researchers from around the world have been regularly using this forum to ask questions and offer advice.

11.4. National Fish Reference Library

A nationally accessible library of fish images and video should be developed and potentially could be stored by CSIRO Marine and Atmospheric Research as part of the National Fish Collection maintained in Hobart. Currently, researchers around Australia are collecting images and videos of fish using SeaGIS Pty Ltd and AIMS BRUVs software. Experts review these images and videos and store the best as 'references' to aid in the identification of fish during video analysis. BRUVers have been building their own reference libraries for some time. An ability to share this wealth of information would be extremely valuable. The central reference library could also be used to aid other initiatives such as Redmap (www.redmap.org.au) and in community outreach. Investigating the potential for development of a National Fish Reference Library are: Alan Jordan, Mike Cappo, Dianne McLean and Tom Holmes.

11.5. National Habitat Classification Scheme and Reference Library

BRUVers often collect information on habitat during the video analysis process. This additional marine environment information is valuable, particularly if collected in a standardised way such that habitat data are comparable both spatially and temporally. Several habitat classification schemes have already been developed for the tropics (AIMS) and more temperate regions (Parks NSW, SEAMAP Tasmania) of Australia. Developing the protocol for classifying habitat from video are: Alan Jordan and Mike Cappo. The resulting document will be reviewed by: Tom Holmes, Peter Fairweather, Russ Babcock, Alan Williams and Jac Monk.

11.6. National BRUVs Facility

In many instances, researchers/managers do not have the funds or facilities to purchase and house BRUVs or the staff expertise required for video analysis and BRUVs maintenance. This issue was also raised at the 2000 National workshop, but is perhaps presently more of an issue as the technique has become much more widely adopted. Workshop delegates identified many benefits and opportunities that would stem from establishing a national BRUVs facility or 'BRUVhub'. The facility would have the following components:

- A pool of stereo-video systems for hire.
- Technical staff for BRUVs maintenance and management.
- A technology working group for testing new BRUVs technology.

- A software working group for further development of video analysis software, including automation.
- A dedicated image analysis centre.
- An ability to store and archive video data.

The BRUVhub would facilitate much wider use of the BRUVs technique, Standard Operating Procedures to be implemented and technological advances to be readily made. An expression of interest FRDC application has been submitted (June 2013) to further advance this proposal.

11.7. National BRUVs Monitoring Program

A National BRUVs Monitoring Program would comprise a working group dedicated to identifying and tackling priority research areas, e.g. influences of climate change and variability (shifting species assemblage and distribution), efficacy of marine reserves and fishery closures (inventory and change), endangered species (distributions, occurrence/relative abundance), effects of anthropogenic activities including fishing, energy resources, oil and gas, desalination developments, decommissioning oil rigs, and aquaculture (broad scale environmental baselines and responses to perturbations), and Commonwealth State of the Environment reporting (metrics of environmental health). The program could become an extension of the present IMOS program to provide a link between the current predominantly physical information being collected and biological data. In addition to aligning a national BRUVs network with existing IMOS deployments, there are a number of strategic deployments that could be undertaken including key reference areas within each of the IMCRA bioregions, in regions experiencing rapid climate change impacts such as the SE and SW seaboards (warming rate 4X and 2X global average respectively) and species of conservation concern such as the deepwater gulper sharks. A working team examining the potential for a National BRUVs Monitoring Program includes: Russ Babcock, Alan Jordan, Kim Friedlander, Euan Harvey, Stewart Frusher, Neville Barrett.

11.8. Bait plume modelling

Online survey respondents and workshop delegates acknowledged that the only way in which the area surveyed when using BRUVs could potentially be determined would be to undertake bait plume modelling. However, it was also recognised that it is probably going to be impossible to accurately determine the area sampled for shallow water environments given the vast number of parameters and contributing factors at play. A small number of potential methods were suggested for obtaining data that may enable some modelling of bait plume dynamics to occur. These included:

- Consistent baiting methods.
- Using current meters on BRUVs to measure direction and strength.
- Observing the spread of dye under various conditions.
- Examining fish arrival times and swimming speeds to determine bait plume.
- Combining BRUVs with acoustic arrays and tagged fish to track their movement and extrapolate this to determining the area accessed by the bait plume.
- Combining BRUVs with deepwater acoustic techniques.

On this final point, Miles Parsons was tasked to investigate the potential of using acoustic sonar techniques in deepwater to track the movement of fish up to and around a BRUVs frame. This may yield data that could be used to model bait plume dynamics and fish behaviour.

It was generally accepted that bait plume modelling might only yield accurate results in deepwater where there is unidirectional current flow over the bait and minimal fish-bait interaction, i.e. at depths >100 m. The sampled area does not need to be known for studies comparing change in the diversity, relative abundance or size of fish from one time to another or from one area to another – assuming similar behaviour of fish to bait at different times, locations, relative abundances and diversity (see priority research questions in Section 10).

11.9. Reducing video processing time

Video processing time will continue to shorten with advances in video and computing technology. There is potential for incrementally automating the length measurements of fish and the species recognition. Initial investigations will occur through ARC Linkage Project 110201008 "Automation of species recognition and size measurement of fish from underwater stereo-video imagery". This research program will link with efforts of others in the US and the UK.

11.10. Ropeless BRUVs

Another possible solution to a BRUVs limitation that received some workshop discussion was the potential for developing 'Ropeless BRUVs'. Where BRUVs are used in areas of high current/tidal flow, ropes with floats that are attached to the BRUVs for their deployment and retrieval can pull BRUVs over.

Furthermore, it can be difficult to retrieve BRUVs via rope in some instances with ropes getting tangled on or cut by propellers. Mike Cappo's suggestion of Ropeless BRUVs would involve developing a system by which an electronic signal at the surface activates a device that then floats a BRUVs to the surface for collection. The electronic device should be able to target a specific BRUVs and the method of floating the BRUVs to the surface should be easily retrievable with the BRUVs system. A twin-acoustic release system and sacrificial anchor weights will be used for long deployments of a deep water BRUVS system being trialled by CSIRO.

12. CONCLUSION

The workshop involved 26 people from a range of organisations (state and federal research and universities, peak body groups, management agencies and industry). The online survey and workshop discussions critically evaluated the strengths and limitations of BRUVs and the techniques ability to provide accurate data that can enable assessment of change in relative abundance, size structure and community composition of scalefish and sharks.

The workshop identified the continued growth and use of BRUVs for assessing the status and composition of marine and freshwater fishes. The key strengths of the BRUVs technique were identified as being:

- Able to sample depths beyond the limits of SCUBA, including the deep ocean.
- Fishery independent and non-extractive.
- Highly efficient and cost effective compared to more traditional methods of sampling fish communities.
- Suited to sampling a diverse array of fish assemblages, including those of relatively inaccessible rocky habitats.
- Statistically robust (efficient and powerful) for monitoring applications.
- Able to retain a permanent video record of species and habitats.
- Able to derive accurate length measurements of individuals.

However, a number of limitations were also identified. These included:

- A lack of a consistent protocols between users may limit the comparisons of data. This needs to be rectified.
- Bait-related biases, including quantifying the area of attraction.
- The inability to use a large fraction of fish observation data, through use of MaxN or similar measure, that avoids repeated counts of the same individuals.
- Video processing time.
- Uncertainties surrounding the use of length frequency data which often assume no size-related behavioural responses.

A range of research questions and priorities were identified to address and help solve these limitations (Section 10). In addition, progression was made towards establishing a set of Standard Operating Procedures (Table 2) and a number of working groups were formulated (Section 11). These working groups were assigned specific tasks that will help advance important national initiatives through the collaboration and sharing of knowledge and expertise. As such, the workshop made significant progression towards improving the ways in which BRUVs and resulting data are used to provide essential information for understanding and managing Australian fishes and fisheries.

13. APPENDICES

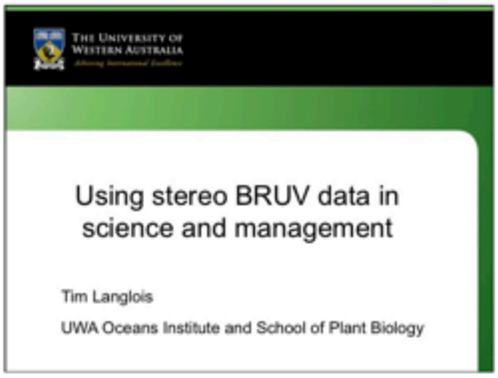
13.1. Appendix 1: Workshop participants

Name	Organisation	Email
Alan Jordan	Parks, NSW	alan.jordan@environment.nsw.gov.au
Alan Williams	CSIRO, Hobart	alan.williams@csiro.au
Bill Sawynok,	Recfishing Research	bill@info-fish.net
Brett Molony	Department of Fisheries, WA	brett.molony@fish.wa.gov.au
Dianne McLean	Mindabbie Marine Consulting, Perth	dianne.mclean@uwa.edu.au
Euan Harvey	The University of Western Australia	euan.harvey@uwa.edu.au
Hamish Malcolm	Parks, NSW	hamish.malcolm@environment.nsw.gov.au
Howard Choat	James Cook University	john.choat@jcu.edu.au
Jacquomo Monk	Deakin University	Jacquomo.monk@deakin.edu.au
Jason Tanner	SARDI	jason.tanner@sa.gov.au
Kim Friedman	Department of Environment and Conservation, Perth	kim.friedman@dec.wa.gov.au
Matt Pember	Department of Fisheries, WA	matthew.pember@fish.wa.gov.au
Mick Haywood	CSIRO, Cleveland	mick.haywood@csiro.au
Mike Cappo	Australian Institute of Marine Science	m.cappo@aims.gov.au
Miles Parsons	Curtin University, Perth	miles.parsons@curtin.edu.au
Nathan Knott	Parks NSW	nathan.knott@environment.nsw.gov.au
Peter Fairweather	Department of Environment and Heritage, SA	peter.fairweather@sa.gov.au
Peter Horvat	FRDC	peter.horvat@frdc.com.au
Russ Babcock	CSIRO, Cleveland	russ.babcock@csiro.au
Shaun Wilson	Department of Environment and Conservation, Perth	shaun.wilson@dec.wa.gov.au
Steffan Howe	Parks Victoria	showe@parks.vic.gov.au
Steph Turner	Chevron, Perth	sturner@chevron.com
Stewart Frusher	IMAS, University of Tasmania, Hobart	stewart.frusher@utas.edu.au

Name	Organisation	Email
Tim Langlois	The University of Western Australia	timothy.langlois@uwa.edu.au
Tom Holmes	Department of Environment and Conservation, Perth	Tom.holmes@dec.wa.gov.au
Wayne Sumpton	DEEDI	wayne.sumpton@deedi.qld.gov.au

13.2. Appendix 2: Workshop presentations

13.2.1. Presentation by Dr Tim Langlois



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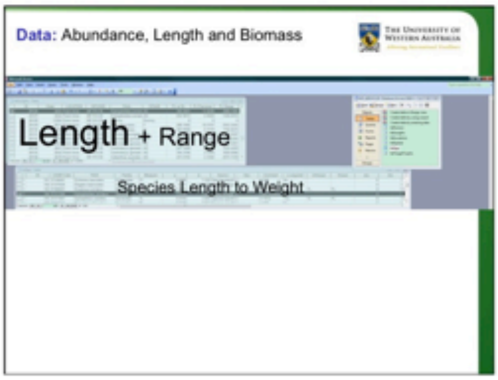

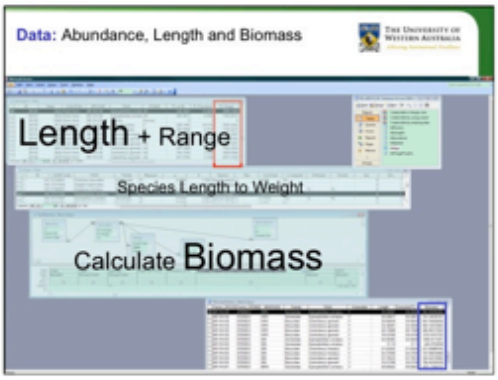

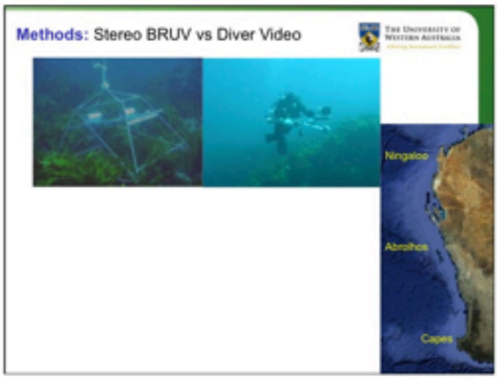

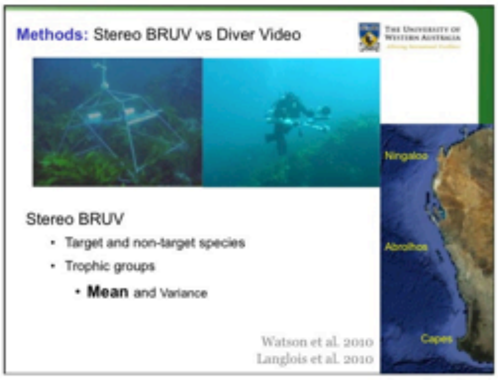

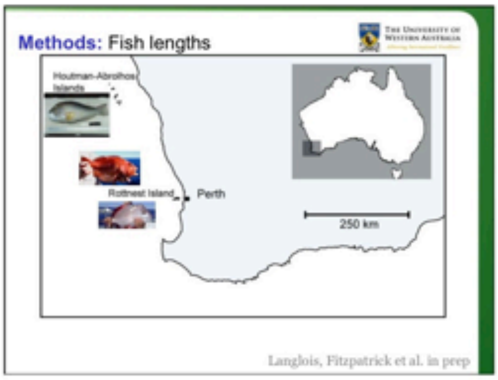

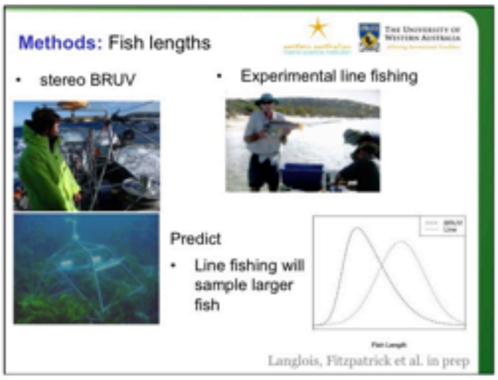

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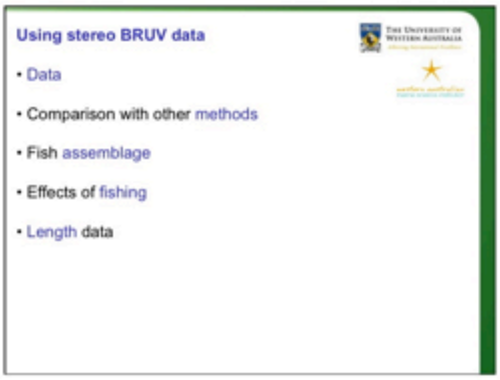

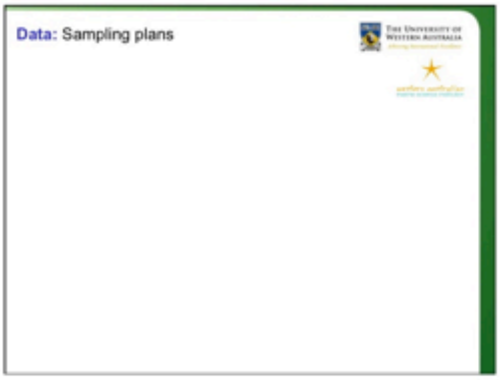

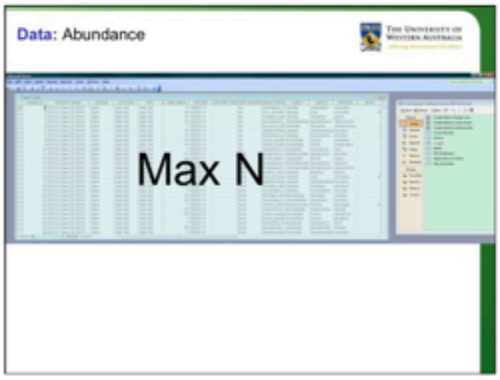

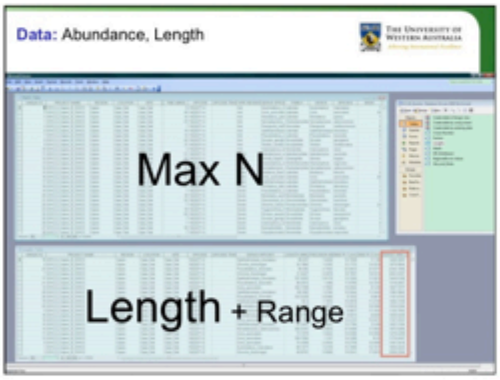

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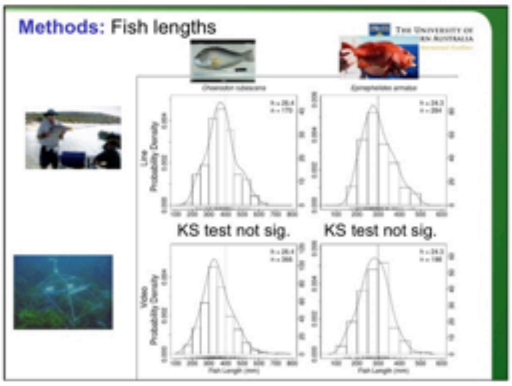

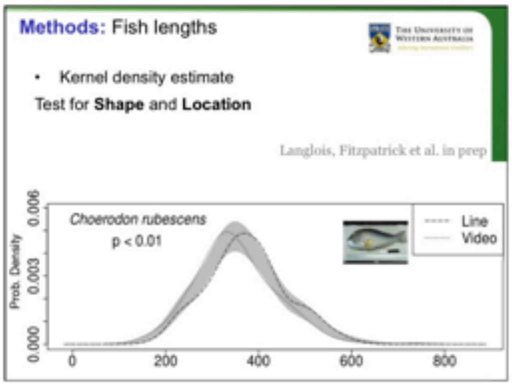

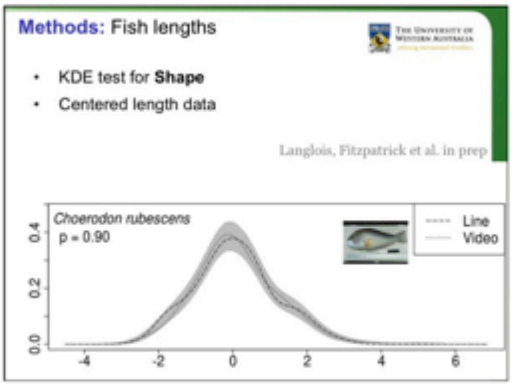

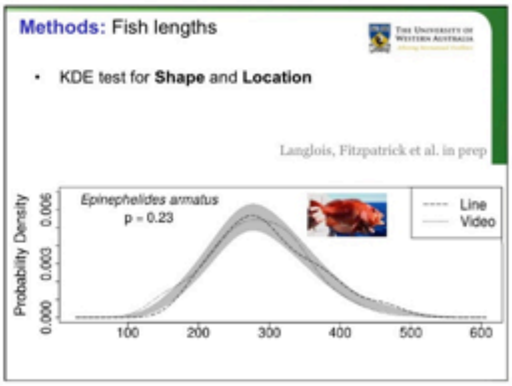

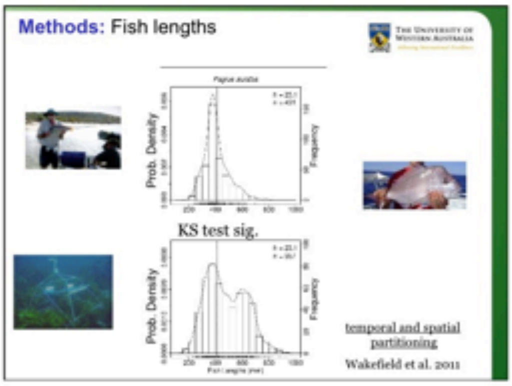

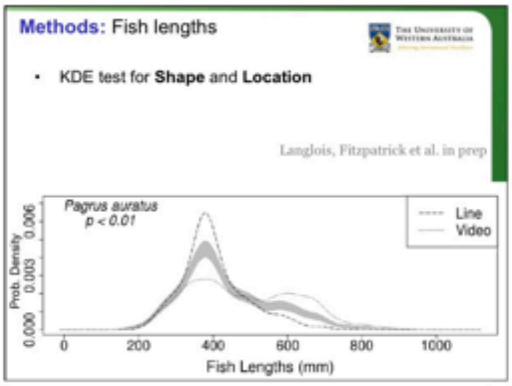

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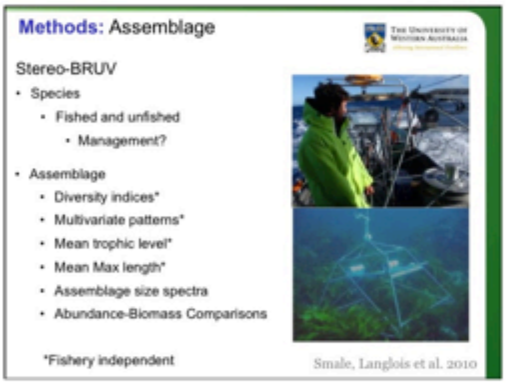

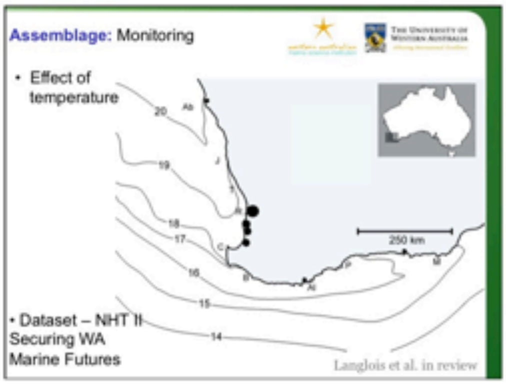

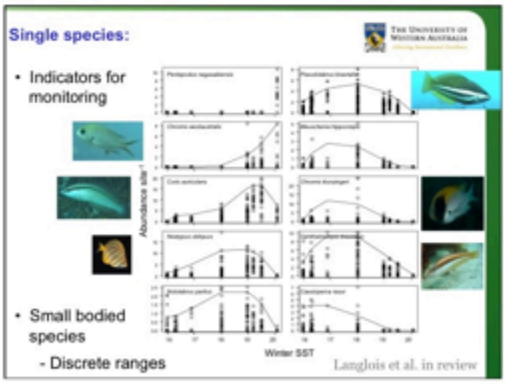

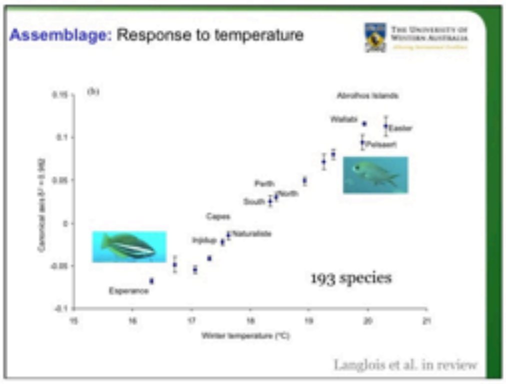

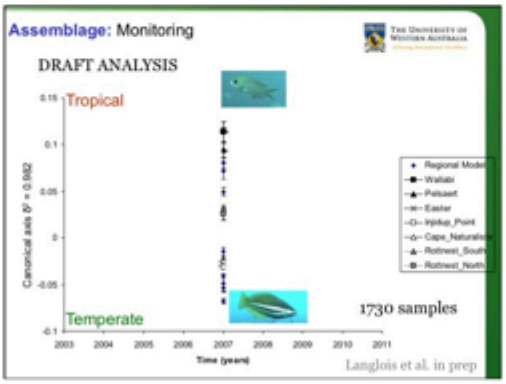

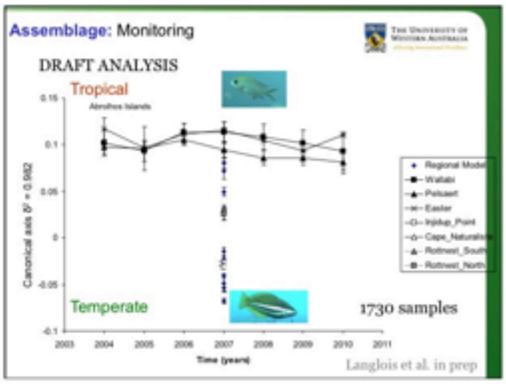

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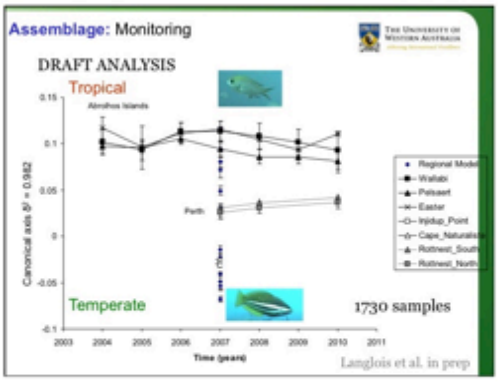

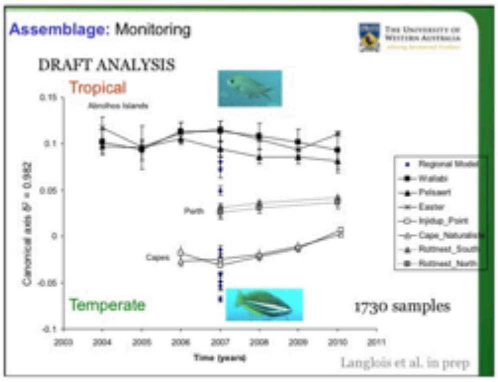

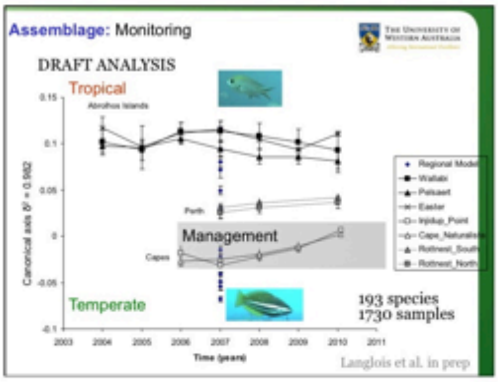

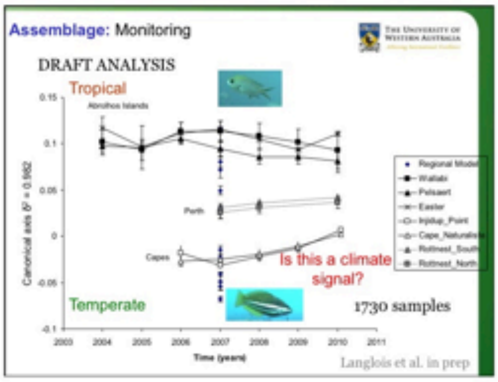

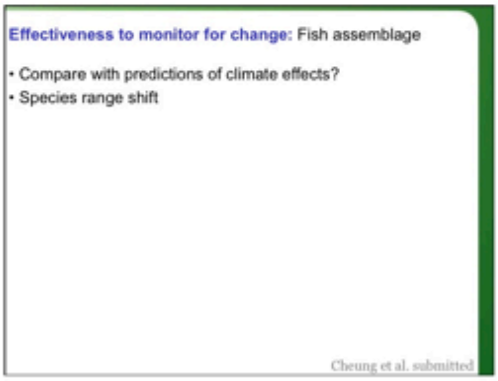

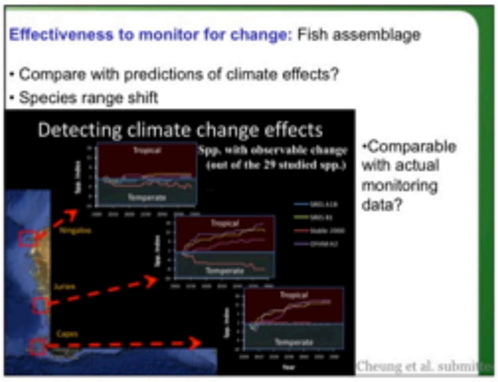

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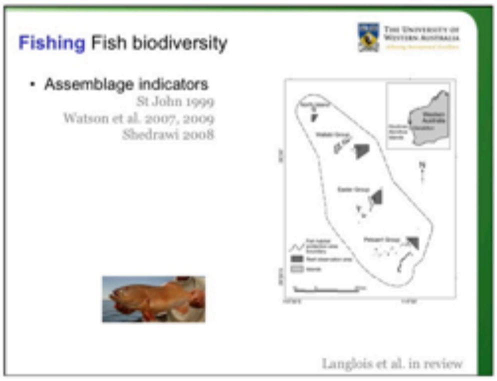

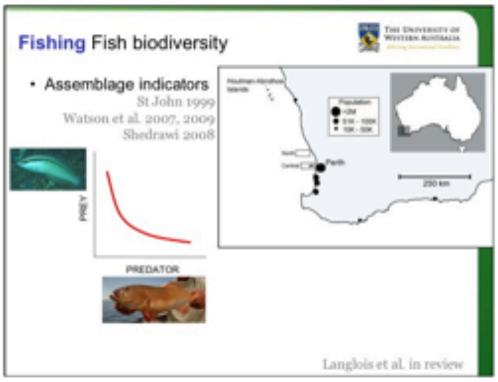

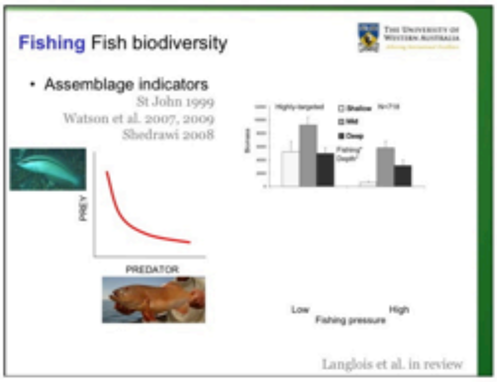

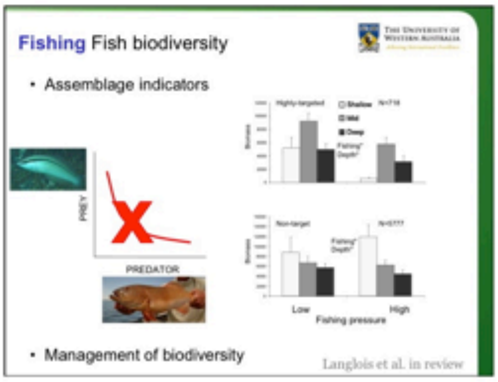

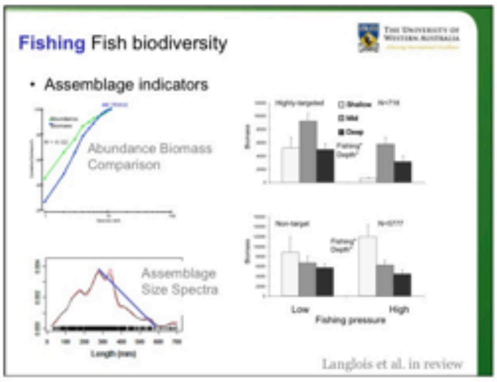

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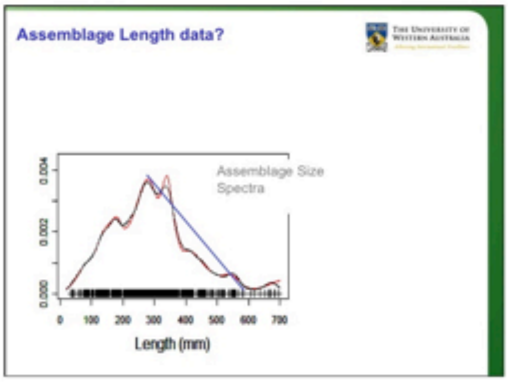
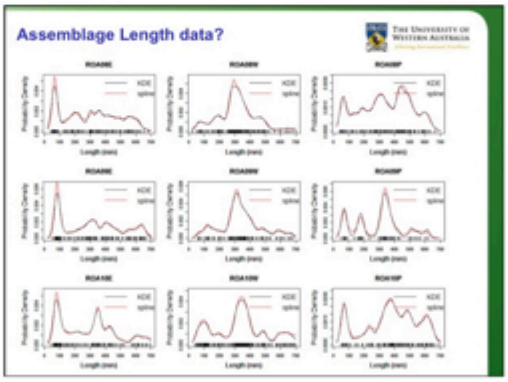
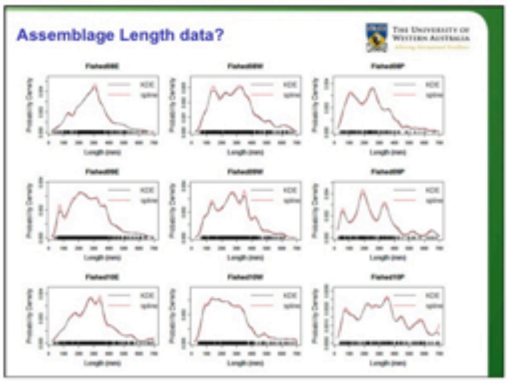
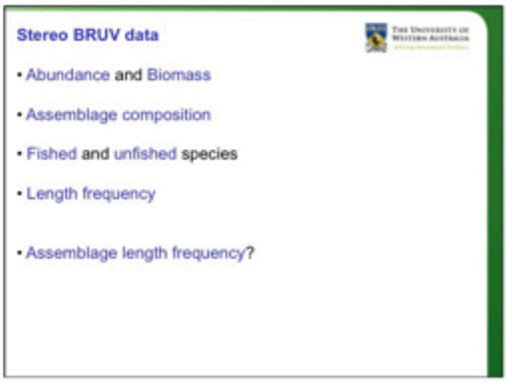
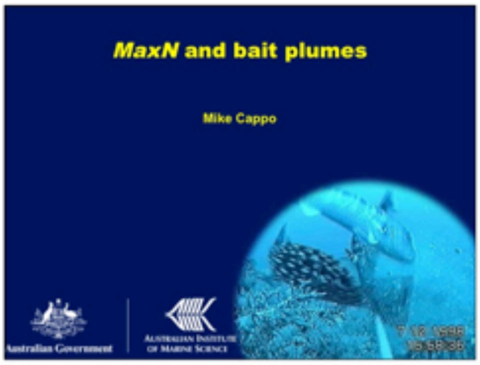


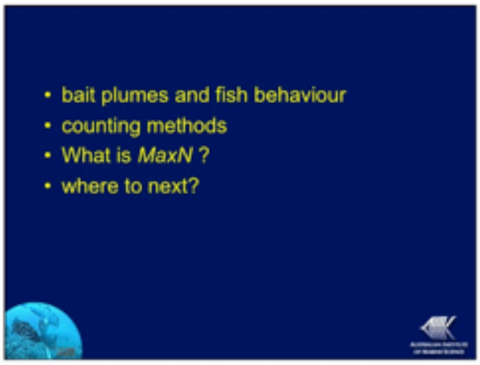


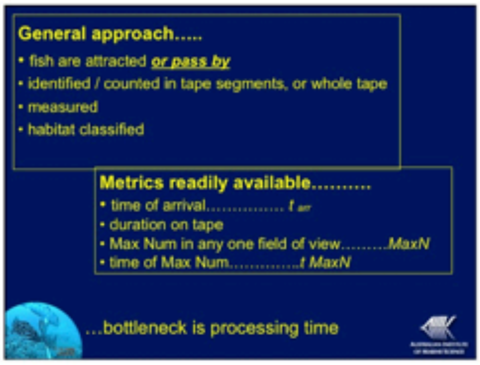


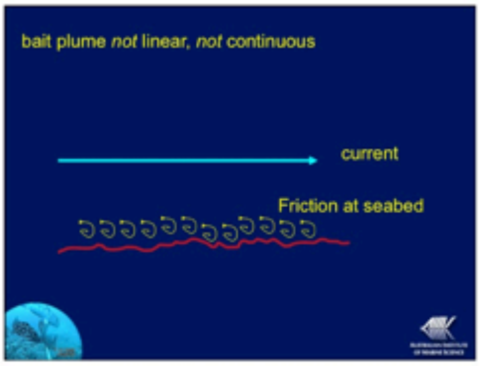


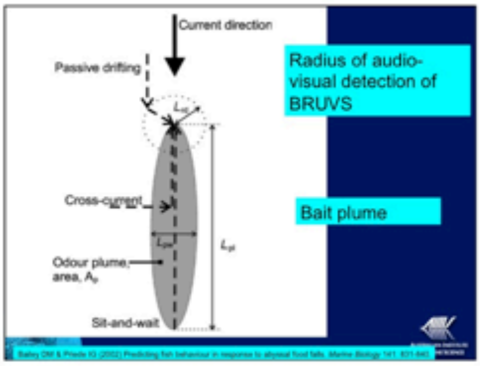
13.2.2. Presentation by Dr Mike Cappo











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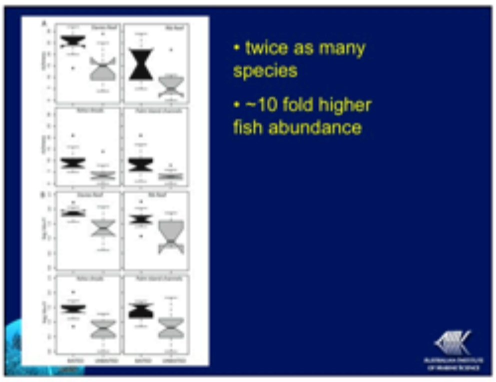

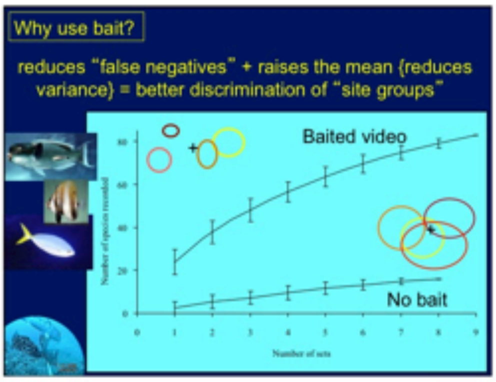

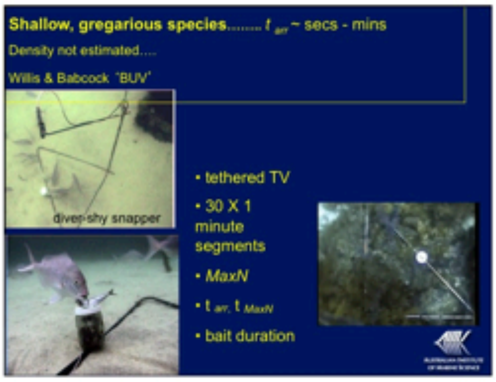

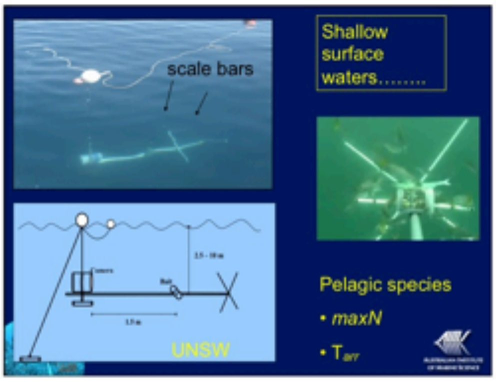

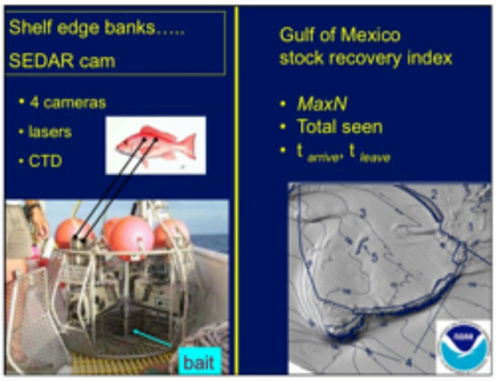

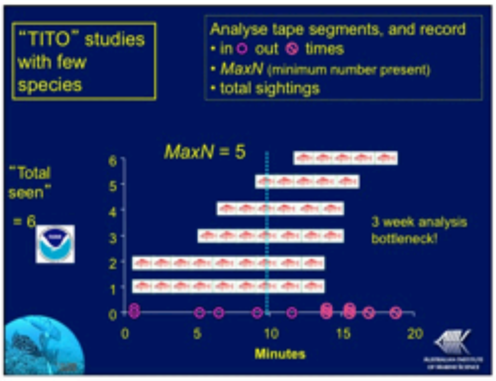

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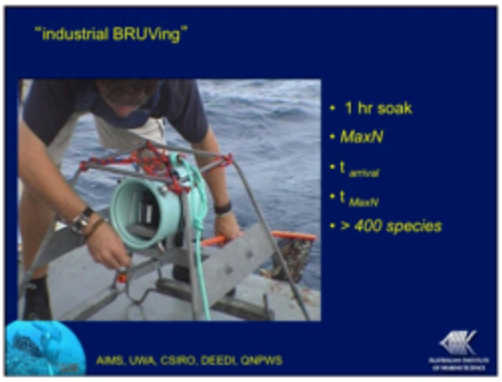
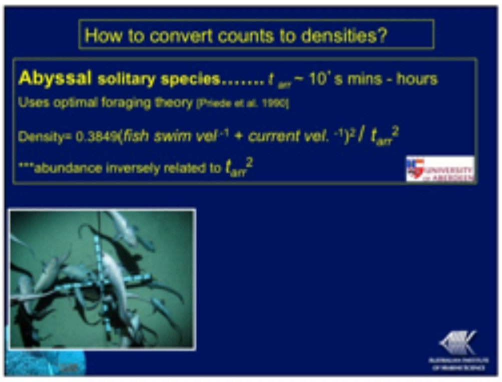
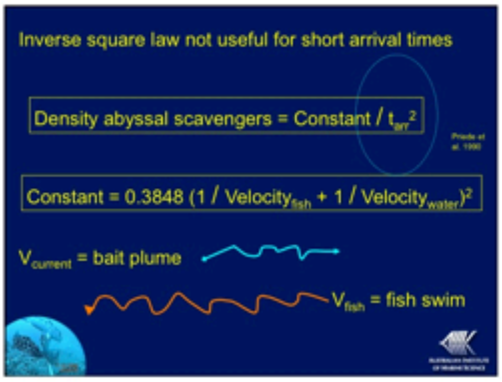
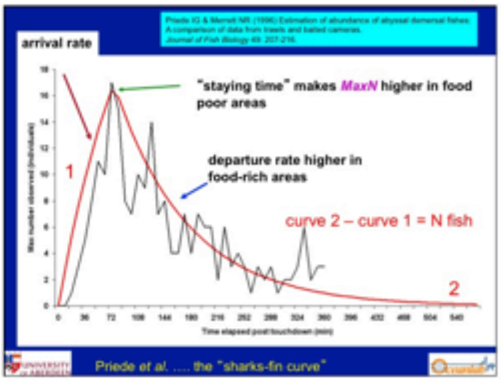
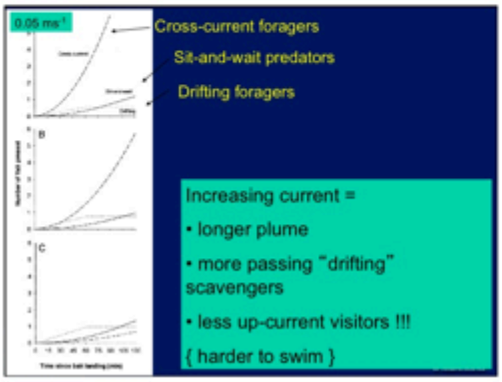
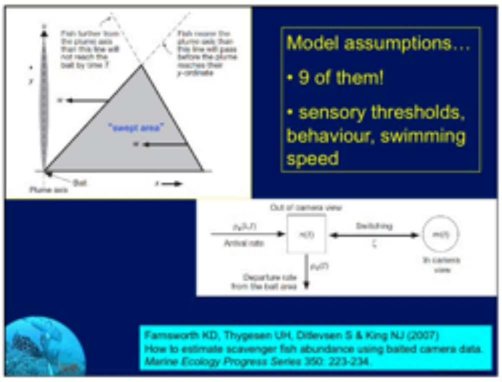




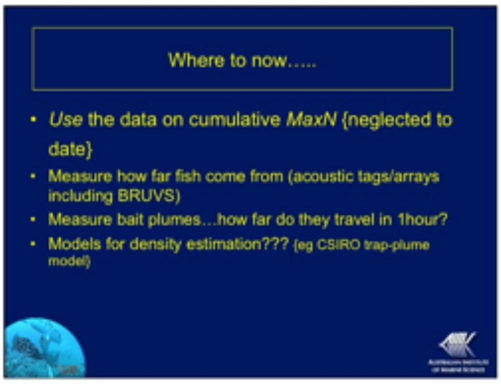








Presentation by Dr Mike Cappo cont…



13.3. Appendix 3: Online Survey Results

These online survey results are presented in full except where specifically stated. Results will be summarised for analysis at a later date and then used to produce scientific publications.

ONLINE BRUVS SURVEY RESULTS

1. Are you a BRUVS user?

#	Answer		Response	%
1	Yes		65	78%
2	No		18	22%
	Total		83	100%

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

Text Response
I am interested in understanding the relationships of demersal fish to benthic habitats and also investigating human impacts on the assemblage structure of demersal fishes and on their relative abundances, biomass, length frequency and mean length of the assemblage and of individual species. I am also interested in investigating the assemblage structure of deepwater fishes in a manner that is comparable to inshore sampling across a broad range of habitats from simple to complex.
Fish Ecology, Marine Reserve Comparisons
Characterise fish assemblages in terms of depth and sst gradients Inside vs outside fisheries closure areas
Whole Fish assemblage composition scale ecological patterns, effects of fishing, broad geographical scale patterns
Assessing fish assemblage structure; understanding processes driving the spatial distribution of fishes; gaining knowledge on what species occur where; fish behaviour; assessing impacts on fish and fisheries.
Assemblage diversity and relative abundance information with particular reference to the difference between natural and artificial reefs
(1) Spatially-explicit predictive species distribution modelling (2) The influence of seascape composition and arrangement on demersal fish assemblages (3) The influence of seascape on relative abundance of demersal fishes
1. Relative abundances of snapper in and out of marine reserves and at different places along the coast. 2. Relative abundances of fishes along a depth gradient and at different latitudes.
Occasional use to contribute to biodiversity mapping

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

Questions of long term change in diversity and biomass

1. Monitor annual recruitment strength of juvenile pink snapper in Cockburn Sound. 2. Habitat associations of juvenile dhufish. 3. Species community composition and habitat associations. 4. Differences in species detection between sampling methods (trap types, BRUVS).

Comparisons of fish abundance, diversity and length data

Spatial and temporal patterns in fish distributions, study of scavenger behaviour

Abundance of juvenile Pacific cod. Abundance of predators on juvenile (age-0) flatfishes in nursery ground

If I was a BRUV user, I would most likely be looking at species identification, size and assemblages for use in acoustic biomass estimation

Differences in species composition, abundance and size in demersal fish communities inside and outside marine reserves

The abundance and size (size data only collected for snapper and blue cod) of predatory fish in 2 marine reserves (full protection) and a marine protected area (partial protection) compared to control sites of comparable habitat but with no protection. There will be error in size data as not using stereo setup (just single cams).

I use BRUVS to record potential feeding impact by herbivorous fishes. This differs from the traditional use of BRUVS to look at largely predatory communities, but the principles are the same, except algal material is used as the 'bait'

Spatial and temporal trends in abundance and biomass measures. Spp composition.

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

Length/frequency distributions.

We are using BRUVS to examine the effects of marine protected area management. We would also like to gain a better understanding of fish-habitat relationships.

Vertical zonation of scavenging deep-sea fish (inc. IDs); species interactions; fish abundance; physiological adaptations (locomotory relaxation or otherwise at depth); interception and dispersal of surface derived carbon.

Presence/relative abundance of species not normally or adequately encountered using other sampling methods (e.g., visual counts, trawl surveys, etc).

Community structure. Behaviour. Habitat preferences. Modelling species habitat relationships

Elucidation of spatial patterns in abundance and distribution; quantification of differences in assemblage composition and abundance inside/outside MPAs

Relative density of particular fish species, size class distribution, habitat association

Relative abundance juvenile fish species on a range of habitats. Relative abundance of Blue swimmer crabs and spanner crabs in areas where destructive sampling methods (Traps) are not appropriate

1. Spatial patterns in diversity for reef fishes 2. Spatial patterns in diversity for fishes on unconsolidated substrata 3. Spatial and temporal comparisons in relative abundance and length for selected fishes between areas under different management strategies (e.g. marine park sanctuary zones, habitat protection zones, outside marine parks) 4. Occurrence and length of black cod (listed vulnerable species) in waters below occupational scuba diving depths

Diver independent assessments of target fishes coral reef fish surveys in water deeper than can be readily accessed by SCUBA divers

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

The diversity, abundance and size structure of fishery targeted reef fish, especially in deeper waters that can be efficiently sampled using UVC and fish species that are generally diver shy and cannot be effectively be sampled with UVC.

Monitor the effectiveness of marine park zones, and environmental impact monitoring.

Evaluate efficacy of MPAs for deepwater snapper-grouper complex

Comparison between fished and non fished zones of fish type and relative abundance to assist in management of MPA and fisheries

1) Spatial patterns in demersal fish, shark, ray and seasnake biodiversity, and how these spatial patterns relate to major environmental drivers (eg faunal boundaries, temperature, sediment type, cover of epibenthos, seafloor rugosity, currents, human impacts) 2) effects of marine protected areas via "open" vs "closed" pairwise comparisons, by accounting for epibenthos and other variables exclusive of fishing effort 3) differences in length of fishes and sharks inside vs outside MPAs to infer effects of fishing 4) location of nursery areas/habitats by measuring length compositions

Indices of predator species and abundance in juvenile rock lobster research

My research focused on addressing the dietary overlap between the slit-eye shark and the surrounding prey communities in Hervey Bay, Queensland. During an elasmobranch survey of Hervey Bay, I caught slit-eye shark at only one of three sites sampled. I investigated the diet of the slit-eye shark through stomach analysis of dissected animals. I used the BRUV to document the prey communities at all of the three sampled sites within Hervey Bay. Overall, I aimed to address the hypothesis that the distribution of slit-eye sharks in Hervey Bay was driven by prey availability.

Length accuracy. Parallax effects and effects of a bent fish body. What would be the best number of size estimates of an individual fish to use? (please note some of the responses below are hypothetical as my use of BRUVS is limited and the answers outline what I would

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

like to do)
Increased understanding of the dynamics of marine systems including who is present where and when and in what numbers. Ability to monitor change over time.
Mainly, to assess changes in the relative abundance and size of fishes across various levels of marine protection zones.
Understanding the effects of fishing at depths not readily accessible by conventional SCUBA.
Quantify fish assemblages in depths outside limits of SCUBA
I have to clarify that we are just starting to put in order a protocol to use BRUVS. We want to evaluate its performance to extend our depth limitations with uvc. Our topics of interest include seasonal and spatial patterns of adult, juvenile and prerrecruits of reef fishes, behaviour, and demography
Differences in abundance between MPA and fished areas. Differences in approachability to the BRUV between different locations/population contingents. Biodiversity of predatory fish throughout a large study area. Comparison of different BRUV set ups
Monitoring fish assemblages over time subsequent to the protection of these areas from commercial and recreational fishing. To identify fish assemblages in a range of habitats in areas that is too deep for divers. To test the effects of possible UVC biases using BRUV
1.) Enhancement of deep-water fishery resource investigations to address knowledge gaps similar to those mentioned above (e.g. deep-water fish populations located adjacent to marine protected areas vs. those areas which are subject to harvest or extraction pressures); 2.) Connectivity assessments between coral reef fish populations in shallow vs. deep (mesophotic) reefs; 3.) Diver-independent quantification of apex predators on reefs in the Hawaiian Archipelago, comparisons of relative abundance derived from BRUVS against those

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

from visual surveys

- Fish assemblages (continental slope, between fished and closed areas) - Recruitment index (juvenile snapper)

• Describe the composition of fish assemblages and the relative abundance of fish and shark species on reef shelf habitats at depths between 30 and 50 metres in the waters surrounding Lord Howe Island and Balls Pyramid (within LHIMP) • assess the influence of marine park zoning arrangements on fish assemblages and key fish species - distribution and abundance of rare, protected and threatened species (ie black cod)

Characterise fish assemblages at Rottnest Island through a benchmark survey, and examine for any differences in the assemblage as a result of protection.

Effects of MPA/Marine Reserves on fish communities (size, biomass, trophic structure, biodiversity). Monitoring Surveys beyond diver depth

Monitoring of fish assemblages and relative abundances on artificial reefs.

Baseline surveys, during construction surveys and post construction surveys Projects likely to include large scale dredging operations, pipeline routes, port construction / expansion projects

Hoping to gain information on fish relative abundance, size frequency and species-environment relationships to establish the effect of protection and the environment on targeted Hawaiian bottomfish species.

To conduct a broad survey of bentho-pelagic fish abundance in estuarine environments.

The BRUVS are used to conduct community based assessments to further the ecological understanding of finfish communities associated with artificial reefs in estuarine and ocean systems- relative abundance (total and individual species), species richness, diversity, species behaviour etc

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

Effects of MPA zoning. Species assemblages across habitats, with particularly focus on temperate estuarine softcoral habitats

Deep water (>30m) fish assemblage structure and size distribution

Comparing abundances and sizes of fish inside vs outside marine reserves

Distribution and abundance of fishes in relation to environmental variation. Effects of management interventions (eg MPAs, artificial reefs)

Examining the spatial structure of fish assemblages in relation to physical variables defined from swath mapping. Evaluate changes in fish assemblages through time in relation to spatial closures.

Is there evidence that fish are present despite low catch rates by recreational fishers? Do fish use different feeding strategies, which affect their catchability? Are there differences in the willingness of fish to feed in no fishing areas (green zones) compared to fished areas?

Influence of fishing pressure on reef fish assemblages. Using BRUVS to non-destructively survey inside and outside MPAs targeting species that are not always seen using traditional diver UVC. Especially targeting greater depths than traditionally surveyed and gaining knowledge on the abundance, size and distribution across depths and gradients of fishing pressure.

Relative abundance and the type and number of species present within a marine park

Monitoring of ecosystem structure inside and outside closed areas, among habitats and along gradients of depth and latitude. Abundance and size/biomass of target and non-target fish and finescale habitat info

2. What questions are you seeking to address, or knowledge are you looking to gain, by using BRUVS?

Population monitoring of deepwater conservation dependent sharks (genus Centrophorus)

Habitat use by fish populations in and around seagrass beds. Species identification, abundance, length

Any management-relevant information on fish communities at depths between 30-150+m. In particular we'd be interested in data that could support the development of allowable catch limits for coral reef fish species.

Fish assemblages composition, fish abundance.

Habitat associations of fish assemblages (fish distributions)

Fish abundance and diversity

Looking at how recreational caught species are affected by different levels of marine reserve management.

LTEM

Population estimates, density estimates.

Examining the effectiveness of GBR zoning on target and non-target reef fish assemblages.

Fish communities - abundance and species richness

3. What data do you collect from BRUVS imagery?

#	Answer		Response	%
1	Fish identification		68	96%
2	Relative abundance estimates		68	96%
3	Behaviour		33	46%
4	Gender		17	24%
5	Length		47	66%
6	Other (please specify)		18	25%

Other data collected from BRUVS imagery (responses summarized)
Biomass
Habitat (9 separate responses)
Visibility, habitat assessments, fish images and video
Degree of damage ie predator interaction
Time to first appearance
Time of first feeding on bait bag
Catching fish vocalisation
Biomass
Year class for snapper (Chrysophyrs auratus)
Species richness, diversity, etc.
Tag number if tagged

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

Statistic	Value
Total Responses	67

Text Response
Our stereo BRUV configuration changes depending on the benthic habitat sampled and on the depth. In kelp habitats we use the frame, which has the base bar approximately 1 m off the bottom so that the camera field of view is not obscured by the kelp. In coral, seagrass, sand and sponge habitats we change the height of the base bar so that is close as possible to the benthos without obscuring the field of view. In general we use stereo baited remote underwater video systems that have a camera separation of approximately 700 mm inwardly converged at approximately 7°
We use 2 Sony CX12 Cameras spaced 80cm apart on a 7 degree angle.
Stereo Sony cx12 Robust galvanized steel frames Either plastic sewer pipe or aluminium housings (I don't see how this question is relevant for a review - except the stereo bit)
Stereo BRUV, 350mm -500mm from seabed, 800mm separation between the cameras
Stereo-video systems as per Harvey et al. (2001; 2002).
Mono and stereo BRUV
SeaGIS designed stereo BRUV (short and long leg extensions) Cams: Canon Legria HFM300. Sony HC 15E Spacing: 0.7m Angle: 8 deg. Materials: PVC housing, zinc dipped frames
The stereo BRUV units used two full High Definition Sony handycams (models HDR-CX7 and HDR-CX500) in underwater housings mounted on a base bar inside a frame21. The bait consisted of two kilograms of frozen pilchard Sardinops sagax (Jenyns) that was thawed, chopped and packed into two bait bags made of steel dipped in plastic coating with a square mesh of 10 mm. The field of view was illuminated by eight blue Cree

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

XLamps XP-E LEDs each delivering a radiant flux of 350-425 mW at wavelengths ranging from 450 to 465 nm25, except for one deployment that used white light. Video analysis and species identification was done on the first 150 minutes of each video deployment.

Canon HV20 single camera

Standard seagis stereo imagery

Stereo Canon HV20 MiniDV cameras at 700mm spacing with 12 degree convergence angles. Single camera BRUVS. galvanised frames, ballast weights, PVC double o-ring housings, conduit bait poles at 1 or 1.5m.

Stereo, mono (standard UWA config)

Have previously used deep-water systems mostly downward looking video and stills baited with mackerel and in a couple of occasions porpoises. Now using Sealife stills cameras with twin strobes and trying out GoPro video cameras as a low-cost system.

Live feed to boat Single camera - AquaVu with Sony Mini digital tape recorder

Stereo HD digital video cameras in PVC housings mounted on galvanised steel frames (SeaGIS)

Camera: Sony HDR-XR350VE. Pressure buoy keeps system (made of aluminium bar) upright. Camera points downwards at scale bar from a height of 115cm. Scale bar (170cm) diagonally across video field of view. Camera housing is cut down fire extinguisher with polycarbonate housing - camera operated by remote. See methods section of: http://www.doc.govt.nz/upload/documents/conservation/marine-and-coastal/marine-protected-areas/marine%20reserve%20monitoring/poor-knights-fish-monitoring-2009.pdf for a similar set-up.

Camera (Sony DCR SR100 in Ikelite housing) is mounted on besser block (concrete building block) on the seafloor and positioned approx 2m horizontally from the bait.

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

BotCam. See Merritt, D. W., M. Donovan, C. Kelley, L. Waterhouse, M. Parke, K. Wong, and J. Drazen. 2011. Botcam: A baited camera system for non-extractive monitoring of bottomfish species. Fishery Bulletin 109: 56-67

two camera system - mounted ~1 meter apart

Usually a 5 Mpixel digital still camera (Kongberg maritime), 2-m above bottom, looking vertically down at one mackerel bait. Alternatively we use the same system but looking horizontally across the seafloor. We only ever use a single flash

Video camera or cameras arranged in lobster trap (or milk crate) for retrieval by boat or divers.

Euan Harvey configuration for Stereo and single BRUVS

Single camera unit baited with 400 g pilchards suspended in net 1 m from lens. Bait arm above camera housing to facilitate clear viewing above kelp. Camera mounted in aluminium frame, weighted with lead.

Lowlight monochrome CCD cameras, ~1m camera spacing, independent power source and dvr system, external video synchronization, 10 to 15 degree downward orientation, floating design, concurrently collect temperature, pressure and current information with attached instrumentation

Ricoh cameras for multiple still images of spanner crabs with downward facing BRUCS. Camera mounted 1.5m from seafloor. Depths 15 to 70m. Sony CX110 video cameras using horizontally facing BRUVS in standard mono housings. Bait 1.5m from camera.

Originally I used 3 single-BRUV 30 minute sets per site, 200m spacing betwen reps. Last year, increased this to 4 replicate 30 minute sets per site (as part of NSW State-wide MER design) This year I am using 4 replicate stereo-BRUVS per site with 200m between replicates. Current camera types = hard drive HD Canon cameras in SeaGIS housings and using SeaGIS stereo-diver base-bars that bolt into steel BRUV frames.

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

Not yet using BRUVS

UWA stereo BRUVS design. Frames 1260 x 850 x 750 mm high from 12mm gal steel. One 2kg weight on front for work in 30m depth more if strong current. 2x Sony CX-7 1080i cameras with WA lens separated by 750mm on 7 degree inward convergence. Previously used for NSW: Port Stephens Great Lakes Marine Park 2007-2009 and surveys for HMAS Adelaide out from Terrigal 2008-Current. Stainless steel frames as described in Cappo et al 2004 with single Sony DV handycams and WA lens. Lord Howe Island MPA, Full HD Canon cameras and single BRUVS from SeaGIS Batemans MPA baseline survey 2007: Custom gal steel frames from Uni of Wollongong and Canon DV handycams cylindrical bait canister Batemans MPA Estuary work 2009 - Frames as Cappo et al 2004 with single Sony DV handycams and WA lens., however bait canister cylindrical.

Sony Handycam HDV 1080i. Mini DV. We use a single camera setup (not stereo). Aluminium frames. 1.5m PVC bait arm. Bait contained in 500ml plastic jars with panels cut out and lined with mesh.

We use the SeaGIS stereo frames, housings and diodes with 20 x 1500mm PVC bait arms. Current cameras are Canon HV30(HD) and Sony DCR-HC52(SD). Would soon like to replace all with HD solid-state cameras. We also have 10 single camera frames (custom made) from steel that use the same SeaGIS housings.

Generally there are two video cameras with auto-iris function to adapt to low light levels at depth. Spaced about a meter apart. Cameras and electronics are mounted in a rectangular welded metal frame. There is also closed cell foam to allow the frame to float ~2m above the ballast.

Single BRUV frame with Canon HG 21 but moving to stereo units in 2012

1) Single-camera BRUVS; Sony MiniDV HandiCams with 0.6X wide angle lenses/Sony "Card Cameras" with 0.6X wide angle lens adapters; PVC/acrylic housings in galvanised rollbar frames; trestle arrangement with cameras facing seabed at 10degree angle --Bait bag ALWAYS on seabed at end of 1.5m flexible bait arm 2) Stereo --same as above, but

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

camera spacings 750 mm and angle of convergence 13 degrees

Custom made by scilex, drop camera on tripod.

The BRUV consisted of a metal pyramidal frame, 0.75 m on each edge. A Huashi HS-110-7A underwater camera positioned directly under the apex of the pyramid, with its focal axis horizontal and parallel with the substrate, was focused on a 20 cm2 x 3 cm high bait holder. The bait holder was held 0.5 m from the camera using 15 mm diameter plastic electrical conduit. During deployment the BRUV was connected to an ARCHOS 05 Series 705 Mobile Digital DVR located in an attendant boat to record video sequences. In all replicates, the BRUV was baited with approximately 0.5 kg of the Australian pilchard.

Canon HG20, 8 degree angle, 0.8m spacing, SEAGIS aluminium construction for stereo. Single camera units use Canon HG20 and Uni of W'gong constructed frames based on those of Cappo.

The configuration we use is that used by Dr Euan Harvey at the University of WA. It is a stereo-video setup.

Ask Euan about Oman work

We use a sony dcr sr300 hdd camcorder into a sport underwater housing (pro 6 equinox U/H). the camera is mounted downward faced onto a stand of 1,2 m height. the bottom area covered rounds 3 m^2 with a 0.38 wide angle lens.

(1) BRUV with vertical camera orientation as designed by Trevor Willis when at the University of Auckland (2) BRUV with vertical camera orientation suspended by flotation ~2 m off the sea floor. This was a very heavy set up with chain, railway iron, acoustic release, seacorder camera, and a surface float used in up to 200 m of water. (3) Horizontal orientation of a single camera on a small aluminium frame with bait on the

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

end of a pole in front of the camera and a surface rope.

We use single BRUV units with Sony Handy Cams using Mini DV tapes.

UWA equipment

Single units currently but just purchased stereo BRUVS and stereo diver frames to use in future. Use HG21 HD cameras

Two Sony HC 15E video cameras are mounted 0.7m apart on a base bar inwardly converged at 8º to gain an optimised field of view with a visibility of 10m distance (Harvey and Shortis 1996).

SONY HC 15E handy-cams with 0.6 wide angle lenses separated on a base bar by 0.7 m and inwardly converged to provide an overlapping field of view from approximately 0.5

High Definition digital video camera (Canon HF100) with x0.7 wide angle lens in a PVC pipe underwater housing, an aluminium frame, a 1.5 wooden bait pole with bait (1.3 m from camera) , consisting of crushed pilchards, chook pellets and tuna oil with two strips of squid and a single whiting head attached to the outside of the cage to entice fish closer to the camera to aid identification and allow for estimates of snapper size class, aided by the use of two 20 cm measuring bars at the front and back of the bait cage.

na

BotCam (detailed in Merritt D, Donovan MK, Kelley C, Waterhouse L, Parke M, Wong K, Drazen JC (2011) BotCam: A baited camera system developed for non-extractive monitoring of bottomfish species Fish. Bull. 109: 56-67)

Standard configuration (not stereo BRUVS)

Initially (2005 - 2009) - multiple frame mounted mono-BRUVS (based on the work of Cappo); Recently begun using stereo BRUV systems (SEAGIS) for in-water assessment of fish communities associated with offshore deepwater fish aggregating devices (FADs);

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

Investigating the potential for flash memory HD camera devices (eg GoPro) for use as mono-BRUVS as a low cost option for ongoing surveillance monitoring of established estuarine artificial reef fish communities.

SEAGIS BRUV frames with Canon HG21 camera's, 1.8m bait arm with approx 700g of pilchard as bait. 2x stereo systems: 2x SeaGIS diver held units with custom made BRUV frames that diver unit bolts into. Canon HG21 cameras

Design in Willis & Babcock 2000, sometimes adapted to be free of boat, i.e., camera is self-contained within housing above bait, with no cable to surface (only a rope to a float).

Sony cameras (tape, memory card), wide angle lens, polycarbonate housing, s/steel frame (same as AIMS design), 1.5 m bait pole, 200 m between replicates

Canon HFS21 Raynox HD6600Pro wide-angle lens Base bars, synchronisation diodes and camera housings supplied by SeaGIS Single cameras mostly used to date, but stereo systems recently setup

Single Deep Blue model by Splash Cam Inc mounted on a custom built triangular frame linked to an onboard CCTV camera .

UWA stereo video design, sony CX-7 cameras. Base bar 125cm and camera spacing 75cm. Stereo convergence 7 degrees. Frames 130 x 85cm and 75cm height from 12mm gal steel. At University of Newcastle in 2007-2009. Used single BRUVS with Sony DV Handycams with WA lens, frame design as of Cappo et al (2004). For NSW MPA work at Lord Howe Island and Batemans marine park used single Canon HD cameras and frame from SeaGIS

Each BRUV unit consisted of a video camera (Sony Handicam DCR-HC52E) enclosed in a transparent waterproof casing, an attachment frame and a 1.5m long bait pole with bait cage (30cm length, 8cm diameter, 5x5cm mesh) on the end (Figure 2.2). The frame was connected to a floating buoy by 30m of polyethylene rope to enable the BRUV to be

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

located and retrieved after deployment. The cage was baited with a standard amount (500g) of dead, chopped-up, pilchards (Sardinops neopilchardis); an effective bait for recording high richness and abundance in underwater assemblages (Wraith 2007). The BRUV unit was then lowered to the seafloor where it remained for at least 35 minutes to allow the unit to settle and record images for 30minutes before being removed.

On lobster pots?

HD hard-drive recording (120Gb) Camcorders (Panasonic HS700), ~800 mm spacing, delrin pressure housings, LED lights

Seagis Stereo Video Cameras inside are Canon HDV 1080i

The only kind my group has any experience with are from UWA & were deployed during a NOAA cruise by Steve Lindfield.

Frame - the same design and materials as in Cappo et al. (2001, 2004), but the camera housing is elevated 150 mm up. Video cameras - HDR-CX350V

Single HD handycams (i.e. not stereo systems) with SD cards and miniDV tapes used. Spaced at 150+ meters within a shallow-water

Single camera, canon HG21 with wide angle lens, 1k cubed pilchards, 1.5 m from camera.

This system consists of a triangular stainless steel stand, with a Sony XC-777P high-resolution colour camera in a waterproof housing, positioned 1.5 metres above a bait container containing four pilchards (approximately 300g), Sardinops neopilchardus. A 100 m long coaxial cable connected the underwater camera to a Sony GV-S50E video monitor and 8 mm recorder on the research vessel. Deployed from the research vessel to depths of up to 65 m at sites at least 500 m from diving activities.

4. Please describe the BRUV configuration you use, i.e. camera types, spacing, angles, materials etc.

N/A
Various digital camcorders with wide angle lens in underwater housing. Fixed into stainless steel frame. Bait bag fixed to pole extending .5 m in front of camera. Field of view estimated at 2 m beyond bait bag for an FOV volume ~ 9.4 m3.

5. At what orientation are your BRUVS deployed at, relative to the seafloor?

#	Answer		Response	%
1	Horizontal		60	86%
2	Downward facing		12	17%
3	45 degrees		2	3%
4	Other (please specify)		4	6%

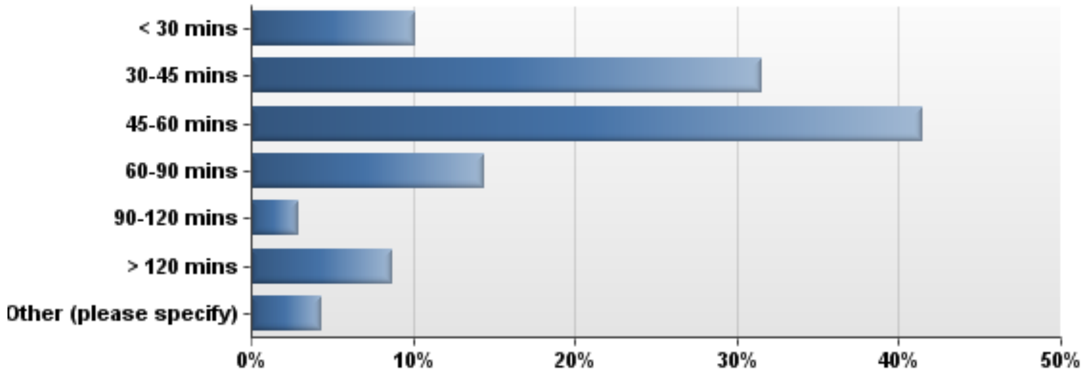
Other orientations specified
I used to use downward facing
About 20 degrees down
Downward when suspended above bait
10 degrees to film bait canister on seabed

6. What definition cameras do you use?

#	Answer		Response	%
1	High definition (e.g. 1920 x 1080)		49	71%
2	Standard definition		28	41%
3	Other (please specify)		3	4%

Other camera definitions specified
Record in HD process in SD
Not sure

7. How long are your BRUV deployments?



#	Answer		Response	%
1	< 30 mins		7	10%
2	30-45 mins		22	31%
3	45-60 mins		29	41%
4	60-90 mins		10	14%
5	90-120 mins		2	3%
6	> 120 mins		6	9%
7	Other (please specify)		3	4%

Other deployment lengths specified
In deeper waters we tend to use longer deployment times
12-24 h
days - weeks

8. Why do you choose to use the length of deployment you specified in Q7?

Text Response
In shallow waters the 60 min deployment time has been based on species accumulation curves developed for the temperate and tropical Western Australian habitats that we sample. We are finding that deeper waters that we properly need a longer sampling period that we have not validated the deployment times as of yet
Previous studies suggested 45 minutes to be sufficient
Appears to be a good time for maxn and species richness to asymptote Easy to standardise - given we used to use 60 min tapes
We have used standardised 1 hour deployments for a number of years. we have found that with deployment times of between 40-50 minutes species accumulation plateaus in both temperate and tropical regions.
Species accumulation curves. A best case scenario for bait persistence, battery life, field efficiency, lab processing time and comparison to past surveys where mini dv tapes were time restrictive.
Based on work by Dianne Watson
So that fish will have enough time to arrive even at depth, where movements can be slow and bait plumes can be carried slowly as well. Another reason is to allow some behavioural information to be collected also.
Based primarily on recording time of camera
Undecided
30-45 time of MaxN in trials 60-90min duration of minidv tapes
Different times are used - dependent on type of survey. Surveys of diversity of species would typically require longer sets (which can vary in different environments/habitats),

8. Why do you choose to use the length of deployment you specified in Q7?

while those for specific species may not (but that is also species-dependent)

Worried that at longer durations the current direction has changed too much to make abundance estimation possible. Usually expect biggest differences in first hour.

To get a quick snapshot of the surrounding fauna with minimal complication of variation in bait plume.

In several of the areas we sample small fish eat most of the bait within this time period. Additionally, we have 200 sites to sample each season and in order to get the maximum done each day we decided to restrict the sampling time to 45 min.

Same as methods used elsewhere in marine reserves in NZ.

To capture as much feeding data as possible, and incorporate any temporal variation in feeding and fish movement.

This was chosen based on some preliminary data to suggest that MaxN was reached in the first 30-40 minutes.

Based on experience id the deep-sea. Normally there is still fish activity at the bait around 12 hours. After that there are often other species arriving, such as squat lobsters, as long as 24 hours after bait delivery.

To maximize encounter probabilities for rare or widely ranging species.

This has historically been because of tape length

Preliminary sampling indicated that full tape length time (60 minutes) was best to sample the full assemblage in our system.

Logistically feasible, statistically relevant, primary species of interest yield diminishing

8. Why do you choose to use the length of deployment you specified in Q7?

returns beyond this time period

When I initially started using BRUVS I found that most species in the area I'm working (subtropical NSW) were detected by 30 minutes. Logistically this was also the best time as by the time I had set 3 or 4 BRUVS there was sometimes just enough time to have a coffee before pulling them up. Going to an hour set greatly reduced the number that could be set in a day.

60min standard UWA practice. Fit 65min of HD 1080i footage on an 8GB card. However I do believe this could be reduced, in tropical reefs an optimation study would be useful. As the extra time in the field (unless using 8 cameras) could be reduced - but more importantly processing time might be reduced and allow more replication for a shorter study. Shorter soak times reduce potential of species attracted from a wide area. Previously used 30min as was used in NZ studies and Hamish Malcolm in Solitary Islands MPA, but more importantly I was maximising replication that we could do using 4 BRUVS - there was little time waiting on the boat. When boat time is limited I believe increasing replication is more important than a longer soak time. Analysis was kept interesting and two drops could be recorded on one 90min LP DV tape. But see Gladstone et al (in press) about estuarine BRUVS in NSW. Longer soak times were required to attract commercially important species - however processing was quick due to a low diversity and narrower field of view. Email william.gladstone@uts.edu.au for an update on that paper.

To make use of the full tapes. Generally retrieval and deployment takes long enough that setups are in place for close to 1hr by the time we are ready to retrieve.

As we are still using Mini DV tapes we are confined to 60 minutes. Long play could be used but not recommended for use with SeaGIS software. 60 mins is also logistically convenient.

Allow enough time for fish in vicinity to arrive at the camera, vs maximizing number of drops

8. Why do you choose to use the length of deployment you specified in Q7?

NSW MPA standard time
1) Logistics 2) in comparison with earlier 90 minute sets, where we found most species seen within 30 minutes 3) bait does not last indefinitely
30 mins provides a good operational time to get enough observations and thus a stable sample from each site, without being too long and limiting replicates
Length of deployment was determined following a trial period of deployments ranging from 10 - 60 minutes. 20 minutes was chosen as it appeared, qualitatively, that attraction of animals did not increase above this time.
Shorter - Ease of deployment - maximise number of drops. Longer - allow fish to acclimate and provide more chance of observing natural behaviour
Logistically, it seems about right to maximise replication throughout each field day and tends to generate reasonable estimates of max n and assemblage diversity.
This is a trade off between obtaining enough data from a single deployment and sampling effectively across the area of interest. Calculation of Species-abundance vs time curves can help with this.
Ask Euan
Based on initial trials. I insist, length of deployment could vary depending on further research
The 30-minute deployment used has become the standard for DoC surveys in NZ. Longer deployments, however, have shown us that larger fish are only willing to approach the camera at times >30 min. Other longer deployments that we have conducted are due to

8. Why do you choose to use the length of deployment you specified in Q7?

using large research vessels that are occupied with other science and the BRUV is simply left in the water until it is convenient to pick it up.

Based on pilot studies completed in our lab 30minutes is sufficient amount of time to capture the species richness in the area.

1.) Comparable to dive-times; 2.) Logistics (i.e. availability of large ship to drop/recover multiple BRUV units, ability of small boat to drop/recover BRUVS units and remain coupled to dive operations, # projected available staff, etc.)

Shorter recording times used for relative abundance of 0+ snapper in shallow water. Longer durations used for continental slope where fish are slower moving and take longer to get to bait.

Standard for NSW marine parks and used one other previous BRUVS survey

Optimized for tropical reef fish composition

Review of literature & field test in a variety of conditions (visibility's & depth)

To obtain biomass estimates which are sometimes more ecologically relevant than abundance data

Established as a convention to optimise the number of fish observed with time. Established by Merrett et all 2011

Limited sampling time, and comparison with longer sampling times did not change result (e.g. abundance saturation achieved in approximately 20-30 minutes).

Deployment length based on the time it takes for >80% of bait to dissipate

8. Why do you choose to use the length of deployment you specified in Q7?

30 mins in the standard method that was previously implemented by H Malcom in the Solitaries MPA and was decided to be the standard sampling time across NSW marine parks. Additionally, Steve Linfield's honours thesis in the Port Stephens Marine Park involved 30 min sets so we continued with this set time to allow for comparison over time.

Followed Willis & Babcock 2000

Pilot studies

Defined from original surveys done over ten years ago, and based on some soak time experiments done as part of an Honours thesis

To allow comparison of data from different sites.

Standard deployment length from UWA studies. Using 1080i get 65min of video on 8GB card. Previously in NSW used 30min as that was used in NZ studies and Solitary Islands Marine Park (Hamish Malcolm) - 30min was optimal for fieldwork times as using 4 BRUVS simultaneously there is minimal waiting between deployments hence maximising replication for fieldwork days. I am of the belief that more shorter duration (ie 30min) maybe more efficient for sampling than a smaller number or longer duration deployments.

This time period was determined to be the most appropriate based on previous studies, as it provides consistent estimates of relative abundances between different sites (Willis & Babcock 2000). Longer time periods did not show much difference to maxN values.

Our new BRUVS are designed for long term deployments with bursts of recording synchronized to bait release. Recording time is limited to ~20 hours total.

Length of tape and confidence in length of battery allows time for multiple deployments

Again, the deployment duration for our cruise was specified by Steve Lindfield,

8. Why do you choose to use the length of deployment you specified in Q7?

presumably using UWA protocols.

Most authors in Australia use this length of deployment.

10 mins soak time before a 30-minute data collection time. Found that baits had attracted the majority of fish within 10 minutes. Longer time periods were not possible due to demands for replication.

Good question. Industry standard? Usually get to MaxN and MaxSpDiv in 10-15 min anyway

From trials this was the optimum amount of time to get the best indication of fish numbers vs practicality.

Experimentally determined

Pilot studies analysed using different time deployment to determine optimum.

9. When deploying multiple BRUVS in an area, what is the minimum distance between neighbouring BRUVS?

#	Answer		Response	%
6	<100 m		3	5%
1	100 - 200 m		18	28%
2	200 - 300 m		24	37%
4	> 300 m		11	17%
5	Other (please specify)		17	26%

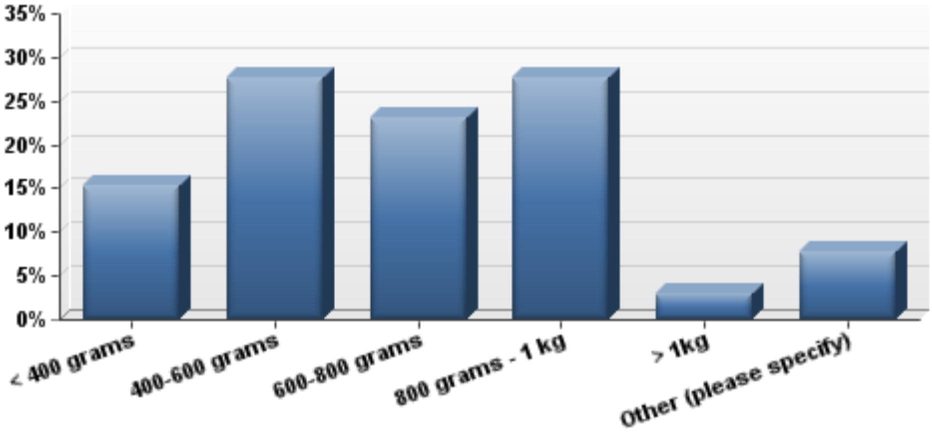
Other distances between BRUVS (summarized)
500 m (4)
1km (2)
Site, species and question specific (2)
450 m when able, but some small reefs do not allow such wide separation
No standard developed (5)
400 m usually more
Multiple BRUVS not used

10. What type of bait do you use and of what consistency is it?

#	Question	Whole	Chopped	Crushed/minced	Responses
5	Canned fish	0.0%	0.0%	100.0%	1
3	Felafel mix	50.0%	0.0%	50.0%	2
4	Other (please specify)	17.6%	35.3%	47.1%	17
1	Pilchards	20.4%	33.3%	46.3%	54
2	Squid/octopus/cuttlefish	10.0%	60.0%	30.0%	10

Other baits used (summarized).
Undecided (3)
Herring or sardine (2)
Macroalgae
Anchovy (2)
Mackerel or tuna (2)
Pacific Saury (2)
Lobster
Chopped silverside with Atlantic bonito, frozen
Chook Pellets & Tuna Oil
Felafel with tuna oil
Fish frames
Aquaculture fish food product by Skretting Australia
Mussels

11. What quantity of bait do you use?



#	Answer		Response	%
2	< 400 grams		10	15%
3	400-600 grams		18	28%
4	600-800 grams		15	23%
5	800 grams - 1 kg		18	28%
6	> 1kg		2	3%
1	Other (please specify)		5	8%

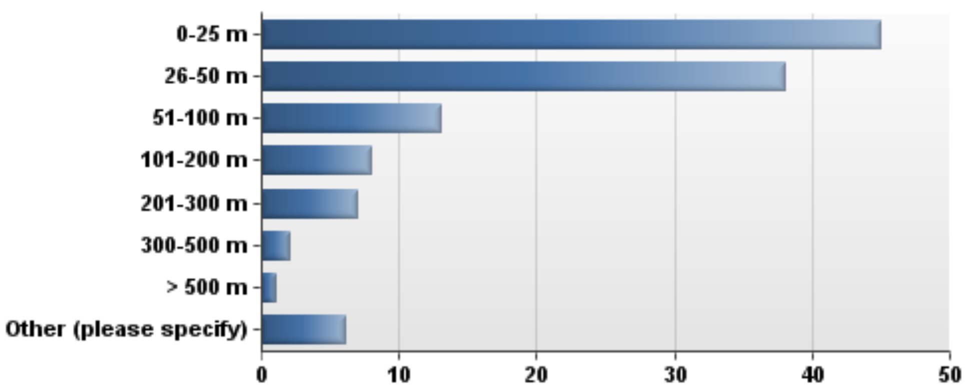
Other amounts of bait used (summarized)
To be determined/undecided (3)
Tuna or cat food can size
Our bait canister holds ~ 7 l so therefore ~7 kg

12. How is the bait deployed?

#	Answer		Response	%
1	Within a plastic-coated wire bait basket		37	56%
2	Within a canister (finer mesh)		12	18%
3	Not contained but tied/hooked onto apparatus		5	8%
4	Other (please specify)		17	26%

Other bait deployment methods (summarized)
Canister PVC pipe with holes
Polypropylene mesh bag
Small plastic burley pots drilled out to improve water flow.
In a pouch made of plastic gutter mesh (2)
Rigid plastic bait bags (3)
Wire basket
Within a jar with holes punched in it (2)
Round plastic mesh bag
To Be Determined
Within chicken wire - shark proof!
Motor driven plunger in cylinder
In a plastic container with holes and a whole pilchard cable tied to the lid

13. What are your typical operating depths?



#	Answer		Response	%
7	0-25 m		45	67%
1	26-50 m		38	57%
2	51-100 m		13	19%
3	101-200 m		8	12%
4	201-300 m		7	10%
5	300-500 m		2	3%
6	> 500 m		1	1%
14	Other (please specify)		6	9%

Other typical operating depths
All of the above
Still involved with abyssal and bathyal studies
2500-5000m
To Be Determined
Designed for deployments to 1000m
30-100 m

14. What is your maximum operating depth?

#	Answer		Response	%
1	50 m		24	36%
2	100 m		12	18%
7	250 m		2	3%
3	500 m		4	6%
4	1000 m		3	5%
5	2000 m		1	2%
6	Other (please specify)		22	33%

Other maximum depths specified (summarized)
8 m
10 m
20 m (3)
25 m (2)
30 m (2)
40 m
65 m
120 m
300 m (3)
550 m
1200-1300 m
5000 m
10,000 m
Ask Euan
To Be Determined (2)

15. Do you use habitat data to *apriori* determine deployment locations?

#	Answer		Response	%
1	Yes		53	79%
2	No		2	3%
3	On occasion		12	18%
	Total		67	100%

16. If you answered 'Yes' or 'On occasion' to Q15, what type of data is commonly used?

#	Answer		Response	%
1	Habitat maps		43	66%
2	Broadscale bathymetry		29	45%
3	Swath acoustic data		33	51%
5	Ecosounder		29	45%
4	Other (please specify)		16	25%

Other data used to determine deployment location (summarized)
Skipper knowledge or direct observation in the shallows
Marine protected area boundaries
Towed video (5)
Ground truthed habitats
Drop camera (2)
Diving/snorkelling (3)
Drop camera survey at 100m x 100m grid prior to determine if reef or sand/mud
Anecdotal
Geo-referenced rocky reefs
LIDAR
Previous experience
Video drops

17. Do you collect any of the following additional data when conducting your BRUVS surveys (from video and/or in the field)?

#	Answer		Response	%
1	Oceanographic		18	32%
2	Seabed structure		30	53%
3	Benthic community composition		34	60%
5	Visibility		27	47%
4	Other (please specify)		11	19%

Other data collected while using BRUVS (summarized)
Temperature - think that was covered in oceanography
Seabed structure as part of the study (conducted prior to BRUV deployment)
Fish transect data
Depth
Current, water temp
Acoustic
To Be Determined
Physical-chemical data (basic variables, e.g. temperature, salinity, pH, turbidity, etc.)
Presence of seaweed
Not sure

18. What future applications might you use BRUVS for, or would you like BRUVS to be able to do?

Statistic	Value
Total Responses	52

Text Response
I envisage that stereo BRUVS could be used in community monitoring and will be extremely valuable tool that detecting large-scale changes in fish assemblage structure associated with climate change and with human impacts. I believe that the baited remote underwater video systems and the resulting imagery that comes out of them can be used as the basis of an extensive education program about sustainable Fishing.
Fisheries Stock Assessment
Lighter and robust frames for shallow work   Should this question be with the first ones about what application you use BRUVS for?   Automate length measurements
Sampling pelagic fishes. Increased light sensitivity for Low light intensity sampling at depth without potentially behaviour changing powerful lights
Sample at greater depths and at night with appropriate lighting. Sampling in 'difficult' habitats and conditions, e.g. mangroves, areas with high tidal movement/poor visibility.
Would like to investigate potential for BRUV systems to work in conjunction with acoustic telemetry
Automated identification and measurement of individual fish and their specific identification.
Primary use would be to compare fish assemblages among sites and over time for impact assessment and biodiversity mapping
Expand variability estimates beyond max n

18. What future applications might you use BRUVS for, or would you like BRUVS to be able to do?

Like BRUVS to be able to initially rotate 360 degrees to capture full habitat type of vicinity.

Sampling of juveniles for recruitment indices

Will be working on iceberg impact on scavenger ecology this Austral summer (Kathy Dunlop PhD). Want to try more freshwater work to see if the method can be applied in large lakes. Always looking for lower impact/stealthier ways of surveying Combination with active sonar and tracking to see fish behaviour over a larger area and before arriving at the bait

Surveys for crabs in Alaska

I would like to see BRUV's incorporate automated image processing for species id and fish length

I would like to try pelagic BRUVS for surveying mackerels I would like to see a image analysis system with the ability to automatically recognise key species

Assessment of small-scale spatial patterns around bathymetric features.

Underneath, in close proximity and away from deep-water oil platforms (i.e. in no-trawl zones). Alternatively we are looking at deploying cheaper compact mini versions (maybe up to 10 systems) to be deployed across an area, especially at hadal depths, to provide greater replication.

Linking behaviour of fish to habitats - moving from a trophodynamic model to a behaviour induced model of top down control

Sampling areas outside of diver depths.

Use lights for deeper deployments and night deployments, Automation of analysis, High Definition Imagery

Might use in areas with large tides and limited visibility (e.g. Kimberley's).

18. What future applications might you use BRUVS for, or would you like BRUVS to be able to do?

Future gear: Automated fish recognition and measurement to reduce analysis time Smaller stereo-BRUV systems Live feed back to the boat so can see if BRUV needs to be re-set (sometime in the technological future) GPS on BRUV positioning so know exactly where it ends on the bottom

Diver-independent assessment of target fishes deep reef fish surveys

Pelagic species

Assessing the performance of marine parks, fish / habitat associations.

Be able to sample at greater depths w/o use of lights. Also, if reliable automated processing of video were possible (size and species ID) that would be a monumental time and money saver.

Endangered species abundance, fisheries management (ie target commercial species and by catch species) and species size

1) "Ropeless" BRUVS with acoustic releases for deepwater work in strong currents 2) 5 frames per second BRUVS to allow longer sets (for some applications) 3) density estimation by "knowing" area fished

I would aim to use BRUVS for a similar application, however I would sample the prey communities at night to determine whether diel variations in the compositions existed. I feel this would be a major step forward for similar work to what I aimed to achieve. Additionally, I have no idea how it would happen, but a BRUV camera that could provide high-resolution video sequences under low water clarity conditions would be extremely beneficial for work within inshore and estuarine environments, such as mangroves.

To have a set array in key habitats to monitor change over time to inform impacts of fishing, impacts of climate change and assist in identifying natural variability in populations.

18. What future applications might you use BRUVS for, or would you like BRUVS to be able to do?

Sampling macrofauna on rocky reefs?

I would like to use BRUVS for long-term deployments to try and gauge species relative sensitivities to diver surveys. For eg.. Some work on the GBR by Bellwood and co. has identified herbivorous species on camera that are rarely seen by divers.

Behavioural records

360' BRUV

Closer coupling of: 1.) Benthic community composition/rugosity/complexity measures 2.) Paring of oceanographic components (water quality measures, bioacoustics) 3.) Long-soak time series (irregular timed bait releases/multiple bait releases) 4.) Examination of bait variation(s) (incl. alternative baits, e.g. algae)

Sample deeper depths, e.g. to 1000 or deeper. Also, sample pelagic assemblages useful for mackerel fishery

Long-term monitoring rare and threatened species, benthic habitat assessments

Long-term monitoring.

As per Q2

I will probably not use BRUVS again in my research

Investigating the potential for cost effective/programmable flash memory HD camera devices (eg GoPro - HERO) for use as mono-BRUVS as a low cost option for ongoing

18. What future applications might you use BRUVS for, or would you like BRUVS to be able to do?

surveillance monitoring of established estuarine artificial reef fish communities.

We are currently utilising BRUVS to sample fish assemblages in an unique soft coral (Dendronenepthya australias) habitat that is endemic to NSW. Habitat is found in 4-16m and we are looking at future BRUVS work in this habitat involving stereo systems.

Pelagic fishes

Examining changes in size structure of fish assemblages in relation to spatial closures

BRUVS are a suitable and highly feasible method for monitoring fish populations; in my case it was part of a marine park monitoring study. They are also appropriate for detection of species, understanding underwater communities and investigating substrate complexities.

Night time deployments of small systems on lobster pots

Monitor offshore Comm MPA's

Fine scale distribution of fish on habitat boundaries   Difficulties due to attraction of fish from other adjacent habitats

It would be worthwhile to calibrate BRUV results with those from divers in shallow (

Stereo BRUVS - fish length measurements

Fish behaviour - interactions between different species.

19. Please rank the following strengths and advantages of BRUVS from 1 (most significant strength/advantage) to 11 (least).

#	Answer	1	2	3	4	5	6	7	8	9	10	11	Responses
1	High sampling efficiency in the field	19.1%	8.8%	11.8%	5.9%	14.7%	5.9%	10.3%	2.9%	11.8%	1.5%	7.4%	68
2	Safety in the field	6.0%	3.0%	1.5%	9.0%	7.5%	9.0%	9.0%	4.5%	13.4%	16.4%	20.9%	68
3	Ability to sample at depth	30.0%	20.0%	12.9%	8.6%	2.9%	5.7%	7.1%	4.3%	2.9%	5.7%	0.0%	70
4	Repeatable	5.8%	14.5%	13.0%	17.4%	11.6%	8.7%	11.6%	7.2%	7.2%	2.9%	0.0%	69
5	Cost-efficient	7.4%	4.4%	11.8%	11.8%	14.7%	8.8%	8.8%	10.3%	8.8%	10.3%	2.9%	68
6	Non-destructive/fishery independent	30.4%	14.5%	17.4%	10.1%	5.8%	7.2%	2.9%	2.9%	2.9%	2.9%	2.9%	69
7	Allows verification of species ID's	1.4%	10.1%	14.5%	10.1%	14.5%	18.8%	8.7%	11.6%	4.3%	4.3%	1.4%	69
8	Collection of permanent video record	1.5%	5.9%	2.9%	8.8%	16.2%	5.9%	10.3%	19.1%	14.7%	11.8%	2.9%	68
9	Accurate and precise length and distance	9.1%	15.2%	9.1%	12.1%	9.1%	7.6%	6.1%	6.1%	3.0%	7.6%	15.2%	66

#	Answer	1	2	3	4	5	6	7	8	9	10	11	Responses
	measurements (for stereo systems)												
10	Sampling of higher abundance/diversity	0.0%	8.8%	2.9%	11.8 %	4.4%	14.7 %	14.7 %	11.8 %	13.2 %	11.8 %	5.9%	68
11	Insight into species behaviour	5.8%	1.4%	4.3%	2.9%	1.4%	7.2%	5.8%	13.0 %	13.0 %	18.8 %	26.1 %	69
	Total	80	73	70	74	70	68	65	64	65	64	58	-

Statistic	High sampling efficiency in the field	Safety in the field	Ability to sample at depth	Repeatable	Cost-efficient	Non-destructive/fishery independent	Allows verification of species ID's	Collection of permanent video record	Accurate and precise length and distance measurements (for stereo systems)	Sampling of abundance/c
Min Value	1	1	1	1	1	1	1	1	1	2
Max Value	11	11	10	10	11	11	11	11	11	11
Mean	5.01	7.60	3.59	4.87	5.84	3.55	5.43	6.81	5.67	6.82
Variance	10.16	9.50	7.93	6.09	7.99	7.66	5.60	6.34	11.73	6.77
Standard Deviation	3.19	3.08	2.82	2.47	2.83	2.77	2.37	2.52	3.43	2.60
Total Responses	68	68	70	69	68	69	69	68	66	68

20. Are there any additional strengths/advantages not listed above?

Statistic	Value
Total Responses	31

Text Response
Ability to survey in marine reserves
Don't need specialists in the field to conduct ID - e.g UVC. V diff to always get specialists. Less hassle than diving (in some ways).
Simple to use
Requires less expertise in the field (ie can survey fish assemblages without someone who can

ID them)
Visual methods are great for education and outreach
Ability to sample in difficult habitats - e.g. kelp and rocky habitat. - very high strength in Alaska nearshore
Assumes that remove any potential bias associated with having divers in the water (ie diver-positive of -negative behaviour
Reduction in observer error
Collection of habitat information
Not just repeatable in terms of the using the same system more than once, but repeatable between different organisations in different geographical and/or bathymetric locations.
Habitat data, species interaction,
Don’t need skilled fish people to execute in the field.
Provide good footage for giving public talks about benefits of marine parks and differences in diversity.
Removes impact of presence of divers
Sampled higher abundance diversity - particularly commercially important species not seen during UVC
Attraction of diver shy species.
Once stereo is used - ability to get size information
1) Useful tools for public outreach 2) can use unskilled staff in the field to set BRUVS 3) training tool for new scientists 4) we see GIANT sharks and real cool stuff!
Possibly less bias of species than using divers

* Video can be collect by generally non-technical staff. * Relatively easy to train up staff on technique and fish identifications. * Potentially future proofs long-term research programmes to possible threats to scientific diving with greater OHS restraints to work place diving.
The method does not involve trained divers
Allows sampling of species which have diver negative behaviour (although it may be sampling these species in a bias manner)
If trends begin to be observed in recordings, new questions can be asked with existing data due to the permanency of BRUV's video recording.
No, but there are many problems in the environment that I work in.
The main reason we use it is to reduce bias due to diver-positive or -negative behaviour (in snapper, Pagrus auratus, in NZ).
Able to use the tapes for effective public communication and teaching unlike UVC data
Can be readily used for communication with stakeholders
No
Targeting species not typically sampled using diving UVC
Avoidance of diver impacts on sampling

21. Please rank the following limitations and biases of BRUVS from 1 (most significant limitation/bias) to 8 (least).

#	Answer	1	2	3	4	5	6	7	8	Responses
1	Bait-related biases (refer to Q22)	35.7%	25.7%	8.6%	5.7%	5.7%	7.1%	10.0%	1.4%	70
3	Cost	3.0%	7.5%	10.4%	17.9%	19.4%	20.9%	9.0%	11.9%	67

#	Answer	1	2	3	4	5	6	7	8	Responses
7	Difficulties identifying species from video	4.5%	9.0%	19.4%	13.4%	10.4%	7.5%	16.4%	19.4%	68
6	Lab processing time	38.2%	20.6%	25.0%	10.3%	2.9%	2.9%	0.0%	0.0%	68
5	Other field logistics	4.6%	3.1%	12.3%	10.8%	18.5%	12.3%	26.2%	12.3%	65
8	Requirement for calibration (for stereo systems)	4.8%	1.6%	9.5%	9.5%	9.5%	12.7%	12.7%	39.7%	63
2	U of MaxN or similar measure	11.8%	17.6%	14.7%	10.3%	17.6%	16.2%	8.8%	2.9%	68
4	Vessel requirements	7.5%	13.4%	13.4%	16.4%	13.4%	17.9%	13.4%	4.5%	67
	Total	75	67	76	63	65	65	64	60	-

Statistic	Bait-related biases (refer to Q22)	Use of MaxN or similar measure	Cost	Vessel requirements	Other field logistics	Lab processing time	Difficulties identifying species from video	Requirement for calibration (for stereo systems)
Min Value	1	1	1	1	1	1	1	1
Max Value	8	8	8	8	8	6	9	8
Mean	2.89	4.03	5.01	4.45	5.38	2.28	5.07	6.05
Variance	4.62	4.06	3.44	3.98	3.80	1.73	5.14	4.56
Standard Deviation	2.15	2.01	1.85	1.99	1.95	1.31	2.27	2.14
Total Responses	70	68	67	67	65	68	68	63

relation to the use of bait, please rank these biases from 1 (most significant bias) to 5 (least).

#	Answer	1	2	3	4	5	Responses
1	Alters species behaviour	4.5%	19.7%	59.1%	12.1%	4.5%	66
2	Attraction of certain species over others	27.3%	48.5%	16.7%	6.1%	1.5%	66
3	Unknown area sampled (bait plume)	57.4%	25.0%	14.7%	2.9%	0.0%	68
4	Inconsistency in bait type/amount/consistency used	9.1%	9.1%	6.1%	56.1%	19.7%	66

5	Translocation issues (e.g. use of temperate baitfish as bait in tropical waters)	0.0%	3.1%	4.6%	21.5%	70.8%	65
	Total	66	70	67	65	63	-

Statistic	Alters species behaviour	Attraction of certain species over others	Unknown area sampled (bait plume)	Inconsistency in bait type/amount/consistency used	Translocation issues (e.g. use of temperate baitfish as bait in tropical waters)
Min Value	1	1	1	1	2
Max Value	5	5	4	5	5
Mean	2.92	2.06	1.63	3.68	4.60
Variance	0.69	0.83	0.71	1.36	0.53
Standard Deviation	0.83	0.91	0.84	1.17	0.72
Total Responses	66	66	68	66	65

23. Are there any additional BRUV limitations or bait biases not listed above?

Statistic	Value
Total Responses	32

Text Response
Biases may differ depending on where and when the units are deployed (e.g., at different depths and under different oceanographic conditions, visibility or current speeds, the properties of these biases will change as well). Non-constant bias in sampling method over a particular study as a whole is difficult to estimate and account for.
Field of view can be obscured by rock or weed. Frame can land on angle or fall over if not deployed correctly. Direction cameras pointing if on habitat boundaries can bias results (eg at reef or at sand).
Like line fishing, bait-based sampling methods will attract not only certain species over others, whether it be primarily carnivores vs herbivores or aggressive species over non-aggressive species, they would also tend to under-represent small species or size classes.
The feedback between fish feeding at the bait and the subsequent behaviour of other fish is a tricky one to deal with - especially with open bait. Does feeding itself attract other fish?
Disposal of anchors or other ballast inability to see behind a typical BRUV or in an upward direction - field of view issues
The limitation is the small footprint of BRUVS therefore the limited sampling area
BRUV is fairly hopeless at sampling small cryptic species, so a good portion of fish fauna is overlooked when BRUVS are deployed in the absence of UVC.
Weather, Depth (depending on gear), Available Light (daytime only drops?), Water Clarity, Oceanographic Conditions,
Need significant sized boat to deploy.

23. Are there any additional BRUV limitations or bait biases not listed above?

If a shark or moray is attracted to the bait and hooks into it, this excites other fish and distributes small bait morsels. This can introduce a bias in the number of fish observed and MaxN when compared with sets that are not affected by sharks/morays
Possible saturation of density estimates?
Potential temporal variations in feeding activity and interest in bait.
Ballast can cause damage to fragile habitats, limits applicability in tropical environments
Apex predators dominating data and possible scaring other fish away
- For some species, smaller individuals show up earliest -- so measuring at time of MaxN is biased - inability to easily represent density - lack of knowledge of tidal/diurnal/seasonal effects in estimating MaxN
species attracted to baits are not necessarily predators of the bait species
BRUV have extremely poor resolution and depth of field when operating in low clarity water. This is a large source of error when operatin BRUVS. The variations in depth of field between high and low clarity water limit the comparisons that can be drawn between BRUV replicates..
Field of view issues and variation in locations and habitat (including complexity) that affect the field of view.
In Patagonia southern right whales can be a serious problem, so use of BRUVS has to be limited from December to June
LIMITATION: Things obstructing the FOV ie. rays, algae, rock OR dropped with orientation facing down or up. BIASES: Many people using BRUV use not only different types of bait and their amounts, but other differences include frozen/unfrozen bait, also some groups use one lot of bait for several drops which biases the first drops over others and makes it more difficult to compare data from different groups.
Field of View. Depth of view sampling Information on potential disturbance (boats, divers,

23. Are there any additional BRUV limitations or bait biases not listed above?

large predators in proximity...)

Yes, I found there were many limitations in the environment that I work in. The most significant limitation is visibility. Because I work in estuaries the visibility is inconsistent and I cannot work in certain habitats at all (e.g. inner estuary areas with high turbidity). This extremely limits their usefulness within the estuary. In my study I had 8 estuaries and in the end only 4 had sufficient visibility to produce enough replicates to be used in final analysis. Another major limitation is that they are selective for fish which are attracted to the bait and also that they cannot sample smaller or cryptic species which are ecologically important but too small/difficult to identify on camera (for example, gobies, dragonets, etc.). Even some larger species cannot be accurately identified to species using a BRUV (e.g. flounders or flatheads). These species could be sampled with a trawl effectively... The results of my work with BRUVS were very different than the results I got with a trawl the following year, and I tend to think that the trawl was far more accurate. Not having biomass or length data is also a hindrance, though obviously this could be overcome with a stereoscopic system. I very much like that BRUVS limit the ecosystem damage and the number of fish killed, but they are ineffective for my work and I won't use them again. The visibility problems are especially frustrating as I lost replicates in many areas which would not have been a problem with a net.

Limited area of view - may under estimate species relative abundances/richness due to competition/shading effects among highly abundant/diverse fish communities

At certain locations (eg Poor Knights Is) our downward-looking BUV has "saturated", i.e., there are sometimes so many snapper under the camera that more could not be recorded. For our purposes (marine reserve vs fished area comparisons) I suspect (with no evidence to support this suspicion!) that fish in reserves are less wary of boats and gear than outside, so are more likely to be come into feed from and be recorded by BUV even if densities inside and out were equal.

Possible temporal/seasonal variation in effectiveness associated with fish feeding biology

Often difficult to use in areas of high current flow

23. Are there any additional BRUV limitations or bait biases not listed above?

No

A suitable bait/system for long-term deployments is quite a challenge.

N/A

Not that I'm aware of.

Big fish dominating the area - not giving a true representation of numbers.

24. Can you suggest solutions for these limitations or biases?

Statistic	Value
Total Responses	37

Text Response
I think it is to be a detailed discussion about whether the use of MaxN can be overcome and also whether it is worthwhile doing bait plume modelling and actually looking at what species may be attracted from over what distances. I believe that this could be done by combining baited cameras with acoustic techniques
-
Surveys at depth where tides are unidirectional and wave action is minimal will benefit from bait plume modelling. Testing bait types, quantities and consistencies in the tropics and temperate waters would provide some insight.
Use of complementary methods
Not readily! Studies of the biases and explicit measurement of these biases under a range of conditions could allow such things to be included in models, but that would be the only way around this, I think...
Use of unbaited BRUV drops or night drops. Rating for field of view. Training for crew to deploy.
That's a tough one! Complementary methods may be the only solution.
We are working on bait plume modelling and relating this to our field data, but it is inherently difficult and doing this for all locations possibly removes the low-cost and time-efficient benefits Current meters on BRUVS help a lot obviously.
For bait plume variation - set with current meter

24. Can you suggest solutions for these limitations or biases?

Development of a standardised methodology
Plume modelling. Note: fisheries dependent data suffers from the same bias.
For anchors in deep water this is tough. A variable buoyancy device (piston driven) might work but would take considerable energy. Field of view issues can be evaluated or overcome by adding more cameras. However, this then increases analysis time.
Use a mix of survey methods
More BRUVS and no bait
UVC, though obviously this doesn't work at deeper locations.
Dedicated vessels and personnel for work that are ready to go when conditions allow, development of lights that limit alteration of fish behaviour, consistent baiting method, measurements of oceanographic conditions/currents with models of bait plume dispersal, develop automation techniques to streamline the data analysis process (biggest hurdle)
Make BRUVS setups smaller and easier to handle (if possible)
Accept these biases will occur and interpret the results accordingly. Sample at high enough intensity to ensure bias is spread over the different factors being compared
More short-term studies looking at short term temporal variation within and between days. Potential effects of tide, moon phase and oceanographic conditions affecting fish behaviour. Fishermen know fish don't bite every day. But are they still there or move away and come back?
No
- Models of bait plumes accounting for frictional forces at the seabed\ - use of acoustic arrays, tagged (transmitters) fish such as spangled emperor/pink snapper/red emperor

24. Can you suggest solutions for these limitations or biases?

and BRUVS to see how far fish will travel to bait

Team results with other observations on predation and limit counts to species of interest

Unknown. Possible use of infra-red cameras within these locations. Cost-effectiveness would become an issue.

Test hypotheses about changes through time which are likely to leave these biases relatively constant and therefore not be overly important.

Read above

The main issue I have observed is the difference in approach distance for fish inside vs outside of MPA's. Horizontal BRUV's probably won't be as affected by this as they can sample fish at a greater distance from the BRUV than a vertical camera orientation can. In addition, fish confidence seems to grow with deployment length. So using horizontal camera angles and/or longer deployments should be adopted in NZ. Current surveys vastly underestimate abundance outside of MPA's due to this bias but this is not recognised.

A small camera attached to the BRUV unit with a line to the boat so that people are aware of what might be obstructing the FOV. A publication that tests differences of all of these differences and highlights the best method.

Have a robust method for estimating the area sampled by the bait plume.

I don't really see how you could get past the visibility issue in the inner parts of estuaries or in heavily modified estuaries where siltation and turbidity are generally high (e.g. Botany Bay or Newcastle for example). Also, I don't think the BRUVS will ever be able to accurately measure small species or cryptic species. Stereoscopic systems could provide biomass/length data.

24. Can you suggest solutions for these limitations or biases?

We're thinking about an unbaited sideways-looking timelapse system left down for a day or so at a time, with a camera in a housing bolted to the bottom or wedged under a rock, with no cable to the surface.
Research addressing these issues
Survey outside peak flow times
No
We are trialling a bait solution in a programmable dispenser but have limited opportunity to test this at working depths as yet
N/A
Unknown area sampled (bait plume) is the most critical issue. However, due to the complexity of inshore marine environment (in particularly - macrotidal environment) a meaningful modelling is impossible.
Have multiple cameras - one down and one horizontal perhaps.

25. If you calculate the bait plume area, please describe how you do this.

Statistic	Value
Total Responses	24

Text Response
We do not calculate

25. If you calculate the bait plume area, please describe how you do this.

-

No

Extremely difficult I am yet to do this other than use a arbitrarily chosen 250 m radius. Ideally, however, it may be possible to incorporate currents and wave exposure to predict the area.

Use of drogue to estimate current strength and direction at time of deployment

Basic method for flat surfaces and Gaussian distribution, but Kathy Dunlop is working with hydrodynamic software now to improve on this. Also modelling animal behaviour around the bait in a more sophisticated way that we have previously.

We deploy current meters with our BRUVS but have not yet tried to model bait plume dispersion. However, when this is done it will have to assume a mean flow and incorporate diffusivity constant for lateral spread of the plume.

Following Bailey and Priede 2002

Yeah ... right ...

Attempts were made to both characterize the flow with current instruments (single point and adcp's) as well as to measure the dispersion directly with the stereo-video system. The work was inconclusive but the method is promising.

I don't, but I know this probably should be done in the future

NA

We do not (5)

I have not estimated it, and suspect that changing oceanographic conditions could make difficult to achieve it accurately

This is entirely possible, but I didn't do it. I have heard of people using a flow meter to calculate

25. If you calculate the bait plume area, please describe how you do this.

water velocity and then to use this to extrapolate bait dispersion.
Current movement (speed and direction) estimated by manual drogue
Spread of dye under various conditions
We haven't done this yet but plan to add a current meter to our deepwater systems to provide surrogate data for bait plume (direction and velocity) dispersal estimates
See Q24.
Tried using a dye to estimate the speed and distance the plume would travel.

26. Should a standard sampling protocol for BRUVS be developed?

#	Answer		Response	%
1	Yes		36	51%
2	No		12	17%
3	Unsure		22	31%
	Total		70	100%

27. Should separate protocols be developed for tropical and temperate regions?

#	Answer		Response	%
1	Yes		24	34%
2	No		8	11%
3	Unsure		38	54%
	Total		70	100%

28. If you answered 'yes' to Q27, please state why you think different regional protocols should be developed.

Statistic	Value
Total Responses	28

Text Response
I believe that the deployment times and the effects of bait will be different in cooler waters. Hence it may be some differences about species accumulation curves and species saturation times.
There should also be standardised protocols for working at different depths.
Different BRUV systems may be required in the tropics (e.g. coral) versus temperate (e.g. kelp forests). Different baits may need to be used in different locations depending on where the bait type is found naturally. Species behaviour and abundance differs from tropics to temperate regions.
Different benthic habitats (e.g. temperate canopy forming macroalgae vs corals in in the tropics)
Kelp forests and temp seagrasses require special consideration
As I have not used them, I am not totally sure about my answer but I would expect there to be varied fish responses in different ecosystems, climates and visibility.
Further than that, the point is not just that there should be separate protocols for different biogeographic regions, but that one protocol won't always work even within a single region. Sampling nearly always needs to be tailored to the specific environment/habitat/aims of a study. For example, to encompass the diversity in a tropical region may require longer or shorter drops than in a temperate region. However, if comparisons are required across biogeographic regions, then obviously to be comparable, standard protocols would be required.

28. If you answered 'yes' to Q27, please state why you think different regional protocols should be developed.

Most of my experience is in the deep-sea, and I am still getting used to the massive differences between the results obtained in different shallow-water environments. We use very similar methods everywhere, but I would like to see a lot more evidence before we settle on one basically similar method for all ecosystems. A protocol for collecting all the essential background information that we all use would definitely be a good idea and would make it a lot easier to share data later (depth, time, date, state of tide, camera and bait description).

My understanding of the differences between tropical and temperate regions is that tropical fishes are more likely to be sedentary (i.e. not attracted to the BRUV from large distances), whereas temperate reef fishes may be more likely to be mobile. This would probably mean different protocols should be developed.

It all depends on the question asked and type of data needed.

The time of deployment and moving from max N for temperate species whereas for tropical species it seems to work well

Different dispersal of odour plume in temperate and tropical systems.

Protocols should be based on the targeted species and habitats.

Presumption of general differences in behaviour, mobility, natural (or possible) densities of fishes in different locations

Differential responses to particular bait, different tropic structure in temperate vs tropical regions affecting attraction to bait. Optimal length of deployment might be different in other regions

I don't know that my real concern is temperate vs tropical, more specific to shallow vs deepwater ecosystems, or relative to specific target groups.

I would think that the much greater diversity of fishes in the tropics would in itself be reason enough to fine tune protocols according to region

28. If you answered 'yes' to Q27, please state why you think different regional protocols should be developed.

For coral reef settings BRUVS are limited in that they don't attract and therefore quantify the most numerically abundant families that of the herbivores like the scarids and acanthurids.

The environment (depth/bottom topography) and the species being surveyed will dictate what a reasonable approach is for each area. For example, in NZ BRUV surveys for blue cod probably don’t need to account for behaviour bias because blue cod are very willing to come right into the bait pot. For snapper in NZ approachability behaviour needs to be taken into account to remove the bias that currently exists in surveys. So protocols for different regions will need to account for these differences.

I assume in warmer areas the bait plume would have a stronger scent compared to colder waters.

Each situation is different, e.g. sampling between Cockburn Sound and continental slope in regards to visibility, currents, depth. If objective is to obtain recruitment index from relative abundance may not be a need for stereo. Also, use of BRUVS for abundance of juvenile West Australian dhufish still being developed but may require night sets with no bait??

I think different protocols are need for different applications and research goals.

Temperate systems generally have worse visibility than tropical systems, and this is the major limitation of the system as I see it. I think most of the time BRUVS would work well on a coral reef for example, but they don't work well in temperate estuaries.

na

Because of the optimal sampling of replication, duration and bait choice will likely be different between regions and habitats (ie seagrass and coral reefs)

Differences should be accommodated for different species (eg use different bait) and different substrata (eg coral reef or rocky reef or seagrass etc)

Mainly due to visibility, i.e., field of view may differ.

28. If you answered 'yes' to Q27, please state why you think different regional protocols should be developed.

Huge differences in fish numbers between tropical/temperate regions.

29. If you collect or use length information, please describe why you collect this data.

Statistic	Value
Total Responses	52

Text Response
We collect length data to look at changes in the mean length or biomass of the fish population or assemblage. I believe that this is an incredibly sensitive indicator as it does not just tell you whether the numbers of fish changing but what the population demographics are and how they are changing over time.
To look at length frequency or convert to biomass.
It is the most important data for studies of the impact of fishing
To gather length frequency data for investigation of changes in size structure of whole assemblages and specific species
To gain insight into life-history characteristics of species and to assess size structure of assemblages such that impacts may be determined, e.g. effects of fishing.
To better understand recruitment relationships between artificial and natural structures
To analyse and predict size-class-habitat ontogenies
Biomass calculations can be informative for fisheries and other ecological hypotheses and biomass estimates can be derived from length measurements in many cases.
Looking for long term shifts related to Natural (recruitment) and Anthropogenic (fishing) pressures
Dhufish - size of individuals to establish approximate age, distance from bait
Compare size distributions among habitats, regions, methods etc

29. If you collect or use length information, please describe why you collect this data.

We collect length data only with very general categories to cover year classes. These are clear from strong modes in Alaska.

We use length information in order to estimate biomass inside and outside marine reserves

To get a size-frequency distribution for key species to determine whether there is a change in size and abundance of fish inside marine reserves compared to control sites outside of the reserve.

The feeding impact of a fish and hence its ecosystem function is often related to its size. Therefore estimating size in important if you are attempting to quantify any of these processes

Biomass and length frequency calculations

To monitor fishing induced shifts in length frequency distributions.

Assuming length as a proxy for age then we use length measurements down, for example the continental slope, to look at life history and bathymetric migration. We also use it for long-term study area to look at seasonal trends and even longer terms study areas to look for changes on decadal time scales

The length information is a proxy for age in some species Subtle changes in length can help assess change before abundance changes

If we were using stereo BRUV units we would have collected length information to complement inside/outside MPA comparisons.

Fisheries stock assessment models, monitoring size class distribution variability inside and outside reserves and over time.

29. If you collect or use length information, please describe why you collect this data.

Will be in the future for monitoring work. Especially for snapper to compare between 'fished' and 'no take' areas. Have done this year for black cod - as part of a study looking at the length structure and relative abundance of black cod

Needed to calculate biomass. Fishing can affect size structure and I use BRUVS for is to look at the impacts of fishing, hence it is necessary. Especially important for fish species with MLL.

To determine the size classes of fish species within and/or across populations and inside and outside marine park sanctuary zones.

University contractor does analysis, but they use software (think they are changing types) and a calibrated stereo-video system to estimate lengths

MPA zoning and fisheries management

- Infer effects of fishing - find nursery areas - show just how big that monster tiger/groper/hammerhead actually was (everyone asks!)

Relationship between length and call characteristics of the fish

To test hypotheses about long-term changes in size in relation to marine protected areas.

It is a major indicator of high fishing pressure and conversely the 'health' of a fish community

Convert to biomass present length frequency information for individual species

We are studying how to do it with one fixed camera. Our system produces high biases in even short distances (for example, it doubles fish size between 0 and 60 cm far from the rule, located 15 cm over the bottom of the stand)

Compare size frequencies between reserve and non-reserve (only really interested if legal fish have recovered, not undersized fish).

We do not.

29. If you collect or use length information, please describe why you collect this data.

Addition information to compliment assemblage comparisons. Can give insight into habitat partitioning by life stage or indicate differences in abundance of legal sized individuals between fished and closed areas.

To gain indication of abundance and life history and also habitat use

Biomass calculation

Length can be used to calculate biomass

To establish whether there is a difference in the size structure of a target species inside versus outside no take zones.

I did not do this using the BRUVS

Diver (on snorkel) operated handheld stereo-video system (SEAGIS)around fish aggregating devices (FADs) - diver enters water up current (approx. 200m) of FAD and drifts a distance of 400m to approx. 200m down current of the FAD filming/sampling fish schools (typically mahi-mahi

NSW MPA are aiming to collect length information in the future to assess the difference in species biomass across various zones in marine park (ie sanctuary, habitat protection, general use) and to sites located outside marine park.

To compare size distributions inside and outside reserves

na

To examine changes in size composition in closed areas thru time

No

na

Useful to have an estimate of age structure - could allow stock assessment, estimate of

29. If you collect or use length information, please describe why you collect this data.

biomass useful too
Population structure ie juveniles verses adults
To examine use of habitat by different cohorts. e.g., new recruits versus 1+ age classes
We'd want size information to develop length/frequency curves.
Want to know if fish sizes are changing over time due to marine reserves

30. Do you use fork or total length?

#	Answer		Response	%
1	Fork length		35	78%
2	Total length		16	36%

31. Do you convert your estimates of fish length to biomass?

#	Answer		Response	%
1	Yes		16	33%
2	No		18	37%
3	On occasion		15	31%
	Total		49	100%

32. If you collect fish length data, how accurate and precise do you need your measurement of fish length to be?

#	Answer		Response	%
1	< 5 mm		5	11%
2	< 1 cm		10	21%
3	< 2 cm		19	40%
4	< 5 cm		9	19%
5	< 10 cm		4	9%
6	Other (please specify)		6	13%

Other length accuracies specified (summarized)
Or < 10 % of total fish length (3)
Depends on species (measuring 10cm fish needs better precision)

33. Please describe the process by which you analyse your BRUVS imagery.

Statistic	Value
Total Responses	61

Text Response
We are now using high definition cameras. Hence the imagery needs to be converted into a format which is compatible with the image analysis software that be used. We now use event measure stereo developed by Jim Seager from SeaGIS undertake our counts, record events and make measurements of the length of fish and also to define the boundaries of our sampling units using stereo imagery
Time on seabed, and then play through getting the MAXN of every fish species over the hour.
Now use new stereo event measure Downlaod Convert Analyses Database
Raw video footage is converted to .avi format using a program such as xilixoft. Event Measure for identifying fish and calculating relative abundance, Photomeasure or Event measure Stereo for length measurements where species identifications are checked. CAL for calibration.
1. Convert video imagery 2. Analyse using EventMeasure for MaxN of every species. Additional behavioural notes also collected. 3. Use EM to measure the length of all individuals at each time MaxN
Use of sea GIS event measure software
Video is processed using SeaGIS software (EventMeasure and Photomeasure) ID's are checked via a image library and QA with experts from Museum Victoria
Colleagues do that bit and they use Euan Harvey's software.
Observer watches footage and manually records max abundance of each species identified

33. Please describe the process by which you analyse your BRUVS imagery.

More than one has ben used

Previously process miniDV tapes using BRUVS software (AIMS), capture sections of footage at times of MaxN, measure key species with Photomeasure. Recently upgraded to Eventmeasure stereo software.

Analysis of single video footage to determine time of first appearance, Maxn, time of Maxn of relevant species/all species, followed by length measurement using calibration marks for downward facing video and stereo BRUVS software for forward facing stereo footage.

Currently just played back and annotated by hand

Replay on large monitor. Time, identify, and count each fish entry into view General notes on habitat features Temperature record, Light level record

Convert tapes or MTS files to avi species ID & MaxN using EventMeasure Length estimation using PhotoMeasure

We have just collected data and are soon to analyse (training of a student that will analyse footage has been undertaken). Maximum number of each species of predatory fish that occur in a frame in a 30 minute take will be recorded. A size estimate of each of the fish in the frame will be taken using image analysis software. However, as not using stereo-video, it will be subject to some error. To reduce error, fish will be measured using 3-point calibration and only measured when at the same level of a calibration point of a known length (such as the bait container.

Video is viewed in real time and feeding by fishes recorded. Fish are identified to species, their lengths estimated, and number of bites taken recorded

See Merritt, D. W., M. Donovan, C. Kelley, L. Waterhouse, M. Parke, K. Wong, and J. Drazen. 2011. Botcam: A baited camera system for non-extractive monitoring of bottomfish species.

33. Please describe the process by which you analyse your BRUVS imagery.

Fishery Bulletin 109: 56-67

Habitat information is recorded (categorical) then the first arrival times and a trained technician determines MaxN of each species. Given deep-water ambient light situations many fish are identifiable to genus or family only. This greatly complicated MaxN calculations. After MaxN are determined, length's of the fishes at a point in the video when the most fish can be measured are made (often at time of MaxN).

Manually identify fish based on morphology. Manually count and measure arrival times then use image analysis software to measure lengths by calibration against a scale bar in situ.

Encounters per unit time or maxN in FOV.

Ask the students - I do not analyse the data

One observer watches all tapes on a computer monitor using Microsoft Media Player (which allows stepping forward and backward in millisecond intervals). All species are identified and MaxN enumerated for each species. Additional information collected from tapes includes: time immersed, time on benthos, time at which each species is first observed.

Each video stream is independently annotated for species counts including time to first arrival, maximum number of each species in 1minute segments and maximum number of each species throughout deployment. Measurements are made for each species around the time of overall maximum number.

Event measure software used to process

Currently using eventMeasure with stereo

33. Please describe the process by which you analyse your BRUVS imagery.

Standard UWA practice using EM. But when measuring fish with EM stereo - I will process all the imagery for a particular area then goes back and do all the measurements. I will have it set up and syncd when running the EM. So when measuring all I have to do is open the EMOBS file and measure all fish. Doing it later all at once allows me to double check IDs that might have changed or a particular species that I had wrong.

Review footage from beginning to end in real time (no fast forwarding). Pausing for new species and maxnum to be entered. For large numbers video watched in slow mode to obtain count. ID of new species confirmed by second person.

Use SeaGIS EventMeasure for species identification and determining MaxN. If stereo units are used, we then use PhotoMeasure linked to EventMeasure files for collecting measurements at the time of each species MaxN.

University contractor does this so not able to relate all details

Event measure, Max N HCA & nMDS

With custom-built BRUVS2.5.mdb database interface, and SeaGis PhotoMeasure for lengths

Counts by species

Video replicates were recorded and played back in the laboratory using VLC video recorder software. Each time a new fish entered the frame the video was paused and the fish identified to family. MaxN was determined for each individual family within he 20 minute video sequences.

User scrutiny

Event Measure Stereo. Tag, identify and measure.

I don’t do the analysis

33. Please describe the process by which you analyse your BRUVS imagery.

Ask Euan

Deployment of bruv is controlled from a monitor installed on the surface. each video is almacenated as a mpeg file in the hard disk drive sony dcr sr300. once at the lab, each video is processed with picture motion browser or adobe premiere, to count maximum number of fishes of each species in the field of view. Each species is counted separately.

Videos are watched right through. All species present are recorded and the frames for which maxN for each species are observed are exported to allow length measurements to be taken. The time at which maxN occurs is also recorded as is the time at which each species first appears on the video and the time at which the bait is first attacked.

An observer processes the tapes SR and Maxn on TV or computer.

Same as UWA

Using Event Measure an EM (stereo)

Goetze et al 2010 fishing impact on fish assemblages

Overlay time code, beginning from the second the BUV hits the bottom. Skim view using pinnacle studio 12, then watch from start, recording onto hard copy data sheets. Data recorded - MaxN, time of arrival, time of first feeding, time of MaxN and presence/absence of species per 30-second block.

Access database and extensions

Manually - I do not use software but instead do manual counts/identifications and keep a tally on paper.

33. Please describe the process by which you analyse your BRUVS imagery.

SEAGIS image analysis software

Eventmeasure - SEAGIS

See Willis & Babcock papers

Estimates of MaxN, time of first arrival, time at bait by playing tape and periodically stopping

Standard processing of imagery using SeaGIS software

Manual processing

Videos were replayed on a computer monitor. The 30 minute sampling period began as soon as the BRUV unit settled on the ocean floor. All data was entered into a Microsoft Excel spreadsheet continuously as the tape was reviewed. The date, time, location, site name, settlement time, time-final (end of 30minute period) and time of removal was recorded for each tape. During the video, the time of first appearance (Tfap), the maximum number of a species viewed at any one time (MaxN) and Time of MaxN (TMaxN) was recorded for each species. When a MaxN increased for a species, this was entered below the previous entry. A fish was recorded if it came within an estimated 2m of the bait cage. Organisms were identified to species level if this was possible. To identify species, several reference books were used (Kuiter 1996, Edgar 2008) as well as internet searches (such as fishbase.org and australianmuseum.net.au/fishes).

UWA collaboration. Use of SeaGIS software

As it is stereo video we use the software and applicable methods provided by Seagis. Normal procedure is: 1) Tag all individuals and identify species, software calculates MaxN 2) Calculate time in view from data 3) Calculate lengths

Steve Lindfield is doing this and providing us a copy of the data.

I am following a procedure described by Cappo et al., 2004 and Watson et al., 2005.

33. Please describe the process by which you analyse your BRUVS imagery.

MaxN determined visually after playback of footage.

Tapes were played back with a real-time counter, and the maximum number of each species of fish observed during each minute was recorded (i.e. thirty counts were made during each 30-minute sequence). Only fish visible at any one time were recorded to avoid counting the same fish twice. The lengths of snapper were obtained by digitising video images using the Sigmascan image analysis system. Measurements were only calculated for fish present when the count of the maximum number of fish was made for each species. While this means that some fish moving in and out of the field of view may not have been measured, it also avoids repeated measurements of the same individuals.

Manual process of watching video on large screen TV. Species ID and MaxN. Univariate and mulitvariate analyses of data.

34. If your analysis is aided by computer software, what software do you use, and for what aspect of the video interpretation?

Statistic	Value
Total Responses	46

Text Response (summarized for matching responses)
We use event measure stereo developed by Jim Seager from SeaGIS to undertake count's, to define distances within a sample units and to measure the lengths of fish from stereo imagery.
Eventmeasure Sea GIS to identify and count the fish as well as measure them.
Event Measure for identifying fish and calculating relative abundance, Photomeasure or Event measure Stereo for length mesurements, CAL for calibration.
EventMeasure (5)
SEAGIS software (7)
Video is processed using SeaGIS software (EventMeasure and Photomeasure)
Euan Harvey's software
BRUVS (AIMS) Photomeasure (SeaGIS) Currently Eventmeasure stereo (SeaGIS) .
Previously freeware (Image J, VLC media player) for downward footage Now relevant SeaGIS software, e.g. photomeasure
TransectMeasure - to characterise habitat around the BRUV sites EventMeasure - MaxN PhotoMeasure - length estimation
Size estimates using UTHSCSA Image Tool.

EventMeasure, CalMeasure
Eventmeasure custom made MS Acess database
Image J
My students (shared with Euan) use the software of Jim Seager
Originally used Microsoft Media Player for annotation and Geomsoft VMS for measurements. Currently using SeaGIS EventMeasure for all annotation and measurement, and CalMeasure for Calibration.
AIMS BRUVS Tape Reading Interface 2.1
SeaGIS EventMeasure and PhotoMeasure (now EventMeasure with combined PhotoMeasure). MaxN and Length.
University contractor does this so not able to relate all details
With custom-built BRUVS2.5.mdb database interface, and SeaGis PhotoMeasure for lengths
VLC Media Player ver. 1.0.5.
n/a (4)
Ask Euan
we use both softwares for reproducing the video. the adobe premire allow to modify the speed of reproduction and it is useful when high number of fish enter the field of view.
EM, wondershare, pixella
Goetze et al 2010 fishing impact on fish assemblages
PhotoMeasure for length measurements
As above

SigmaScan to measure lengths
SeaGis Eventmeasure
ImagePro Express; for percent bottom cover assessment.
Sigmascan image analysis system

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

Statistic	Value
Total Responses	55

Text Response
The major disadvantage of MaxN is that we are throwing 95% of the data away. Similarly, I am particularly worried that MaxN may mean that we are missing representative counts of fish at different sizes. For example we may get three small fish of the species but only one or two larger individuals which is a natural structure of fish populations. Hence we may be under sampling and under representing those larger fish.
We use it as it prevents counting the same fish multiple times. It is however a conservative measure of abundance.
Conservative estimate
Advantage: Conservative measure that avoids recounts of the same individual fish. Disadvantage: Same, this may underestimate the actual abundances of fish, may lower the resolution of this measure in detecting change
Collected to avoid repeated counts of the same individual. Advantages are that you are not making repeated counts and are unlikely to overestimate the abundance of a species. Disadvantage is you are likely underestimating the abundance of a species in the area where only a portion of them may be viewed at one time. Another disadvantage is the use of MaxN where length measurements are made at this time; e.g. Cappo et al. (2009).
Advantage is that it provides a measure of relative abundance Disadvantage is that it is affected by the various sources of bias associated with this method and does not provide a means of deriving actual abundance

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

It is a conservative measure of relative abundance. However, if an individual fish is clearly identifiable from others, and is not captured by MaxN, the individual is included.

Advantages are that this is going to avoid counting a fish more than once. Disadvantages are that much of the relative abundance information might be lost if the field of view gets filled with fish and MAxN is hard to determine.

Simplest available measure that is widely accepted. Major issue is that it can underrepresent actual number of fish attracted to the bait.

Used as a relative abundance and time for efficient measuring of species, Advantage Sets a standard measure for relative abundance, Disadvantage obscuring of individuals in school make counts difficult and imprecise. School is rarely all visible. Appearance of distinctly different individuals not captured by MaxN (eg 2 different sized juvenile, 2 female and 2 male dhufish can be observed over 1 hour but MaxN could be only 3).

It is possibly the only appropriate measure of relative abundance. It avoids recounting the same individual, but is likely to be conservative, measure of abundance.

Easy to collect but I have serious doubts about how useful it is. We use a lot of stills so we collect MaxN over whole deployments. But this is clearly a really unreliable measure, at least around here.

For our data other metrics have been more closely associated with traditional survey methods e.g., total numbers seen over 15 minute camera sets.

We use MaxN to avoid double-counting individuals. The advantage is that it is a very

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

conservative estimate of abundance however; it is invariably an underestimate of the number of individuals of each species that have visited the BRUV during a deployment. Also, it will generally underestimate the abundance of solitary species.

Standard technique

to assure that fish are not recounted.

It is a conservative (minimum) estimate of relative abundance. It has correlated well in some studies with abundance estimates from area coverage type techniques such as scuba transects etc. time of first arrival varies but are typically within the first couple of minutes. This situation does not provide the resolution needed to accurately estimate density as has been done on abyssal plains.

We measure this as part of the course, normally it doesn’t do anything except for trends throughout multiple deployments. The time of maxN is more important as it shows where the peak occurs very quickly (highly efficient scavengers) of much later on (waiting for better conditions, i.e. something else has opened the bait). Likewise a maxN towards the end of a deployment after a gradual rise in numbers indicates a gregarious species (e.g. zoarcids) rather than a species adopting optimal foraging theory.

Most unambiguous and straightforward.

MaxN is a single snapshot of fish abundance - it is limited and I would like to use all the tape despite the bias counting of a single fish multiple times

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

We do enumerate MaxN for each species on each tape to facilitate comparisons between BRUV deployments. Disadvantages include that the entire tape has to be viewed (as opposed to using time of first sighting, for example). But the ability to standardize this metric to allow between-deployment comparisons far outweighs any disadvantages.

MaxN avoids recounts of the same fish as it enters and re-enters the field of view and is conservative. It has been well correlated to CPUE in some conditions.

Used widely in the literature

Relative abundance of particular species for comparing between different factors in a sampling design using univariate stats. Relative abundance of all species observed for comparing assemblages using multivariate statistics (generally in PRIMER)

It is the only way I can think of for counting abundance in a time efficient fashion. Advantages - Cannot possibly double count the same fish. Easily interpreted and quick to process. Provides a time to measure size of fish without measuring the same fish twice. Disadvantages. Requires concentration and practice so that you do not miss species and always have an idea on their current MaxN. Conservative measure of abundance which unfortunately does not capture every fish and hence measuring the fist occurrence of a fish and a different size fish occurs later – Analysis is not accurately capturing the size structure of the population.

Not aware of another useful standardised measure that could be applied to BRUVS footage that would ensure that no fish are double counted. The main disadvantage is when you 'know' there are more fish (ie when one leaves just before another enters on opposite side) but strictly speaking the MaxN cant include both. Similarly a large school that swims past may only be half counted as the school is leaving as more are still entering. This creates a downward bias to the abundance estimates. We use a slight alteration to maxN in that if

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

Male and Female of a species which is easily distinguished enter at separate times this is counted as a MaxN of 2. In retrospect not sure if this is a good idea and would reconsider its suitability in future studies since it creates a slight bias to those species which sexes are readily distinguishable.

We use this because it is used widely and supported by our analysis software. In addition it lessens the chance of double counting the same fish.

Eliminates possibility of double-counting fish. MaxN is useful in as much as it has a direct relationship to overall abundance. Could be limited in areas of high abundance when a cloud of fish extends outside (laterally) or beyond (too far away) the frame of view.

NSW MPA standard

- Conservative estimate - peer-reviewed - cost efficient

I used MaxN as it is considered the standard measure for relative abundance when operating BRUVS. Advantages are its simplicity and repeatability. Disadvantages is that is most likely under-represents the true abundance of a particular fish/animal.

n/a

It seems sensible.

it seems adequate for our system. Since we deploy the BRUVS directly onto the reefs, fishes reach the bait almost instantaneously. Major disadvantage is that the field of view saturates quickly and no more fish enter the area. so, it is useful only for distinguishing between areas with relatively low densities of fish.

This became the standard in NZ after University of Auckland work around Leigh.

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

To gain an estimate of abundance in the area.   It's an efficient way of collecting abundance estimates without harming the fish in any way. Unfortunately you do not capture some fish as they swim behind the camera and are not recorded or observed, however all recordings are the same so the bias across the board.

Disadvantages - conservative particularly for larger species

It is generally accepted that MaxN provides a useful, albeit conservative estimate of relative abundance and allows comparison of species abundance between sites.

Comparison to other studies. Lack of valid alternatives

Effective for comparison between different habitats. Disadvantage is obviously underestimate of actual population

A conservative choice and an accepted convention.

I use this measure as a relative measurement of abundance. I personally do not think this is a problem as any fish sampling is essentially a standardized relative measurement of abundance unless you are doing something really big.

We use MaxN as the primary indicator of species relative abundance to allow calculation of relative finfish community proportions

- Advantage: Can be used consistently across all species and site. - Disadvantage - may actually be more individuals of each species seen on the video than is reflected in the MaxN total.

We followed Willis & Babcock 2000

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

I use it because it is widely used and understood by others. Advantages are that it is easily understood, there is some research on its actual meaning. Disadvantages include the time taken for practitioners to become skilled in its use and potentially inter-observer variation, and understanding what it means in relation to bait plume area

Because it is the standard measure used in BRUVS programs and provides a comparable measure between surveys in different regions conducted by different researchers

Not used

MaxN was determined to be a suitable index of relative fish abundance as it precludes the possibility of counting a fish twice. When tallied successively, it can also be used to determine the relative rate at which species are attracted to the bait (as the MaxN increases with time).

For low frequency visitation likely to be a value of 1 for species of interest when we might be seeing more than one animal. This is where length data will add to the data by identifying (be different length) individuals visiting

As a measure of relative abundance. While it gives an indication of the number of individuals in shoals etc it does not indicate how long they use a habitat for, e.g., a swim past vs foraging in the area, Hence the use of Time in View

1. To standardise and to make my data compatible with other author studies. 2. All papers on BRUVS use I saw so far use 'MaxN' Advantage - a conservative estimate. Disadvantage -

35. The relative abundance measure 'MaxN' is defined as the maximum number of fish seen of a particular species in one video frame. If you collect MaxN data, why do you use this measure? What are the advantages and disadvantages?

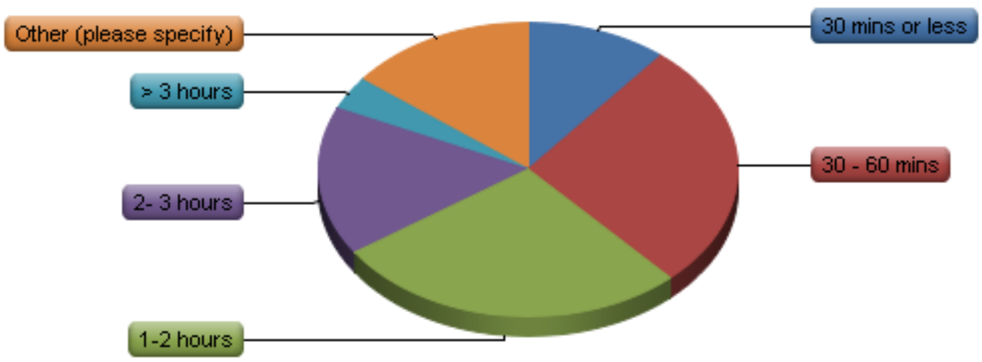
group species abundance may be underestimated.

It is the most accurate I believe to reduce the chance of overestimating fish numbers via the resighting of individuals. The problem of course is the possibility of underestimating fish numbers as it is assumed that each fish species will enter the frame at its maximum number that is attracted to the bait - this is unlikely.

Measurements were only calculated for fish present when the count of the maximum number of fish was made for each species. While this means that some fish moving in and out of the field of view may not have been measured, it also avoids repeated measurements of the same individuals.

Used as a measure of relative abundance that can be compared/contrasted between sites, locations and time periods. Avoids over-estimates based on duplicate counting of the same individual.

36. On average, how long does it take you to analyse relative abundance for all fish species from a 1-hour BRUV sample?



#	Answer		Response	%
1	30 mins or less		6	11%
2	30 - 60 mins		15	27%
3	1-2 hours		15	27%
4	2- 3 hours		9	16%
5	> 3 hours		2	4%
6	Other (please specify)		8	15%
	Total		55	100%

Other analysis times specified
Not sure - someone else does that.
Varies greatly
Dependent on diversity
mmm, don't do this any more
Presume will take 2-3 hours per 1 hour of footage.
Unsure
Ask Euan's slaves
More than 3 hours in murky water

37. Do you use software that automates fish identification and counting?

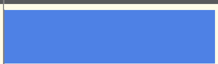
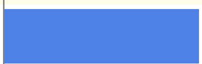
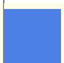
#	Answer		Response	%
1	Yes		4	7%
2	No		53	90%
3	On occasion		2	3%
	Total		59	100%

38. If you answered 'Yes' or 'On occasion' to Q37, please provide information on the software and its strengths and weaknesses.

Statistic	Value
Total Responses	6

Text Response (summarized)
SeaGIS software(3)
I guess a grad student is not really software ... but if you exclude the boney parts????
The software is good in its simplicity. Easy way to keep track of species present and max N. The use of a species drop down list ensures no miss-spellings etc occur. Main weakness is the difficulty in extracting data. User needs to have familiarity with access to extract data. Many (including myself) do not really know how to use access query's well.
NA

39. Do you standardise the field of view from which you identify and count fish (width and range)?

#	Answer		Response	%
1	Yes		26	46%
2	No		24	42%
3	On occasion		7	12%
	Total		57	100%

40. If you answered 'Yes' or 'On occasion' to Q39, please specify how you determine your field of view, the range of fish and whether they are inside or outside your sample unit.

Statistic	Value
Total Responses	28

Text Response
Because we are using stereo video systems we can define the distance and also the field of view. Depending on visibility and light availability we can standardise our sampling units within a particular sampling program.
In the calibration process we can get distance and we reject any measurements over a certain distance.
Stereo range estimate
Range measurements and distance from the centre point of the camera systems are provided from measured fish.
Using EM we can measure distance and therefore limit range to 7 m. Width not limited. Range can be adjusted for visibility.
Stereo-video deployments allow the standardisation of the field of view.
Based on the video frame and scale bar.
The field of view horizontally is fixed by the camera geometry. We occasioanlly standardize by distance using the maximum distance at which a fish was measured across all species in that video.

40. If you answered 'Yes' or 'On occasion' to Q39, please specify how you determine your field of view, the range of fish and whether they are inside or outside your sample unit.

The field of view is relatively large (i.e. few fish are seen on the periphery). We have also performed experiments with 2 cameras with one looking down-current of the bait looking for 'stragglers'. We use a standardised height above bottom and a calibration scale in the centre of each image.

Define a sampling envelope

Range and Angle from Stereo Measurement

Sometimes we count fish at the bait

I standardise by range, with fish past a certain distance excluded (usually about 2m past the bait). This is based on an estimate only so will have inaccuracy associated. In the future stereo measurements will enable this to be more rigorously determined

Stereo video for Eventmeasure. I will standardise the field of view for a particular size class of fish to allow accurate size measurements for as many fish as possible. I will measure distances to seabed features at the start of analysis to guide me. If I think a fish is outside the area I will measure it when performing MaxN analysis and if outside area I will not count or classify its stage as blank if an important species that might be of later interest for P/A data. Ranges are as follows; Small fish up to 100mm are only sampled within 3m from the cameras. This is because I cannot accurately count or identify small damselfish and fast little wrasse at a greater distance. These distances below are from the Harvey et al 2011 paper with 3% error in Fig 5. They generally work out so that I can get less than 10% precision on a fish length and can define the head and tail depending on the size of the fish. Fish 100 to 250mm - no greater than 6m from cameras. Fish 250 to 500mm - no greater than 7m from cameras Fish 500 to 1000mm - no greater than 8m from cameras Fish larger than 1000mm no greater than 9m from cameras.

We determine the field of view relative to the distance of the calibration cube from the

40. If you answered 'Yes' or 'On occasion' to Q39, please specify how you determine your field of view, the range of fish and whether they are inside or outside your sample unit.

cameras (1-4m). This distance should provide accurate length measurements and is a distance which is frequently achievable with the water visibility in South Australia.

NSW MPA standard

I don't as yet, but feel this is something that should be done.

Ask Euan

The camera has been installed in a fixed position. We measured the bottom area included in the field of view straightforward. However, we are exploring the possibility of estimating a volume, which would give a more realistic abundance index.

With vertical camera orientation the camera is at a fixed height so the field of view is fixed and all fish within it are counted.

Visibility estimated to be

The camera points down at an aluminium frame

Pilot study, with area of seabed demarcated

Fish were counted within an estimated 2m of the bait cage, this was determined by use of the fact that the bait pole was 1m long (and visible on the tape)

Stereo overlap area and range from stereo

Cameras have a set wide-angle adaptor with a consistent width and height of frame. Depth of frame is not standardised in any way other than ensuring water clarity is greater than a prescribed minimum.

40. If you answered 'Yes' or 'On occasion' to Q39, please specify how you determine your field of view, the range of fish and whether they are inside or outside your sample unit.

Stand is calibrated prior to surveys and this information is entered into the software prior to analysis.
The cameras field of view provides the 2-dimensional width/height boundaries, whilst the distance from the lens to ~ 2 m behind the bait bag is visually estimated.

41. Do you estimate the volume of water sampled when identifying and counting fish?

#	Answer		Response	%
1	Yes		3	5%
2	No		51	86%
3	On occasion		5	8%
	Total		59	100%

42. If you answered 'Yes' or 'On occasion' to Q41, please specify how you estimate the volume of water sampled.

Statistic	Value
Total Responses	10

Text Response
Because we are using stereo video systems we can define the distance and also the field of view and hints calculate the volume of water sampled.
Standardised max range of the fish included
Independent calibration of a cube using the stereo-video fields of view.
Using the filed of view of the lens and the range of the furthermost identified fish from each deployment.
We only do this if estimating abundance of swimming holothurians passing through the field of view. We take a 2-D triangle perpendicular to the current direction multiplied by the current speeds to calculate the total water mass passing through the image. Then we calculate the volume of the filed of view 'cone' to work out the proportion of that total water we have sampled.
I generally turn such data into relative abundance estimates for community analyses so actual density is not required.
Jim's software
See 40
NA
Previous testing of cameras with known measures for 3 dimensions.

43. If you calibrate your BRUVS, please describe this process.

Statistic	Value
Total Responses	32

Text Response
We calibrate a stereo BRUVS using the three-dimensional cube following the processes outlined in Harvey and Shortis 1996, 1998. We use the CAL software developed by Jim Seager of SeaGIS.
We use a cube with dots in known locations and rotate the cube in the pool. We then use the program CAL to locate the points and calculate the calibration.
Do it is the pool. Euan makes us rotate the stereo base bar and the cube - I don't understand the logic of this. I would just rotate the cube through different angles. When sampling - the base bar does not get rotated? And cameras should be tight - not flopping around inside
In the pool. Cameras are held stationary. Calibration cube is rotated to each orientation ie 4 times. First with cube flat, then angled left approx30 degrees, then right, then up, then down. Footage is analysed and Calibration files on camera orientations created using CAL
Using a calibration cube and the software CAL we make specific rotations of the cube which is filmed by each camera pair.
use of measurement cube in a pool
As per SeaGIS Cal software
Collaborator does that bit!
Cube for stereo
Following SeaGIS CAL procedure in swimming pool with calibration cube.

43. If you calibrate your BRUVS, please describe this process.

Appropriate calibration square for stereo camera arrangements

Footage is recorded from each stereo pair in a swimming pool and a SeaGis calibration cube is rotated and various angles in front of the cameras. The footage is then analysed using the SeaGIS calibration package - Cal.

Standard process in a pool with a calibration cube using the subprogram Cal (SeaGIS)

Euan and the student calibrate cameras using cube and software from Jim Seager

Custom built calibration cube in a fresh water swimming pool. 20 orientations of the cube are collected.

This year, using stereo-BRUVS they are calibrated using a calibrati9n cube and the SeaGIS CAL program

Standard UWA calibrating in a swimming pool and processed using SeaGIS CAL software

As per SeaGIS instructions.

Not sure of details

Use "CAL" and inpool filming of calibration cube (no speedos please)

Calibration cube in pool using CAL software.

Ask Euan's students and slaves

We use PT lens software for correcting optical deformation in the field of view when snapshots are taken to size fish.

NA

Using cal cube initially, then cal bar in field and then cal measure (SeaGIS sodtware). Undertaken usually after every sampling day

43. If you calibrate your BRUVS, please describe this process.

Harvey and Shortis 1996, 1998; Harvey et al. 2001, 2002
See Merritt et al 2011
BRUV used in swimming pool with SEAGIS calibration cube. Calibration performed using CAL software.
Standard SeaGIS software and cube
Stereo calibration techniques using 3D targets on a cube and SeaGIS stereo calibration software
Pool calibration with measurement cube etc as specified by SeaGis
Stand is measured prior to starting the surveys.

44. Please select your age group

#	Answer		Response	%
1	17-30		10	14%
2	31-40		28	41%
3	41-50		19	28%
4	51-60		11	16%
5	60+		1	1%
	Total		69	100%

45. How many years of experience do you have with BRUVS?

#	Answer		Response	%
1	None		4	6%
2	1 year		9	13%
3	2 years		13	19%
4	3 years		12	17%
5	4 years		7	10%
6	5 years		6	9%
7	5-10 years		14	20%
8	10-15 years		4	6%
9	15-20 years		0	0%
10	> 20 years		0	0%
	Total		69	100%

46. What country do you work in?

Statistic	Value
Total Responses	69

Text Response (summarized)
Argentina
Australia (44)
Australia and Guam
Australia and New Zealand predominately. I am also doing some work in the United States.
Australia and USA
Fiji
Guam
Guam and Oman
New Zealand (6)
NZ and Australia
UK
UK
USA (10)

47. What state/province do you work in?

Statistic	Value
Total Responses	66

Text Response (summarized)
Western Australia (14)
NSW (14)
Victoria (3)
SA (2)
Queensland (4)
Northern Territory
Tasmania (3)
Western Australia, Victoria and New South Wales
Qld, WA, NT
Completed BRUVS in NSW, now working in QLD
Auckland (2)
Scotland
Aberdeenshire
Alaska, Oregon
Washington
Taranaki
Hawaii (7)
NSW in Australia and Guam in the USA
Used off New England, Florida, Belize

Victoria / California
Chubut
Northeast NZ
n/a

48. Please select the categories which best describe your interest in BRUVS.

#	Answer		Response	%
1	Manager		13	19%
2	Researcher		62	91%
3	Student		12	18%
4	Educator		5	7%
5	NGO or peak body representative		2	3%
6	Commercial fisher		0	0%
7	Recreational fisher		3	4%
8	Other (please specify		2	3%

Other (summarized)
Consultancy (2)

49. Thank you very much for completing this survey. Once you have logged out, your responses will be submitted and cannot be changed. If you have any queries please contact euan.harvey@uwa.edu.au. If you are willing to be contacted about your responses could you please put your email address in the box below.

(Email list not provided here)

50. Timing

#	Answer	Average Value	Standard Deviation
1	First Click	10.40	53.75
2	Last Click	42.06	58.14
3	Page Submit	66.21	129.70
4	Click Count	6.17	2.93

13.4. Appendix 4: Standard Operating Procedures

Different organisations around Australia have developed their own set of Standard Operating Procedures for BRUVS. Included here are those from the Australian Institute of Marine Science (13.4.1), CSIRO Marine and Atmospheric Research (13.4.2), and the School of Plant Biology – The University of Western Australia (13.4.3).

13.4.1. Australian Institute of Marine Science SOP

Australian Government | Australian Institute of Marine Science

Illustrated guide to assembly, deployment and retrieval of

BRUVS©

(Baited Remote Underwater Video Stations)

Updated September 21st 2009

INTRODUCTION

BRUVS or Baited Remote Underwater Video Stations have been developed by AIMS as a simple and effective tool for surveying fish diversity and abundance.

The following guide details the components, maintenance and use of the single BRUVS in the AIMS fleet. Also provided is a generic procedure for deployment and retrieval of BRUVS, however this is provided as a guide only as every vessel is different and procedures will have to be adapted in consultation with the master and crew to suit the vessel.

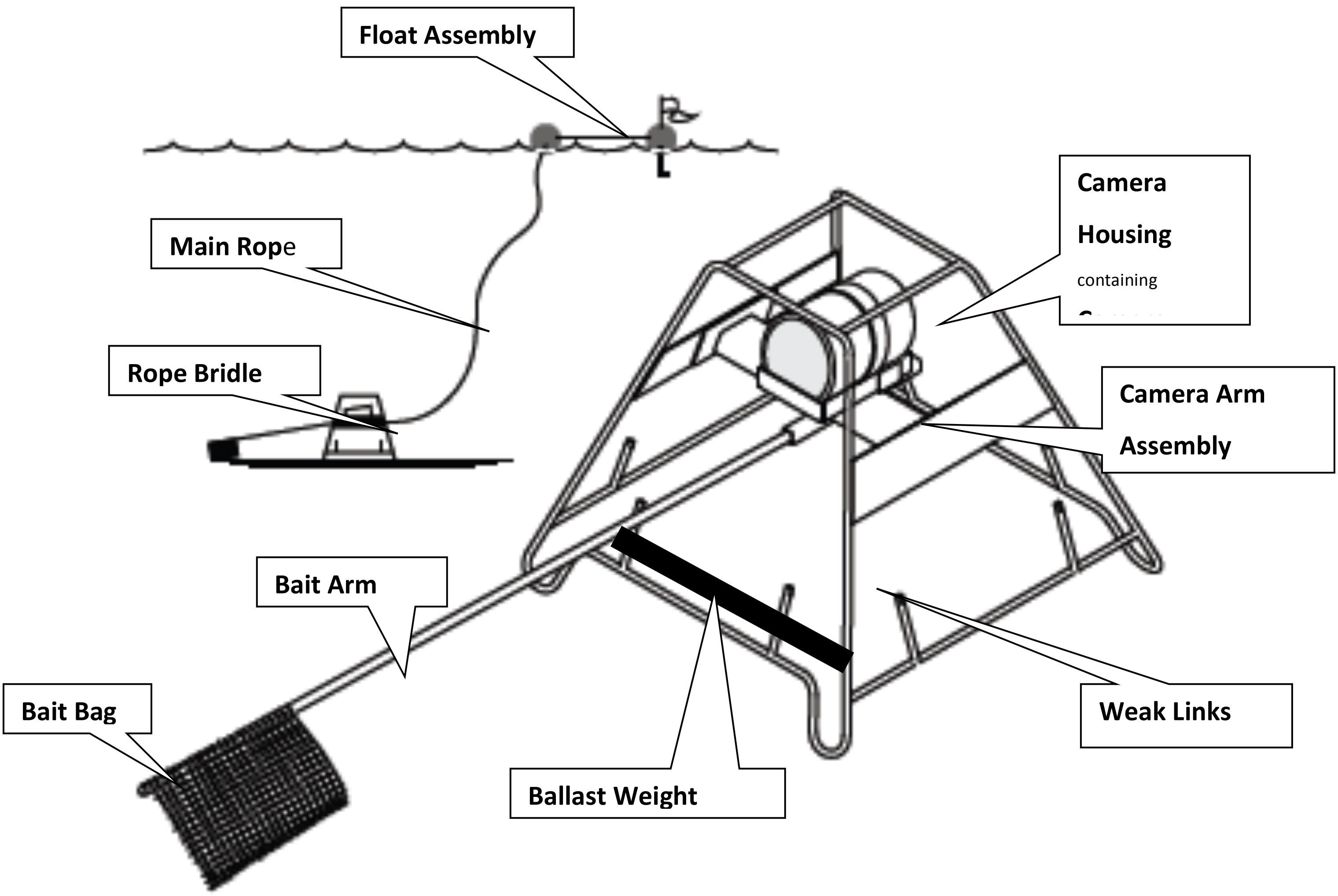


Figure 1. Major components of a single BRUVS rig

SPECIFICATIONS AND COMPONENTS

Dimensions and weight

The current model of AIMS single-camera BRUVS are trestle-shaped to maximise stability. They can be stacked on deck, and they raise the field of view of the camera up off the seafloor and above obstacles. Single BRUVS frames have a tare weight of 15 kg with dimensions of length 800mm X width 780mm X height 650mm. The frame holds the camera housing 350mm off the seafloor. In use the frames hold a variable number of steel ballast bars (weighing 5 kg each) and a watertight housing with video camera (weighing 3 kg).

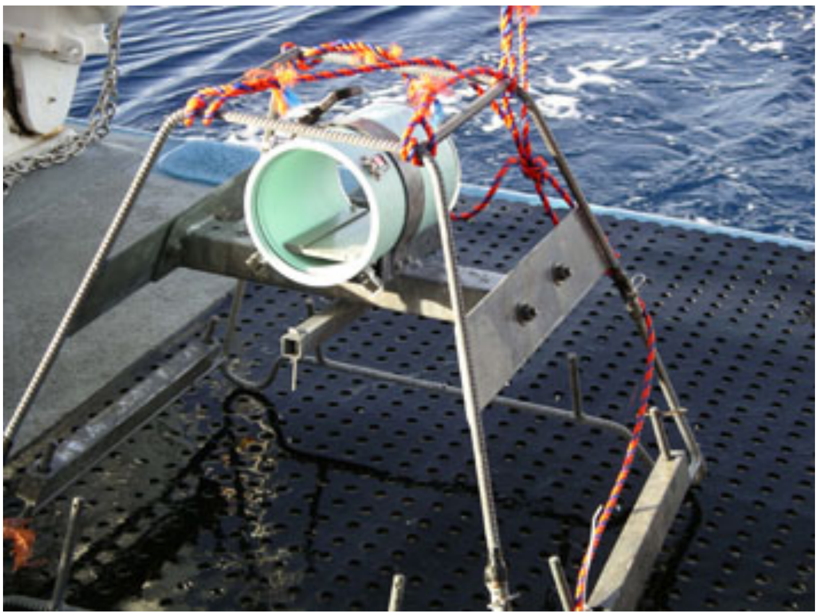


Figure 2. An assembled single BRUVS.

Ballast weights

Normal operations in conditions of minimal swell and current use 1 ballast bar at the front of the rig to counteract the lift of the bait arm when the unit is deployed. Therefore the total weight would normally be 23 kg for single BRUVS. In extreme conditions of swell and current, a fully loaded single BRUVS rig with 5 ballast weights will weigh up to 43 kg.

Ballast weights are secured using one straight leg zinc plated R clip per peg (65 mm X 18mm X 3mm Zinc plated R clip [*Boltmaster's* product code ZRC03Z]).

Figure 3. Removable steel ballast bars are pinned on pegs on the base of the BRUVS frame with ‘R’ clips. Ballast is removed and replaced every set, according to local conditions of swell and current.

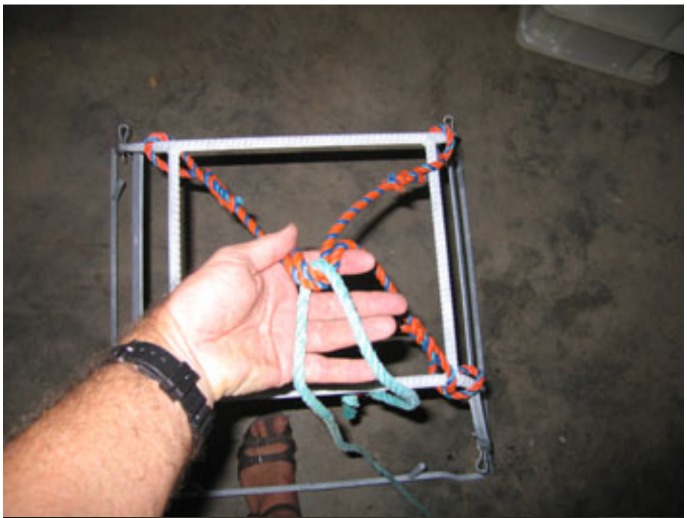
Camera arm assembly

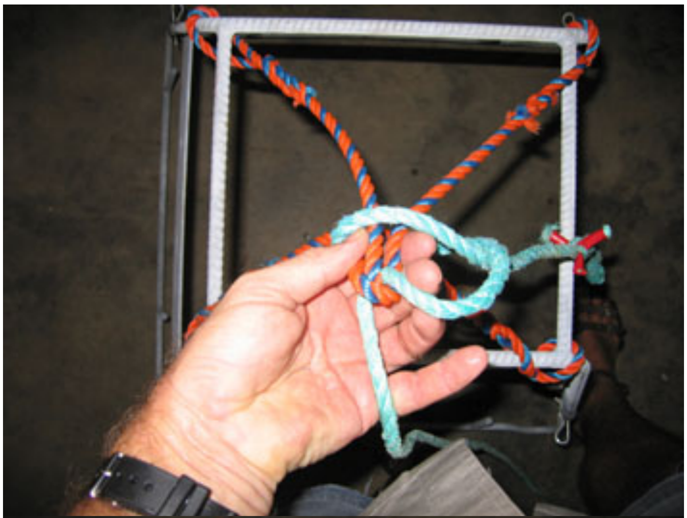
Camera arms are bolted onto frames through slots allowing 10 degrees of downward tilt. A locator lug mates with a socket in the camera housing faceplate. Rubber tie-downs are used to hold the housings on camera arm clamps and enable quick release. M12 x30mm bolts, nuts, and flat washers are used to assemble camera arms in frames (4 fasteners per BRUVS frame). Once bolted in the camera arms are rarely removed from the frames.

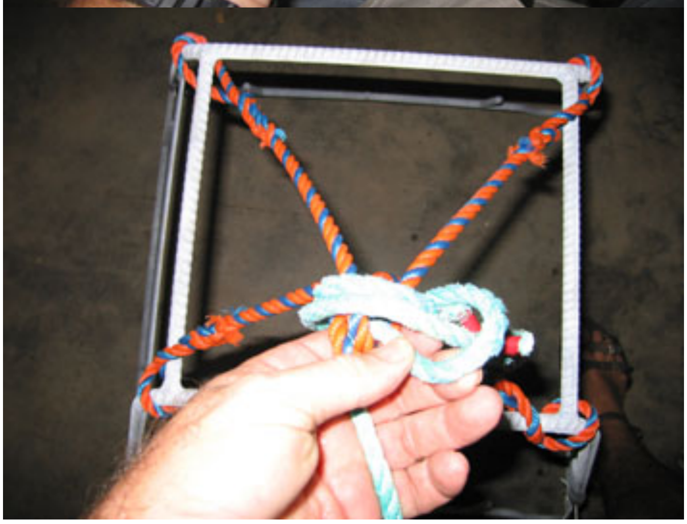
Figure 4. Camera arm assembly

Rope bridles

Ropes are attached to the BRUVS frame via a spliced rope bridle. Bridle ends are passed twice around a frame corner before being spliced together. A Double sheet-bend with locking bowline is used to secure the 8mm main BRUVS ropes to the bridles on frames.







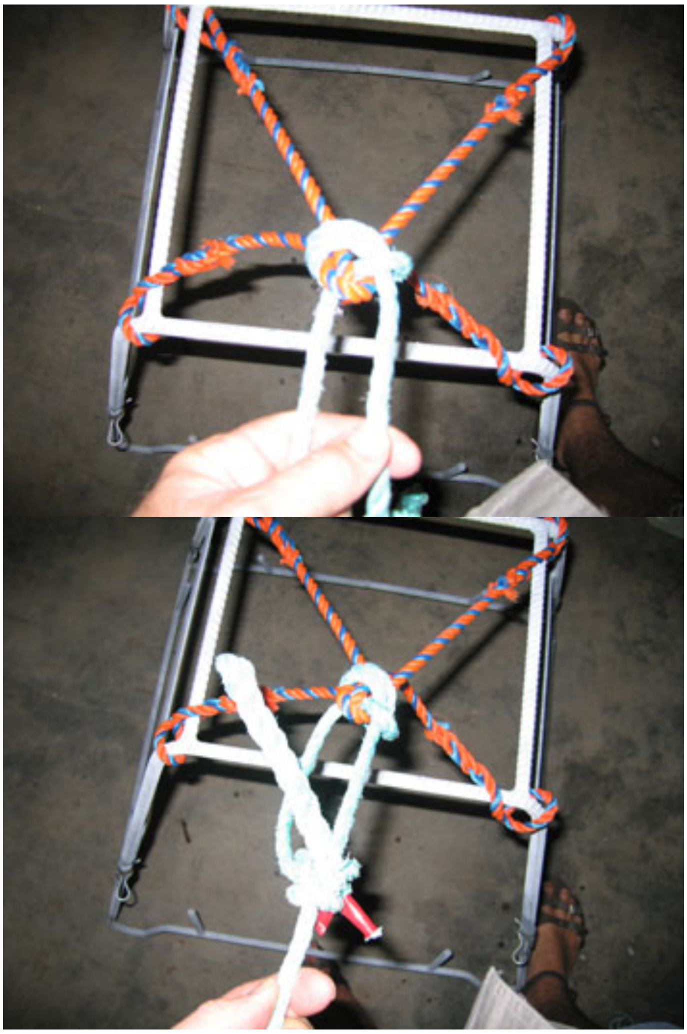


Figure 5. Attachment of ropes to the BRUVS frame using a spliced bridle with the rope tied to the bridle using a double sheet bend

Floats assembly and main ropes

BRUVS have a rope to the surface to facilitate retrieval, with a float line assembly on the surface.

The float line assembly consists of one 10 inch polystyrene float with a flag pole attached on a leader of approximately 4-6m to a 12 inch leader float. In conditions of extreme current and swell it is possible to add additional 12 inch floats slipped onto the leader. Marker flags are custom made by *Ede's* in Townsville and should be ordered with blind sleeves and tie cords. These cords are passed through a hole drilled in the conduit and tied off. Floats are tied onto the poles. Eye splices hold floats in position. A lead sinker is cable tied into the female conduit socket acts as a counter weight to keep the marker flag upright.

Float lines are secured to the main rope by a double sheet bend, plus locking bowline

The main ropes used are 8 mm ‘sea green’ stapled polypropylene rope. This rope is typically used in rock lobster fisheries and has good characteristics of flotation, handling, coiling, abrasion and wear resistance, and is suitable for pot hauler winches on most vessels.

The length of main rope used should be 2x the water depth in <50m water depth, and 1.5x water depth in water deeper than 50m.

Pay attention to rope condition and discard any rope that is worn or shows deterioration of any kind. Ropes are best stored by flaking into a large basket. Wash them with fresh water after a field trip and ensure they are dry before long term storage.

Figure 6. A float line assembly showing the10 inch flagpole float separated from a 12 inch leader float by a 4 to 6m rope leader. This section of rope between the floats is the target for grappling during retrieval.

Weak-links in BRUVS frames

An important safety feature of BRUVS when working in snaggy (e.g. coral reef) locations is the incorporation of a breakaway mechanism in the frame legs. These links have repeatedly proven their worth by returning the whole frame (albeit bent open and sometimes deformed) after snagging on underwater cliffs and bommies. Bent frames may be straightened using a pipe sleeve so the male and female parts fit together again.

The weak links are made from a short piece of 18 gauge (1.25mm) galvanised wire passed through the hole and twitched together. Gaffa tape should be wrapped around the weak link assembly to prevent the wire ends from scratching people handling the frames.

The galvanised wire weak-link should be changed approximately every 5 days as it may begin to corrode after this period. Tests at *All-Rig* showed the weak link with new wire the assembly shears apart under ~150kg of load, significantly less than the breaking strain of the main rope.

In circumstances where snags are unlikely (e.g. sandy and muddy habitats) the weak link can be bypassed using a 3mm R clip.

Figure 7. Male and female parts of the weak-link in each leg of the frame.

Figure 8. Galvanised wire (1.25mm or18 Gauge) is used as weak-link. The ends of a short piece are passed through the holes and twitched together. R clips are only used to bypass the weak link where snags are not encountered e.g. on sandy seabeds. *Note: the wire ends should be pressed flat against the leg and gaffa tape should be wrapped around the wire to prevent scratches from the wire ends.*

Bait bags and bait arms

Bait bags are made from black plastic *Nylex* oyster or general purpose mesh [Nylex NM1212 GP 30m X 1.5m black plastic mesh.]. Each bag is made up from a rectangle of mesh *30 meshes wide X 25 meshes long*. Fold in half long-ways and use netting clips to make a bag. Netting clips are 16mm X 2.4mm and are available for purchase from hardware stores in bags of 500 . Use a stainless tie wire tag of ~25cm long twitched on at top corner to close bag. Fasten bags to bait poles (1.5m length overall) with the opening pointing up the pole. Fasten bags to bait arm poles using cable ties clipped off neatly (x4).

Bait arms are 20mm heavy duty orange plastic electrical conduit. Bait arms are 1.5m long in total for single BRUVS. A quarter-inch drill bit is used to drill 4 holes in distal end of bait arms, about 80mm apart. Cable ties go through these to fasten the bait bag. Another hole is drilled 50 mm from the proximal end of bait arm base to take stainless R clip that locks the arm in the BRUVS frame socket.

Baiting procedure

Ensure the mouth of the bag points up the bait pole. One kilogram of oily pilchards or sardines is *crushed* by hand packed in the bag to produce a bait plume. A short length of *VB* cord closes the bag mouth. Immediately before deployment pin the bait arm into the socket on the camera arm with custom made stainless R clips.

Figure 9. A bait bag and bait arm; baiting in progress; attachment of bait arm using the stainless R clip.

Camera housings

The camera housings are custom made and will suit a variety of miniDV and hard drive camera models owned by AIMS.

The camera housings are held within the BRUVS frame by a rubber bungee strap. Gaffa tape can also be used for extra security. Be sure the camera housing locates fully onto the circular lug on the camera arm before securing the bungee,

The camera housings are opened by undoing the 4 clips on the rear faceplate levering off the acrylic rear port. *When levering open the housing use a screwdriver shaft placed between the steel jaws of the clasps to avoid damaging seals and soft plastics used in housings*. *Never use the screwdriver to lever against the plastic components as damage will result.*

The camera housings are relatively low maintenance but rear o rings should be regularly inspected for grit or other items that may affect the seal. The rear o rings should also be cleaned and regreased with silicon grease at least every 5 days at sea. Housings should be rinsed with fresh water after each field trip.

Periodic housing maintenance involves stripping down housings completely and checking o rings and all other components for damage / deterioration. Each camera housing has a total of four O rings. Namely two O Rings 155 X 3mm for slots machined into housing walls face/back and two O Rings 150 X 3mm for seal on face and back plates.

Figure 10. Camera housings showing the dovetailed plate that accepts the camera baseplate..

Cameras and batteries

Each camera is mounted to a dovetail baseplate via a UNC 1/4" X 1/2" countersunk screw. The baseplate can be left attached to the camera for the duration of use.

The cameras used are *Sony* MiniDV Handicams with 0.6X wide-angle lens. There are several models in use and they vary slightly in their operation. Refer to the user manual for each particular model if in doubt about selecting the required settings.

Generally the settings required for BRUVS work are as follows:

- Date and time set to local time
- POWER knob turned to CAMERA (**not** memory or VCR)
- PROGRAM mode set to SP (standard, short play) for 62 minutes of footage
- PROGRAM AE exposure set to AUTO
- FOCUS button at front left set to INFINITY/MANUAL
- ZOOM lever on top set to the WIDEST-ANGLE of view (beware bumping this exposed lever)

Before putting cameras into the housings, fold open the LCD screen and check:

- REC recording mode is highlighted in red
- BATTERY life is sufficient
- TAPE is loaded
- SETTINGS (AUTO, SP, INFINITY (a small mountain symbol)) are correct
- TIME/DATE are CORRECT but NOT DISPLAYED on tape

Cameras are routinely used with long life lithium batteries, A long-life battery easily allows up to 6 sets per day. Be sure to recharge the batteries each evening. Charging is done using the Sony fast chargers and takes 1-2hrs.

To secure the camera in the housing the dovetail baseplate is slid into the matching plate in the housing until the locator pin locks onto a female lug on the camera baseplate. BEWARE of bumping the cameras zoom lever during this operation. The female lug should be slightly lubricated with silicon grease on a regular basis to prevent wear and fatigue of the mating pin and lug.

BEWARE to avoid any drips or splashes entering the opened tape carriage. Use a dry bin with a towel liner to move cameras to and fro between storage cases and housings.

ALWAYS use dry hands when handling tapes and cameras

DO NOT take cameras straight from air-conditioned rooms to the back deck – moisture sensors activated by the resultant condensation will render the camera inoperable. In very hot climates [like NW Australia], leave cameras in bin in shade or non-airconditioned space for at least 30 mins before use.

Figure 11. Sony MiniDVCameras and a charging and playback station. Note the dovetailed baseplate attached to the cameras which interlocks with the matching plate in the camera housing.

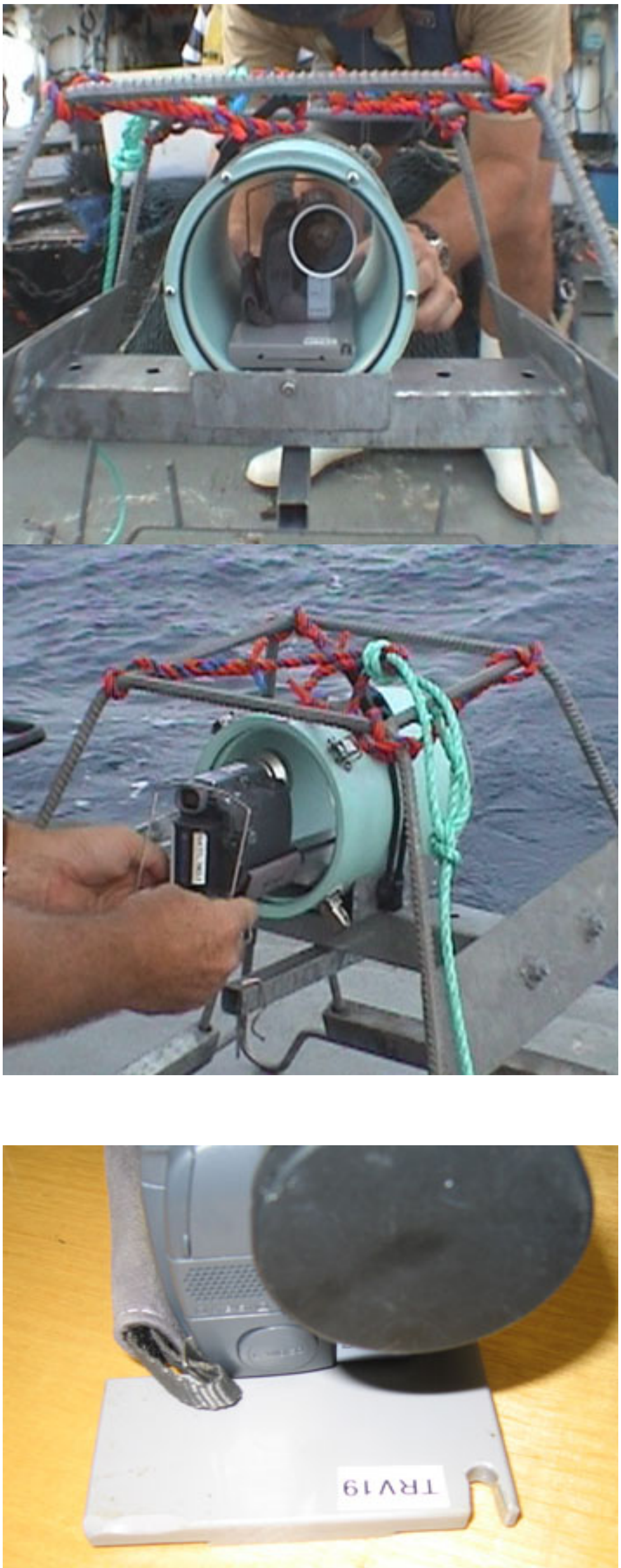


Figure 12. Inserting a camera into a housing. Note the locator slot at the front of the baseplate that locks into the lug on the housing dovetail plate. The slot should be regularly greased with silicon grease..

DEPLOYMENT- A general guide

BRUVS are generally set at least 400-450m apart during daytime only. Soak times are up to using 1 hour using standard play tapes (or longer if using hard drive / memory stick cameras if the job demands increased duration).

Ahead of deployment

- *Flake ropes out of rope bin into individual baskets, to get floats on top of coils (they go out first)*
- *Fill bait bags with crushed pilchards*
- *Ensure cameras are ready (batteries fully charged, tapes labelled etc)*

Preparation for deployment (approx 3 mins prior to arriving at waypoint)

- *Ballasting: In calm conditions, with minor current and no wave action – ALWAYS use 1 ballast bar on the pegs directly under the bait arm (front of BRUVS frame). This counter-balances the bait arm drag when unit sinks. In any chop or current, use 4 bars – 1 each side of the frame. In worst conditions of high waves and current, use additional ballast bars on the front, back and sides of the frame. Ensure all ballast bars are secured with R clips.*
- *Insert the bait arm assembly prefilled with 1kg of crushed pilchards and secure with the custom bait arm R clip.*
- *Check camera settings (see box below), insert camera in housing and start recording*
- *Close the housing and do a quick inspection of the whole rig.*
- *Film the site and date information on the clapper board.*

Deployment

- *The camera person gives the all clear that the housing is sealed and the camera recording*
- *Skipper takes way of the vessel and advises at 200m to the waypoint.*
- *A crew member streams the rope, floats first from the vessel. If necessary the rope can be locked off once fully streamed by taking wraps on an appropriate strong point.*
- *Once rope is fully streamed deck crew indicate their readiness to deploy.*
- *Skipper indicates when to deploy (either verbally or via sound signal)*
- *Two crew manoeuvre the BRUVS frame gently into the water. One crew member retains hold of the rope momentarily to ensure BRUVS is deployed upright.*
- *Crew indicates to skipper BRUVS is deployed and steaming to next waypoint commences.*

Data Recording

- *ENSURE an "event" is marked with camera number, time, DEPTH and position (5 decimal places) in appropriate electronic database.*

Figure 13. Site information is filmed on a “clapper board” to ensure no confusion if tape labels become lost or damaged.

Figure 14. Floats and rope are streamed out the back of the vessel first, and locked off on a suitable strong point to await the final position of the drop. Length of ropes is twice water depth in water less than 50m deep, and 1.5 to 2 times water depth in water over 50m deep.

Figure 15. Ensure the BRUVS are deployed in an upright position by holding the rope immediately above the frame momentarily after the frame is slipped into the water. Dropping or tossing the BRUVS without due care causes failure and damage to cameras.

RETRIEVAL – A general guide

- *Before approaching a pick up ensure main hydraulics are turned on , the pot hauler is operational and pot tipper locked in the correct (down) position.*
- *Vessel approaches upwind or up-current to bring the floats within grappling range.*
- *The grapple is cast to catch the float assembly.*
- *The floats and rope brought onboard and through the gunwale fairlead on the pot tipper.*
- *Floats are passed aside and rope passed around pot hauler wheel, ensuring the rope is wrapped around in the correct direction (usually clockwise).*
- *Pot hauler operator waits until rope is in the pot hauler wheel and verbal confirmation is received that deck crew are ready to commence hauling. Pot hauler is then engaged with controls.*
- *Pot hauler operator adjusts rate of recovery whilst a second deck crew 'tails' or coils the rope into a basket.*
- *Hauling slows as the BRUVS approaches the surface then stops with BRUVS at gunwale height alongside the pot tipper.*
- *The crew then remove ballast bars one by one and set them aside.*
- *The BRUVS frame is then gently lifted on board (by two persons if necessary) and set aside out of the way.*
- *Camera removal. If the conditions are dry and no spray is expected, the housings can be left in the frames and opened on deck after being dried with a towel. The cameras can be removed and tapes/batteries changed. In conditions of rain or spray, the cameras can be removed along with housings via with quick-release brackets to be taken into the lab where the housings can be opened away from salt spray.*
- *Cameras are best stored between use on towels in a Nally bin* ***out of direct sunlight and in a non air-conditioned space****. The cameras will fail, due to condensation alarm if transferred directly from cold air-conditioning to hot deck space.*
- *When tapes are removed, the tape slider should be shifted to SAVE to prevent overwriting. Tapes should be in an orderly fashion in cool dry conditions. The must be labelled correctly with station details and camera number.*

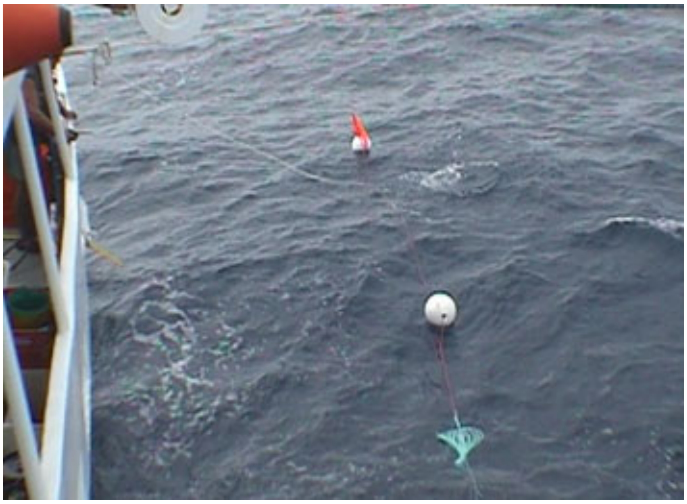


Figure 16. The vessel comes upwind or up current alongside the lay of the floats, and keeps slow forward movement. A grapple is cast between the flagpole and leader float to snag the buoy line and bring it onboard the vessel and on to the pot hauler for hauling.

Figure 17. The floats are brought inboard through the gunwale mounted fairlead or pot tipper roller guide

Figure 18. The rope is passed around the pot hauler winch, with one operator tailing the rope into a basket and another controlling the winch. Once the frame is at gunwale height the ballast is unloaded and the frame gently slid or lifted inboard by two people.

Figure 19. The BRUVS and ropes should be neatly stored in readiness for the next deployment. Note that the ropes will need to be reversed (i.e. floats ends at top of the coils) in readiness for the next deployment.

IN THE EVENT OF A SNAG WHEN HAULING

Several modifications to hardware and procedures have been made to reduce the risk of snagging of BRUVS frames on the seabed.

- The legs of the BRUVS frames have been cut apart to include a male pin in a female socket. The pins are held in place by R clips AND #18 gauge galvanised shear-pin wire. On snaggy seabeds, the R clips are removed leaving the shear-pins to hold the frames together. The wire shear-pins will fail under a load of 150kg, freeing the camera housings from the ballasted legs. The frame usually bends open and rises. It can be straightened and re-pinned

- A short section of 7mm rope has been inserted immediately above the BRUVS frame, before the main rope. In the event of a serious snag and rope overload to breaking point, this should ensure the rope breaks at the seabed, eliminating the possibility of backlash of the rope.

- A flow chart has been developed that should guide the actions of the deck crew in the event of a snag. Under no circumstances should risks be taken in attempting to retrieve snagged gear. The gear can easily be replaced See appendix 1.

ITEMS OF SPECIAL CARE

- The acrylic front ports are very soft – avoid any scratching or scuffing by keeping them away from all other surfaces.
- Never place the housings facedown on a hard surface without protecting the acrylic front port.
- Do not manually scrub or wipe off salt crystals or foreign matter– it will scratch the port.
- Front ports can be washed only by hand with dilute detergent using only the skin to wipe away grease – remove any rings from fingers during this operation and rinse off with deck hose.
- Cameras will be damaged in hot conditions – do not leave them in the sun, inside the housings
- Exposure to sun causes back ports to burst off housings in hot conditions when opening the clamps – this may damage edges and seals if they hit the deck.
- Use lens caps on the cameras when not in use.
- Taking cameras direct from an airconditioned cabin outdoors will often result in condsensation on the lens (fogging) or the electronic moisture alarm in the camera activating. To avoid this the cameras should be equilibrated to outside temperature well in advance of their use.
- If the condensation alarm prevents camera use, store them in the ambient air conditions for 1 hour to dry them out.
- Always store loaded or unloaded cameras in dry *Nally* bins with the lid on in case of unexpected splashes**.**

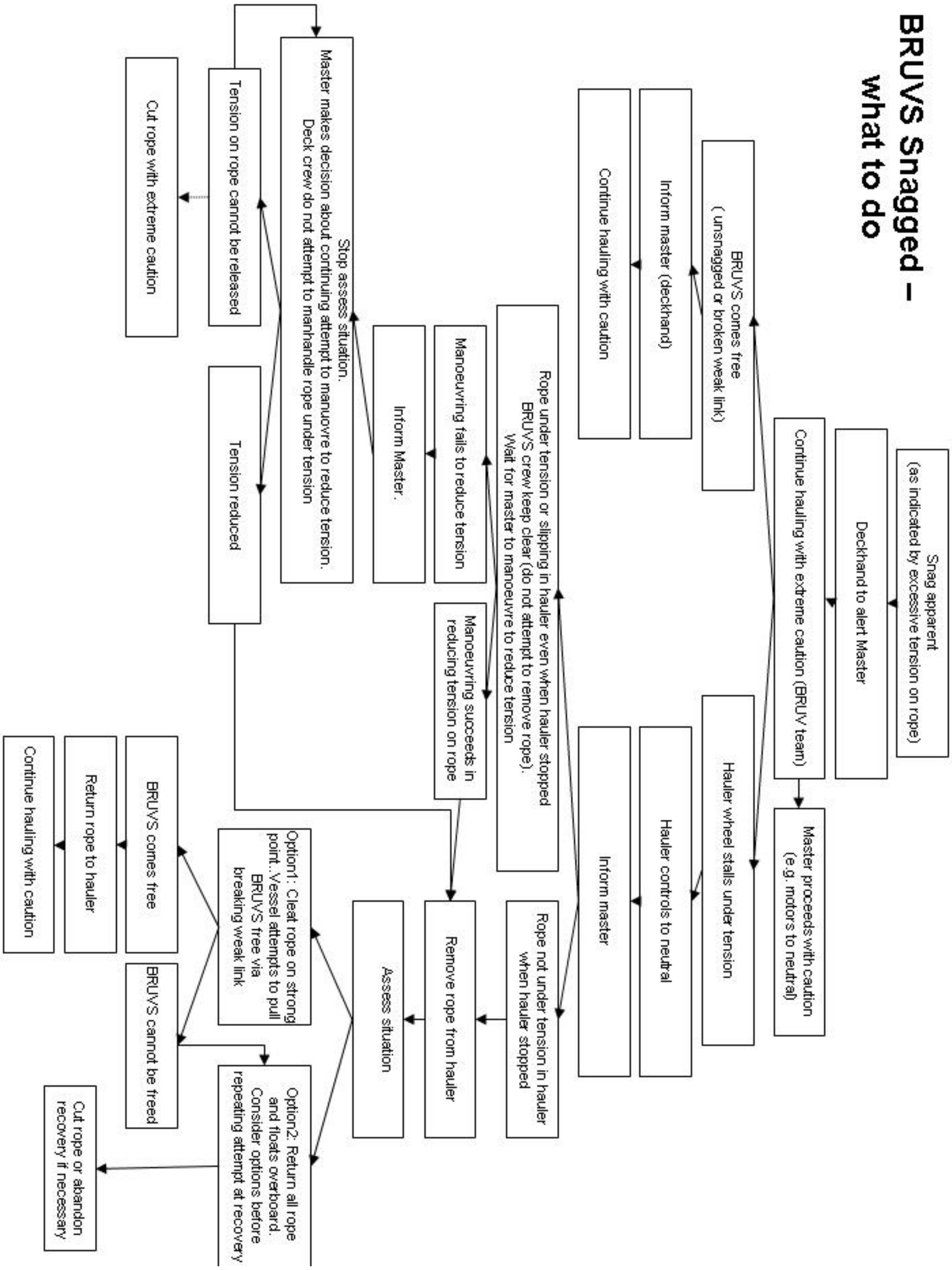
LOADING OPERATIONS DATA INTO THE BRUVS.MDB DATABASE

Use the Excel template (mikesessentialdata.xls) or a table exported from onboard waypoint database (bruvswaypoint.mdb) to load operational metadata into the parent database using the form "**frmAddBRUVSData**". This will distribute the operations data to relevant tables in the BRUVS.mdb parent tape reading database.

Supply the LogReq Number and Cruise Number from the AIMS LOGREQ system.

The fields operational metadata required is as follows:

Gear	BRUVS, SBRUVS etc
Destination	general reef name or region
CruiseStartDate	day of departure
CruiseEndDate	day of return
Boat Name	vessel name
MaxSeaFile	name of MaxSea file for drop waypoints
DataFile	name of electronic datafile for trip
OpCode	code for single operation, linking all labels to tapes [eg site 2143]
Location	precise location of operation [eg lagoon, drop-off]
Camera	identification number of individual BRUVS units in an operation [1 to 6 if using 6 cameras]
depth	water depth below hull in metres
timein	date/time gear dropped in [but see field below]
timeout	date/time gear pulled out [but see field below]
lat	DECIMAL LATITUDE
lon	DECIMAL LONGITUDE
comments	notes on operation, including observed failures
WPt/OpNum	number in MaxSea identifying drop position
GEOID	all WGS84 in new studies, but some vessels still use AUS66
OPDate_Time	date/time gear deployed [14-Nov-2004 08:03 AM] – supercedes Time_in above



13.4.2. CSIRO Marine and Atmospheric Research SOP

<u>CMAR BRUVs Standard Operating Procedures</u>

Camera Calibration: Cameras are calibrated prior to the commencement and at the conclusion of each BRUVing season. This is done by recording various orientations of a calibration cube in a pool, then using Cal (SeaGIS Pty. Ltd.) to determine the position of each camera relative to its stereo partner, allowing for lengths to be calculated later in video analysis.

Preparing BRUV equipment:

- Purchase 20kg of frozen WA pilchards for every day of sampling planned.
- Thaw approximately 4kg of pilchards.
- Fully charge camera batteries.
- Attach 8mm diameter rope of appropriate length to the BRUV frame via a D-shackle and swivel. Length of rope ~2 x depth
- Attach a large inflatable float (80 cm diameter) to the end of the BRUV rope via a shark clip.
- Attach two 25cm diameter foam buoys to the surface grappling line (3m length of rope) to the end of the BRUV rope via a shark clip.
- Add the appropriate number of weights to the BRUV frame and secure with pins. High current will require more ballast to ensure BRUVs land upright. Normally two weights on the front tho counter the drag of the bait basket and a single weight on the rear.
- Cut numerous1.2 m lengths of 19mm PVC pipe with one hole drilled towards one end (to allow attachment to the BRUV frame) and two holes at the other end (to allow attachment of the bait bag).
- Cut numerous 450mm lengths of 10mm mesh-sized gutter guard, then fold back (approximately 190mm) and secure with zip-ties along both sides to make a bait bag. A reusable zip-tie is used to close bag.
- Attach bait bags to bait poles via zip-ties.
- Label all HD cards with a unique number.
- Upload all sites onto the vessel's GPS navigation system and onto a handheld GPS to be kept on the back deck when deploying BRUVs.
- Replace all diode batteries.
- Check, clean and regrease all O-rings on camera housings.

BRUV deployment:

- Fill bait bag with approximately 700g of pilchards.
- Crush pilchards in bag to ensure maximum dispersal of fish oil and flesh – and increase the vomit factor on the back deck of the boat!
- Insert and secure with a pin to the BRUV frame both the diode and bait pole with full bait bag.
- Turn on diode.
- Select cameras which have camera numbers matching camera housing numbers, otherwise calibration files will be inaccurate, resulting in inaccurate length measurement.
- Ensure cameras:
    - have a sufficiently charged battery attached,
    - have an SD card inserted with sufficient free memory
    - are set to record to SD card and not internal memory,
    - are set to fully automatic,
    - are set to the widest zoom angle,
    - have focus set to infinity,
    - are set to FXP quality (17 Mbps).
-
- Record date, site number and area on a slate.
- Turn cameras on and press record.
- Record footage of the slate with the site details.

- Ensure camera housings are clean and dry.
- Insert cameras into their respective camera housings and secure with pins.
- Move BRUV to the edge of the stern deck.
- Place rope over block and wrap around bollard.
- Skipper will notify when vessel is on site.
- Wait for boat to stop.
- Push BRUV off boat and stop the rope from passing out until the BRUV is stable i.e. upright in the water before releasing.
- Quickly remove rope from block and bollard and let it free-fall through the water column.
- When BRUV hits the sea floor, inform skipper to move slowly forward.
- When all of the rope and the buoys are off the boat, inform the skipper “All clear”.
- On the datasheet record date, time, area, site number, depth, BRUV frame number and camera numbers.
- Other variables are recorded throughout the day – water temperature (using TS meter), secchi depth, sea height and wind speed and direction.

BRUV recovery:

- After at least 45 minutes on the seafloor, vessel slowly approaches the BRUV.
- Pick up surface line with grapple hook.
- 1 person on the stern deck pulls in the rope and one at the winch coils the rope into the lug-basket.
- Pull in all slack rope while signalling to skipper the direction of the rope in the water so that the vessel slowly manoeuvres above the BRUV on the seafloor.
- Once the BRUV is directly below, wrap rope clockwise around capstan ~ 3 to 5 times.

  The more wraps, the easier it is to pull the BRUV up, but the easier it is to get rope tangled on the capstan. Control winch speed with the lever at your knees. If it gets tangled or the rope on the capstan doubles up stop the capstan immediately and get someone to take the weight off while you untangle.

- Place rope on block pulley and then side pulley.
- Inform skipper “Winch on”.
- Signal when BRUV is 3 m from surface so that winch speed can be slowed down.
- If bait pole is pointing to the bow of the boat, stop pulling BRUV up and turn it around.
- Continue pulling and lift onto stern deck.
- Request skipper turns the hydraulics off.
- Rinse housings with fresh water and towel dry.
- Remove pins, open housings, take cameras into galley.
- Stop cameras (if still recording) and remove SD cards from cameras.
- Record SD card number on data sheet.
- Insert SD card into a reader connected to a laptop and view a few sections of the footage to ensure it is suitable for analysis – i.e. landed upright, good visibility, etc.
- Check battery power and change battery if necessary.
- Insert new SD cards into cameras.

Converting files:

- Footage recorded on the SD cards is recorded in 2GB mts files – each 45 drop produces up to 4 mts files.
- Each group of files is renamed to reflect the drop number and the camera side (left or right).
- Files are then downloaded from the SD card (so the card can be used the following day) and copied to two external hard drives (one for back-up).
- At the end of each BRUV session, the individual mts files for each drop camera are joined and converted to avi format using Moyea MTS Converter (Moyea software) with the following DivX-AVI video settings:
    - Codec – xvid
    - Size (pix) – 1920 x 1080
    - Bitrate (kpbs) – original
    - Frame rate (fps): 50

Video Analysis:

- Both left and right avis are quickly viewed to determine which avi is the best to analyse to obtain species composition and abundance information.
- EventMeasure (SeaGIS Pty. Ltd.) is used to determine the abundance of each species at each site by determining the maximum number of recorded individuals in any image.
- PhotoMeasure (SeaGIS Pty.Ltd.) uses footage from both cameras and the camera calibration files to determine the lengths of all individuals which can be seen simultaneously both camera view.
- Output from EventMeasure is used in PhotoMeasure to drive the files directly to the frames where species were identified (MaxN frame).
- A visibility range is also determined to calculate the volume of water sampled in each BRUV.

Maintenance of Equipment:

Cameras

- Wipe clean to remove any salt spray.

Housings

- Replace hose clamps after every season
- Clean and grease o-ring after every season– or replace if necessary

BRUV Frames

- Replace ropes after every season
- Replace D-shackles after every season
- Replace quick-release wire after every season

Diode

- Replace battery after every season
- Clean and grease o-ring after every season – or replace if necessary.

BRUVS field datasheet

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

Date:	Area:	Control/Reserve	Site ID:	Depth (m):	Temp:	Salinity:
BRUVs frame ID:		Lat:	Lon:	Wind:	Sea:	Secchi:
Left Cam ID:	Right Cam ID:			Comments:		
Left tape ID:	Right tape ID:	Time in:	Time out:			

13.4.3. The School of Plant Biology, The University of Western Australia SOP

Stereo-BRUV Standard Operating Procedures 1: Deployment and field data management

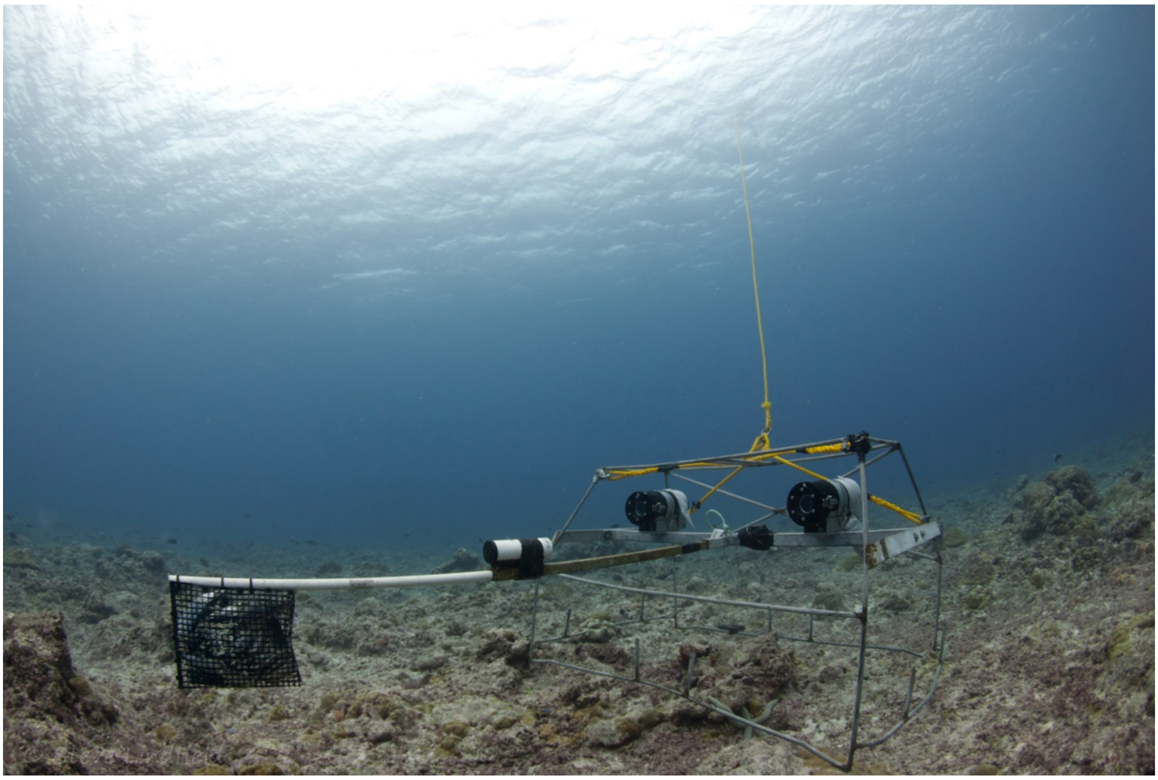


Image courtesy of Steve Lindfield, UWA

The Marine Ecology Group

The UWA Oceans Institute and School of Plant Biology

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

Updated: 03 July 2013

INTRODUCTION

Baited remote underwater stereo-video systems (stereo-BRUVs) are becoming widely adopted as a non-extractive technique for sampling the relative abundance and length of fish assemblages. As a non-extractive technique, stereo-BRUVs have little short-term impact on the ecosystem being studied. They have an advantage of overcoming some of the biases associated with Underwater Visual Census (UVC) techniques. The method eliminates the need for divers, reduces the risk of incorrect fish identifications, reduces observer and inter-observer variability, and produces highly accurate length measurements. The elimination of the need for divers presents a strong safety advantage over traditional methods of measuring fish assemblages. The risk of serious accidents is lowered, and the viable working depths are increased without prohibitive costs. Video techniques can access depths that are off limits to divers and provide a permanent record of the fish observed. The use of bait increases the relative abundance and diversity of fishes observed, particularly species of interest to fisheries, without precluding the sampling of prey or herbivorous fish species. Multiple systems have been constructed and can be deployed in the field consecutively, making efficient use of researcher and boat time. This allows for the possibility of large spatial coverage and high replication within short field campaigns.

BRUV techniques do have limitations and biases. These include the reliance on good visibility (usually greater than 3 metres) and the complexities in determining the true area sampled due to variability in the bait plume. Similarly, the responses of different fish species to the bait and the distances they will travel to get to the bait is unknown. For these reasons, counts of fish from stereo-BRUVs are currently limited to measures of relative abundance rather than density. Another limitation is in determining whether fish that are seen in the field of view at one time on a recording are different individuals to those observed at a different time on the recording. To overcome this, counts of the maximum number (MaxN) of individuals of any one species seen over the entire recording have been used. The use of MaxN avoids recounting fish and ensures independence in the counts. It also results in conservative estimates of the relative abundance and biomass of fish. While stereo-BRUVs are unsuitable for estimating

density, they are a powerful and cost effective method for detecting spatial and temporal changes in the relative abundance and lengths of fish assemblages.
This document outlines the standard operating procedures for the deployment of stereo-BRUVs and the standard procedures for the management of footage and data that is generated in the field.

PRIOR TO LEAVING FOR THE FIELD CAMPAIGN

1. Complete and submit animal ethics approval.
2. Complete and submit field safety plan.
3. Develop and if necessary get approval for sampling plan.
4. Print recording sheets and end of day recording sheets.
5. Order sufficient hard drives and format each one. (**NOTE**: You will need to allow for three copies of every deployment, one raw, one converted and one backup. A single 60-minute video is between 6.5 and 9 GB depending on whether you are using the Sony CX7s or CX12s).
6. Order bait. Allow at least 1 kg per planned stereo-BRUV deployment when ordering. Allow 20 % extra for repeating failed deployments.
7. Ensure cameras are all in working order and have been recently serviced. Cameras are to be serviced at least once every 12 months. Records of service history are available on the MEG server, in the Gear maintenance folder.
8. Ensure that tagging of all electronics is current.
9. Check and charge batteries.
10. Check field computers (functional, licences current, logins).
11. Inspect housings for damage and check and replace o-rings if needed. Oil housings.
12. Check diode batteries and timing of diodes. Ensure that you have silicon oil to put in diodes.
13. Check spare parts kit, make sure tools are oiled and in working order.
14. Ensure sufficient memory cards are packed. Plan ahead for the number of deployments that can be downloaded every day, allow spare memory cards.
15. Make up spare bait baskets.
16. Check bridles, ropes and floats for damage.
17. Make up spare ropes and floats.
18. Assemble base bars and check that cameras are securely attached, tighten bolts. Check condition of hose clamps and replace if necessary.
19. Calibrate each stereo-BRUV system before shipping.
20. Ensure that housings are shipped with the end caps in place. This will prevent damage to the housing sealing surfaces and face plates.
21. Use the stereo-BRUV shipping checklist to ensure that everything is packed before shipping.
22. If anything needs to be purchased, order in plenty of time for delivery before the field campaign begins.

ON ARRIVAL

1. Unpack gear, set up electronics and analysis area.
2. Check for damage and repair / replace any damaged items. (**Note** that this will take a few hours, allow for this time).
3. Assemble bait arms, reinforce with spare pipe and align holes for shark clips. This will save time and bait arms. For deep water reinforce bait arms with fibreglass rod.
4. Regular stereo-BRUVs / large vessels: Assemble stereo-BRUV frames, attach base bars prepare ropes.
5. Defrost enough bait for first sampling site. (A solid box of bait will take at least two hours to defrost enough to be usable).
6. Discuss daily plan with all involved. Consider sampling plan, make your daily scheduled call to the relevant authority to inform them of your sampling plan for the day, modify daily sampling plan to fit in with shipping movements, on water conditions, tide and water clarity.

Prior to reaching site for deployment

1. Fill bait baskets with crushed pilchards to help disperse bait. A full bait basket will hold approximately 800 grams of bait.
2. Have recording sheets ready.
3. Check camera settings and zoom prior to deployment (see next section).
4. Light weight stereo-BRUVs: Attach the base bar to the support legs ensuring wing nights are secure and will not come undone during deployment. Base bar height of 35 cm height is standard and comparable to medium sized (coral) stereo-BRUVs.
5. Light weight stereo-BRUVs: If necessary, adjust height of the base bar to suit the habitat. Ensure that the screws holding the base bar in place are secure and tight.

HD VIDEO CAMERA SETTINGS

Turn cameras on **format the memory cards** and **make sure settings are correct**

Sony HDR CX12 Settings:

1. Focus:

   To Set: Press menu icon at bottom left of screen. Press the second camera tab at the bottom of the screen, Select focus, set to manual and zoom to infinite by pressing and holding the right arrow.

   Settings: Manual focus with the infinity and mountain symbols (See figure below).
2. Movie Settings:

   To Set: Press Home (house symbol), then press the toolbox/suitcase symbol, then press movie settings, scroll up and down using arrows to select settings as below.

Settings: Set record mode to HD and FH quality. Make sure night mode and steady shot are off. Ensure that the conversion lens, wide conversion setting is on. (See Figure 1 below).

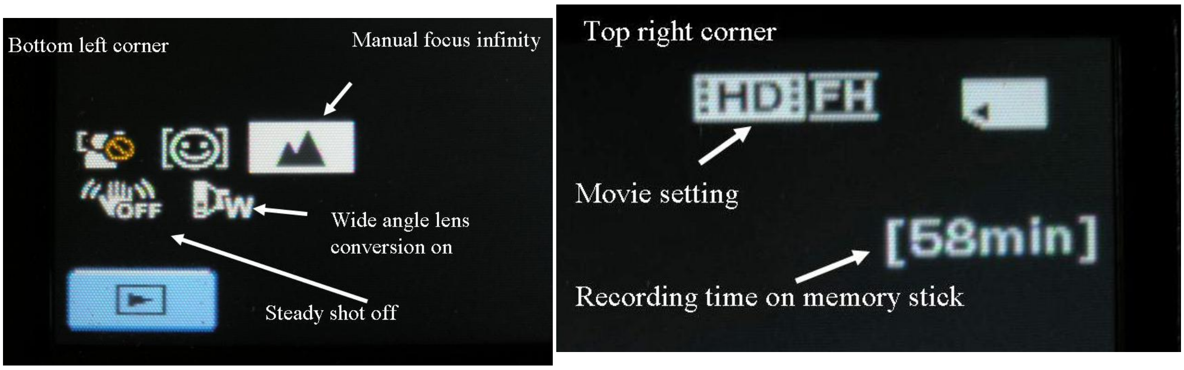


Figure 1 HDR CX12 Camera settings

Sony HDR CX7 Settings:

1. Focus:

   To Set: Press menu icon at bottom left of screen. On the first camera tab at the bottom of the screen, Select focus, set to manual and zoom to infinite by pressing and holding the right arrow.

   Settings: Manual focus with the infinity and mountain symbols

2. Movie Settings:

   To Set: Press Home (house symbol), then press the toolbox/suitcase symbol, then press movie settings, scroll up and down using arrows to select settings as below.

   Settings: Set record mode to HD and XP quality. Make sure night mode and steady shot are off. **Note**; There is **no** wide conversion lens setting on CX7

General:

1. Make sure you are zoomed right out and take care not to bump this when loading the cameras (Use Blu-tac to keep zoom from moving).
2. Make sure the lens and housing o-rings are clean and ready to go.

DEPLOYMENT PROCEDURE

1. Note the housing and memory card numbers on recording sheets for each deployment.
2. Film the recording sheet with both cameras such that all details for the deployment will be clearly visible.
3. Make sure o-rings are clean (no sediment).
4. Move the stereo-BRUV frame to a secure position on the deck where video cameras can be added. Make sure the inside of the housings are dry.
5. Affix diode and bait arm.
6. Make sure the rope is secure and tidy ready to deploy.
7. Add video cameras to their housings ensuring they remain recording and zoomed out (careful not to bump any buttons). Make sure that the seals are flush and the clasps shut securely.
8. Two people lift and place the stereo-BRUV onto the edge of the boat and hold it steady until the skipper has the vessel in position for deployment. **Note;** the lightweight frame and housings are approximately 16 kg, regular frames are considerably heavier. When using additional weights use a davit or crane to deploy stereo-BRUVs.
9. Check that the benthos matches the target habitat. If possible check benthos with a bathyscope, otherwise check on echo sounder and discuss with skipper.
10. Once the skipper has manoeuvred the boat to the GPS locations and is ready for deployment, the skipper indicates to the crew to drop the frame.
11. Two crew members lower the stereo-BRUV over the side of the vessel. **Important:** During deployment the skipper must keep the vessel directly above the site until the cameras reach the bottom and the crew gives the all clear to depart, i.e. all ropes clear of the boat. If the boat moves off the site before the cameras reach the bottom they will likely be pulled over.
12. **Important:** In shallow water environments a crew member needs to ensure the stereo-BRUV frame lands upright by halting its decent just before it reaches the bottom to right the frame. This is also important in coral environments to minimize damage to the coral. In deepwater environments weights should be added and will ensure the frames land in a stable position.
13. On recording sheets note the exact time of deployment and depth off the echo sounder.
14. Log the GPS coordinates of the deployment on the recording sheet and also mark a waypoint.

RETRIEVAL PROCEDURE

1. After no less than 65 minutes, the first stereo-BRUV that was deployed may be retrieved.
2. The skipper should motor up to the floats and drive alongside the ropes towards the cameras, enabling a crew member to grapple the rope near to the floats and quickly pull in the slack by hand.
3. Once the skipper has the boat positioned above the camera frame the rope should be added to the pot hauler/winch.

4. **Important:** The pot hauler should not be used until the boat is positioned above the frame. If they are pulled sideways the bait basket, diode and fragile habitats can be damaged.
5. A person trained in the use of the pot hauler should winch in the stereo-BRUV. If needed, another crew member should watch it's progress towards the surface and communicate with the winch person.
6. A second crew member should tail and coil the rope to reduce the risk of entanglement.
7. Once the stereo-BRUV is in view or within 3 m of the surface, slow ascent to a crawl and make sure that the diode and bait arm are not jammed under the boat. **Note:** This often happens and either the skipper can manoeuvre the boat such that the frame swings around or the observing crew member should use a boat hook to pull the diode arm out from under the boat.
8. Once free from obstruction, the stereo-BRUV should be hauled up onto vessel. Two crew members should then pull the system onto the deck.
9. Towels dry the seals around the housings and carefully remove the cameras. **Note:** Use outside clip pliers to open difficult housings. Do not lever with a screwdriver.
10. Either set up the stereo-BRUV for re-deployment or disassemble and store the frame in a secure position on the deck.

After each retrieval

1. Check the video footage. Make sure the cameras were recording with the correct settings, the frame landed correctly on the bottom and the view is not obscured by benthos. Redo if necessary in a location at least 250 m away or in the same location on a subsequent day (to minimise fish association with bait).
2. Remove memory cards and store in a waterproof container.

AT THE END OF EACH FIELD DAY; DATA MANAGEMENT

1. **Important:** Before you use a hard drive label it with the Project name, Date, Contents and hard drive number. For example; 'Rottnest stereo-BRUV May 2011 Raw 1' or 'Jurien stereo-BRUV August 2011 Converted 2'
2. **Important**: At the end of each day (or during the day if you have time) – download footage off each of the memory cards onto hard drives. There will be numerous .MTS files for each deployment so ensure that the folder structure they are in is labelled with the unique <u>OpCode and camera numbers</u>.
3. Name the folders according to the following convention:

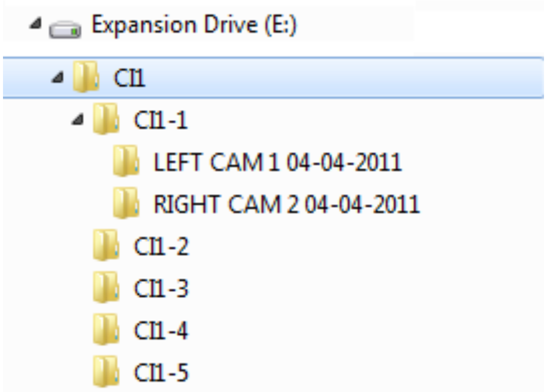
    Folder 'OpCode (for site)'

        Folder 'OpCode-Deployment'

            Folder 'Left Cam # dd-mm-yyyy'

            Folder 'Right cam # dd-mm-yyyy'

For example:



4. **Important**: Once all video files are loaded onto hard drives, make a back-up copy of each onto another hard drive. Name the hard drive appropriately. For example; 'Rottnest May 2011 Raw Back-up 1' or 'Jurien stereo-BRUV August 2011 Converted Back-up 2'
5. **Important**: Transcribe all field data sheets into the excel lab sheet.
6. If time allows concatenate video files and set to convert.
7. Once downloaded clear memory cards.
8. Charge camera batteries.
9. Complete end of day recording form.

RECOVERY OF A LOST STEREO-BRUV

In the event that a stereo-BRUV system is lost (rope cut or the current drags the camera system) the following procedure should be followed:

1. In shallow water attempt to grapple camera frame.

If the resources are available and health and safety restrictions for the campaign allow proceed to the following steps:

2. In deeper water locate lost stereo-BRUV using drop camera system if available.
3. Lower the drop camera on the grapple rope to locate frame.
4. Winch as usual.
5. If the stereo-BRUV system is not retrieved within 30 minutes – mark its exact location with GPS and/or anchored rope with buoys and mobilize dive team if in shallow enough water.

FIELD RECORDING SHEETS

Date	OpCode	Memory Card #'s Left	Right	Cameras Left	Right	Time In	Time out	Eastings / Lat	Northings / Long	Depth (M)	CX7 / CX12 NTSC / PAL	Wind / Sea / Swell / Cloud / Tide / Notes	HDD #

UWA end of day field report

Project: Date:

Tasks planned for day

Sites visited

Sites completed

Weather Conditions

Wind	Sea	Cloud	Visibility	Depth

Difficulties encountered / overcome

Issues to be discussed

Advice received

Plan for next day

STEREO-BRUV SHIPPING CHECKLIST

Stereo-BRUV Hardware:

☐ Stereo-BRUV frames, include 1 spare (in good order, check bridles and stainless wire in break-away legs, replace if necessary)
☐ Base bars with housings securely attached (check condition of hose clamps, replace if necessary)
☐ Bolts for attaching base bars (4 for each system), Lightweight stereo-BRUVs check wing-nuts are in place and pack spares
☐ Diode arms for each system
☐ Diodes
☐ Shark clips for each system
☐ Bait arms (include spares)
☐ Bait bags and gloves for handling bait
☐ Ropes (ensure correct length for planned depth)
☐ Buoys (deep water at least two sets for each system)
☐ Weights and wire to attach weights (Deep water stereo-BRUVs only)
☐ Bin and lid for bait

Tools:

☐ ¾” spanners x 2
☐ Outside clip pliers for opening housings x 2
☐ Pliers
☐ Large shifting spanner
☐ Medium shifting spanner
☐ Knife
☐ Allen key for camera mounts
☐ Phillips and flat head screwdrivers
☐ Grapple
☐ Silicon Grease
☐ Spare ‘O’ rings
☐ Lanox
☐ Spare hose clamps
☐ Spare bolts and wing nuts
☐ Duct tape
☐ Cable ties

Protective clothing:

☐ Rope handling gloves
☐ Long PVC chemical gloves for bait handling
☐ Appropriate footwear
☐ Weather protective clothing
☐ Any other job specific Personal Protective Equipment

Electronics:

☐ Hard drives

- ☐ Memory cards
- ☐ Batteries
- ☐ Battery chargers
- ☐ Power boards
- ☐ Laptops
- ☐ Spare video cameras two each of CX12, CX7, NTSC and PAL as needed
- ☐ Card readers

Paperwork

- ☐ Field recording sheets
- ☐ End of day field reports
- ☐ Safety Plan
- ☐ Animal ethics approval