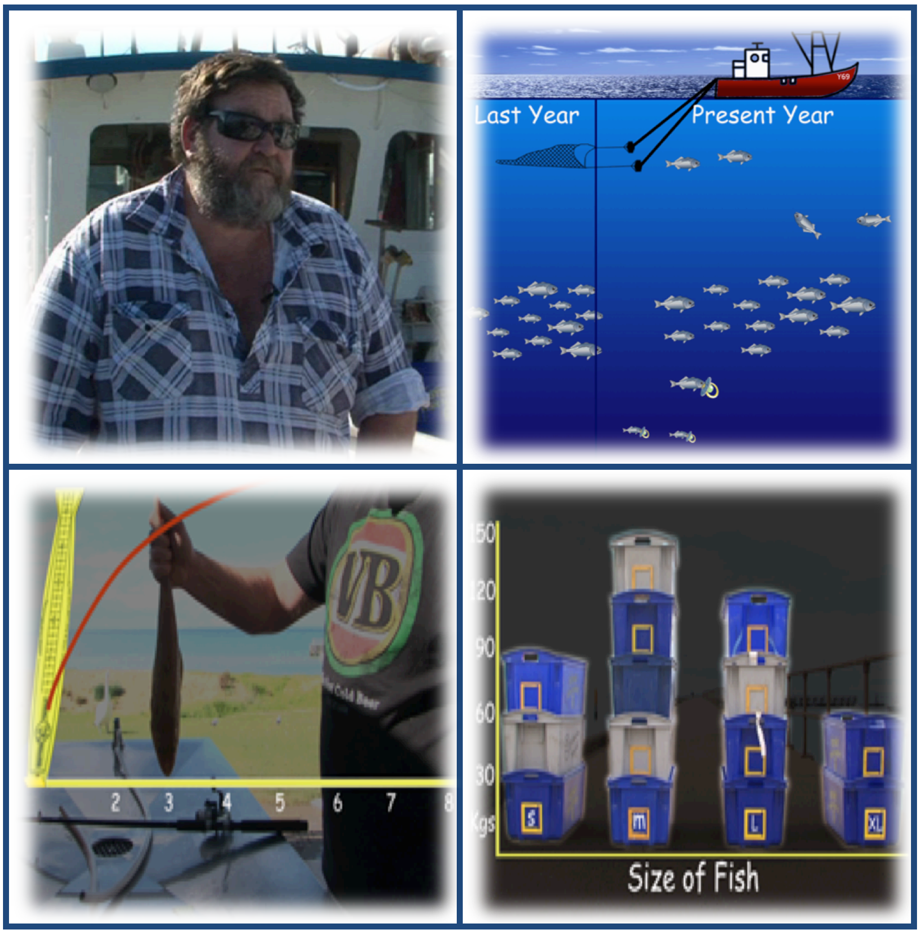
Empowering Industry through Improved Understanding of Stock Assessments and Harvest Strategies



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FRDC Project 2010/306

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Executive Summary

Participation of commercial fishing industry and recreational members in the stock assessment process is vital and there is a need for good support and succession planning for their involvement in Management Advisory Committees (MACs) and Resource Assessment Groups (RAGs). Often, the scientific discussions that take place at MAC and RAG meetings are highly technical in nature and may be difficult to understand by those not experienced in the process. This lack of understanding may deter people from participating in such forums and can lead to a level of frustration, confusion and inefficiencies in meetings. It also may lead to a more widespread lack of support for research and assessment results and their use in harvest strategies.

A series of PowerPoint™ presentations and short videos were produced that used case studies from various Australian fisheries with simple language and graphics to explain fundamental concepts used in fisheries biology, population dynamics, stock assessment and harvest strategies. The videos are available on You Tube or as DVDs that have been distributed to key commercial and recreational associations and other interested stakeholders. The immediate outcome from this project is that commercial and recreational fishers and other stakeholders have an increased knowledge of stock assessments and harvest strategies. The desired long-term outcome of this will be a better understanding of the underlying science and improved participation by commercial, recreational and other stakeholders in the stock assessment process.

The choice of method for information delivery was a key component of this project. Based on a review of education programs from around the world and our experience in communication with fishers, we considered that an appropriate method for information delivery to the target audience was a video available on DVD and over the internet. This media has many benefits over other information delivery formats (e.g. workshops, printed media) by being easily and widely accessible, having the ability to hold the interest of the target audience (if produced well), being enduring and enabling cost effective distribution.

In collaboration with BioMedia – a professional video production company – a concept was developed for an educational video that would hold the interest of the intended audience of commercial and recreational fishers. A narrated video format was chosen that used footage on fishing operations, and included interviews with "case study" fishermen. Segments of fishermen talking about stock assessment and how it relates to their fisheries assists getting technical the subject matter across to other members of the fishing industry. Further, interspersed between these segments and across the narration, footage of fishing vessels and deck operations is of visual interest to fishers. Development of the script was an iterative process to ensure the appropriate technical information was presented, while maintaining a style and language that was suitable for the target audience. Several reviews of the script were necessary to ensure technical accuracy without overcomplicating the language.

The content of the video was decided in consultation with co-investigators, and comprised 11 different chapters each with a specific topic: introduction; fish stocks; recruitment; age and growth; mortality; selectivity; catch rates; data collection; stock assessment models; model fitting; and harvest strategies.

During post production, various chapters of the DVD were shown during a number of different forums to fishing industry members of the East Coast Tuna and Billfish Fishery

(ETBF), Northern Prawn Fishery (NPF), Great Australian Bight Industry Association (GABIA), Melbourne Seafood Centre and SESSRAG and as hyperlinks through the South East Trawl Fishing Industry Association (SETFIA) web-based newsletters. Comments received were used to refine the final DVD. Through this process, hundreds of people viewed the chapters and requests to obtain copies of the entire series were received from schools, universities, government departments and individuals. This broader interest from groups outside the intended target audience required some slight modifications to the script and footage to make the DVD appropriate for a more general viewing audience and distribution.

Review of the efficacy of the use of DVD to educate fishers on stock assessments was largely qualitative, based on verbal feedback, however, quantitative feedback was obtained from NPF Industry Association members and from two different groups of ETBF workshop participants at the "Improved Environmental Work Practices" (held at various ports during late 2012) where the DVD was shown. Feedback was excellent, providing support that the DVD would be an effective method for this type of information delivery. 94% of respondents reported that the technical level of information provided in the episodes was "about right", and most of the respondents indicated that the videos rated > 8/10 as a means of improving the understanding of the science behind stock assessments and harvest strategies, and that it did increase their knowledge of stock assessments and harvest strategies.

The final DVD, comprising the 11 chapters is of 1 hour 38 minutes duration, and was used as the Stock Assessment unit during the Eastern Tuna and Billfish Fishery (ETBF) workshop titled "Improved Environmental Work Practices". Chapters of the DVD will be shown in future *Improved Environmental Work Practices* workshops. During May 2013, all chapters were uploaded to You Tube (www.youtube.com/FishwellConsulting) and have already received over 1000 views. The series was made available for the recent RAG induction workshop and the chapter on harvest strategies was presented at the Indian Ocean Tuna Commission workshop on Management and Allocation Workshop held on 17-18 June 2013

Dedicated promotion of the series on the You Tube channel and distribution of DVDs to commercial and recreational industry associations as well as other stakeholder groups is expected to result in improved understanding of fisheries stock assessment and harvest strategies across a broad viewing demographic particularly in Australia but also overseas.

Keywords: Training, education, stock assessments, harvest strategy, video, DVD.

Acknowledgments

We would like to thank the skippers that gave up their time to be involved in this project as "case study fishermen": Tony Lavalle, skipper of the *Shoalhaven*, Wayne Cheers (*Nungurner*), Russell Potter (*Diana*), Russell Frost (*Karlene Maree*) and Darren Dodge (*Game On*), and also vessel owners and crew for allowing us to film on their vessels. Additional footage was supplied by Luke Pitman (Observer Program, Australian Fisheries Management Authority), Paul McCoy (DPI - Fisheries Victoria), Daniel Ierodiaconou (Deakin University), CSIRO Marine and Atmospheric Research and the Fisheries Research and Development Corporation (FRDC).

We appreciate the access given to us for filming at additional locations. These were onboard the fishing vessels *Western Alliance* (Corporate Alliance Enterprises Pty Ltd) and *Petuna Endeavour* (Petuna Sealord Deepwater Fishing Pty Ltd), White Fisheries Pty Ltd (1/35-39 Murradoc Road, Drysdale VIC), Lakes Entrance Fishermen's Co-operative Society Limited (Bullock Island, Lakes Entrance, VIC), Reef and River Aquatics (East Geelong, VIC) and Fish Ageing Services (Portarlington, VIC).

DPI (Fisheries Victoria) kindly granted permission to film during the Port Phillip Bay Trawl Survey.

DVD music was composed and produced by Lachlan Mcleod.

Introduction

In managing Commonwealth fisheries, the Australian Fisheries Management Authority (AFMA) draws on advice from Management Advisory Committees (MACs) and Resource Assessment Groups (RAGs), each of which are comprised of a diverse range of members including scientists, managers, recreational and commercial industry members, conservation members. The main role of RAGs is to provide advice on the status of fish stocks (through stock assessments), species (target and non-target), and on the impact of fishing on the marine environment. MACs consider the advice of RAGs and provide recommendations to the AFMA Commission based on how different management options will contribute to meeting the overall management objectives for a particular fishery.

The diversity of MAC and RAG membership ensures that management decisions are based on information and views from a range of different stakeholders. Fishers are important participants in these groups, contributing knowledge and information into the stock assessment process that augments the data gained from mandatory fishing logbooks. Their years of fishing experience also brings a level of "hands-on" understanding of the fishery that no-one else can provide. Such additional information includes environmental observations, understanding of fish and fleet dynamics and how fishing practices may change in response to management regulation (Hilborn, 1992). Often, the scientific discussions that take place at MAC and RAG meetings are highly technical in nature and may be difficult to understand by fishers not experienced in the process. This lack of understanding may deter fishers from participating in such forums and can lead to a level of frustration, confusion and inefficiencies in RAG meetings. It also may lead to a more widespread lack of support for research and assessment results and their use in harvest strategies.

Participation of commercial fishing industry and recreational members in the stock assessment process is can foster a better understanding of the science behind stock assessments, and create more support for buy-in of subsequent management decisions. Without industry and recreational sector participation, catch and effort data would be used without a full understanding of the factors that influence these data, beyond what is collected in logbooks and by observer programs. Participation however, is more effective if they have a working knowledge of the data collected, and the processes and models used to assess fish stocks. This will lead to more effective, beneficial, informative participation in the stock assessment process, and overall, better stock assessments and management of the fishery. A sound understanding of the stock assessment processes and harvest strategies by commercial and recreational industry members will also improve the level of co-management that can be achieved in a fishery.

Despite improvements in the assessment and harvest strategy process over the last decade, there remains a great deal of industry frustration and misunderstanding about how this translates into management decisions. In discussions with industry members, we understand that much (but not all) of this frustration is a direct result of lack of knowledge about assessment techniques and assumptions, and how these interplay with the harvest strategy. Once fishers have acquired this knowledge, they will become even more valuable contributors to RAGs / MACs and can help improve the assessment and management process, and facilitate the understanding of that process by other industry members.

This project was listed in the ComFRAB November 2009 call for research proposals. At its December 2009 meeting, ComFRAB recognised that this will be a very valuable extension and capacity building project and gave the proposal a high priority endorsement. It was ranked as ComFRAB's third highest priority proposal submitted to FRDC for funding in the 2009 open call round. In developing the proposal for this project, we communicated with industry members from Commonwealth fisheries to obtain their support for the project and to get initial agreement for us to film and conduct interviews on vessels from those fisheries and a recreational fishing charter vessel. This close relationship with industry was considered critical to the success of this project.

Objectives

1. Identify a possible suite of capacity building approaches that would suit commercial and recreational fishers and assist them to actively participate in resource assessment groups through improved understanding of stock assessments and harvest strategies.

2. Determine the most suitable suite of capacity building approaches for commercial and recreational fishers through testing with selected fishers.

3. Use the results of objective 2 to deliver capacity building to a broad group of fishers in 3 case-study Commonwealth fisheries.

4. Review the efficacy of the capacity building undertaken in the 3 case studies.

Methods

Information delivery medium

The choice of method for information delivery was a key component of this project, and was driven by our experience in communicating with fishers, experiences from other primary industry education programs in Australia, and similar programs around the world. Aside from the content, key aspects of the delivery method were that it would: reach the target audience (including cost effectiveness of widespread delivery); hold the interest of the target audience; and, be enduring.

A desk-top study was conducted to identify approaches used around the world for education and capacity building of stakeholders involved in fisheries stock assessments and harvest strategies. A number of projects were identified and summarised, and results were used to guide the approach taken during this project. Based on this study, it was apparent that there was workshop material in the form of PowerPoint presentations and booklets that usually required some level of third party facilitation or presentation. Some good educational books have also been produced on these topics but with few exceptions (eg. Cooper 2006) most are designed for readers with a strong scientific or mathematical background (eg. Hilborn and Walters 1992; Quinn and Deriso 1999; Burst and Skrobe 2000; King 2007; Haddon 2011).

During preliminary discussions with the commercial fishing industry, their only real interest was in video as the delivery medium for this type of information. The repeated response from a range of industry sectors to suggestions of any written media was that skippers and crew were unlikely to read it and it would "just collect dust". Given this was exactly the opposite to the key aspects of delivery we were trying to achieve, and that there was already some literature in this space (eg. Cooper 2006), we focused on video as the primary delivery medium. This direction was further encouraged by the fact that there was nothing available in video format to explain stock assessment and harvest strategy to fishers or the general public. One concession, however, was that we would augment the videos with similar PowerPoint presentations that would be suitable for a workshop with a qualified facilitator or presenter.

As a result of the consistent message from industry about the use of video for this project, our previous experience supported the efficacy of video for educating skippers and crew on board fishing vessels (eg. Stewardson and Knuckey 2006; Knuckey and Ashby 2009), and that nothing was currently available to them in this format, the more formal evaluation of the most suitable suite of capacity building approaches was forgone to allow more resources to focus on the most appropriate development of the video medium. This process is discussed in more detail in the Results and Discussion section.

Video production

Consideration of factors described above resulted in the choice of a video production as the primary information delivery medium. Matthew Woods of Biomedia — a professional video production company with experience in science communication to primary industry stakeholders — was engaged to assist with all aspects of the production.

The general format considered appropriate for the target audience of commercial and recreational fishers was a narrated video that included interviews with "case study" fisherman, and a scientist. Inclusion of fishers, and video of fishing operations, was used to ensure interest and engagement of the target audience. Segments of fishermen taking about stock assessment and how it relates to their fisheries assisted getting technical subject matter across to other members of the fishing industry. Further, interspersed between these segments and across the narration, footage of fishing vessels and deck operations is of visual interest to fishers.

Scripting was an iterative process. A draft script was written by one of the project scientists and the video producer. This was done to ensure that appropriate technical information was included, but that it was presented in a clear and simple manner, suitable for the target audience. During filming and editing, it became necessary to modify the script several times, often requiring more technical input from project scientists. Each draft of the script was reviewed by the other project scientists to ensure technical accuracy without overcomplicating the language.

Drafts of the final video were shown to industry members, scientist, managers and FRDC staff for comment. Where possible, comments are reflected in the final video.

Content

Content to be included in was guided by discussions with MAC and RAG members, reviews of stock assessment text books, other similar programs identified during the desk to study, the Commonwealth Harvest Strategy and our own knowledge of the Commonwealth stock assessment process. It was considered important to capture the various aspects of fish biology and population dynamics and how they form an integral part of stock assessment.

Results and Discussion

Information delivery

A desktop study revealed several programs that have been undertaken to improve knowledge of stock assessments to industry members and/or fisheries managers. They comprised two different media, workshops and printed material. Each program is briefly described below.

Western and Central Pacific Fisheries Commission

The Western and Central Pacific Fisheries Commission (WCPFC) run 10–16 day workshops targeted at improving Pacific Islander Fisheries Officer's understanding of stock assessments (eg. SPC 2011). The aims of that program are to increase the capacity of participants to:

1. Understand what the various components of a stock assessment model are, how these are derived, and why each is important to the assessment;
2. Understand the key outcomes/recommendations and how they relate back to the model outputs and data;
3. Identify and question weaknesses in an assessment and understand statements regarding uncertainty; and,
4. Form conclusions regarding the implications of the assessment's outcome for tuna fishery management at national and regional levels, including the risk associated with different management options.

This program is aimed at trained Fisheries Officers, which are likely to have a greater understanding of stock assessments than the target audience of the current project, and is clearly endeavouring to instil a much greater level of understanding of stock assessments.

International Council for the Exploration of the Sea

The International Council for the Exploration of the Sea (ICES) run a program titled *Opening the box: Stock assessment and fisheries advice for stakeholders, NGOs and policy-makers* (ICES 2012). As the title suggests, this program was aimed at policy-makers, NGOs and stakeholders, the latter of which include fishermen's association representatives. Like the WCPFC program, participants of the ICES program usually have some background in biological sciences. The general objective of that project is to train participants in basic population dynamics and stock assessment.

The course is held over three days, and covers a similar range of subjects as those identified for the current project including basics of stock assessment, data on fish and fisheries, management of fisheries, basics of stock assessments, reference points and stock recruitment relationships and dealing with uncertainty.

Oregon State University

During 2006, the Oregon State University initiated a project titled *Improving Participation in Fisheries Management: Stock Assessment Training for Stakeholders* during 2006 (Sylvia et al. 2009). This program was aimed at fisheries stakeholders and managers requiring knowledge on basic principles of stock assessment. The program was structured around two case study fisheries, the West Coast stocks of Canary Rockfish and Pacific Sardines. Delivery was intended to be a 1.5 day training workshop based on 'decision–focused teaching'. Decision–focused teaching programs are supposedly more active and engaging because the students or trainees studying the case are compelled to face alternatives through integrative analysis and strategic problem-solving about a real management problem. The expected outcome of this program is to make a significant contribution to development of stock assessment training strategies and products identified as essential to fisheries' management-capacity building initiatives in the Pacific Northwest (PNW), as well as other U.S. regions and other fishing nations. Due mainly to staffing issues, this project has yet to be completed.

University of New Hampshire

A Guide to Fisheries Stock Assessment from Data to Recommendations is a 45 page book that covers data collection, population dynamics, biological reference points and stock assessments (Cooper 2006). It is aimed at stakeholders with "some working knowledge of the fisheries management process, but no modeling or statistics background is necessary". Each of the subjects is covered in some detail and includes graphs and tables.

SETFIA Accreditation of skippers for improved environmental operation

This FRDC funded training course was presented to skippers and senior crew operating in the in the Commonwealth Trawl Sector of the SESSF, and includes a subject titled "Stock Assessments" (Boag et al. 2011). During this 2 hour Power Point presentation, a very basic description of stock assessment modelling and the Commonwealth Harvest Strategy is given. Being so short, the level of detail and the use of key terms are kept to a minimum, to avoid confusing participants. The level of knowledge conveyed was probably not enough that it would result in a large increase in the level of participation in stock assessment processes, but participants would have improve understanding of the aims of the harvest strategy, the importance of maintaining accurate logbook records, and the importance of industry participation in stock assessments.

Appropriate content for the target audience

Apart from the SETFIA accredited course, each of the programs described above appears to assume some level of previous knowledge of population dynamics, stock assessment or fisheries management. They also convey a higher level of scientific detail than this project aims to convey. The level of information to be conveyed during this project should fall somewhere between the SETFIA accredited course and the *Guide to Fisheries Stock Assessment From Data to Recommendations*, and getting this right balance was one of the main challenges. It was clear from presentation of the SETFIA course that we cannot assume any level of knowledge of key terminology or principles used in stock assessments, or even that the audience will understand how to interpret a graph. This understanding was critical in correctly designing the level of information and how it was portrayed to the target audience.

Choice of information delivery method

Workshops appear to be the most commonly used format for delivery of this sort of information. Workshops have the advantage of the participants being able to interact with the presenters by asking questions, and also for the pace of information delivery to be adjusted based on the level of understanding. The main problems with this approach are the amount of time taken to deliver the information, the expense in doing so, and the small number of participants that can be involved in each workshop if it is delivered locally – at a port for example. If a larger workshop is held more centrally, it often requires fishers to travel for at least a day to attend and then return from what would be a 1-2 day workshop. This length of time away from their fishing operations is often not feasible for commercial fishers. We believed that in a program designed for wide-spread application, a workshop did not appear to be an appropriate method. Nevertheless, we agreed that PowerPoint™ versions of the program should be developed for use by a presenter in a workshop format.

The book produced by the University of Hampshire clearly aims for a much higher level of scientific detail than will be achieved during this project. The advantages of this format of information delivery are that it can be read at a time that is convenient to the reader, and can be re-read to reinforce understanding. The disadvantages are that some of the target audience may not like to read, especially a potentially 'dry' subject such as stock assessments. Further, this method of delivery relies on the audience having a level of reading ability that enables comprehension of technical writing and graphs. This is not always the case and based on the experience of staff on this project, reading is not a particularly popular pastime for a significant proportion of crews on commercial fishing vessels.

For this subject matter, it appeared that video media provided an innovative and appropriate method of information delivery to the target audience. As far as we could determine, this media type had not been used for delivery of this type of information to such an audience. Videos can be delivered via DVD or online through websites such as YouTube, Vimeo and Facebook. This means that the information is available to a very wide audience, at very little cost, and can be viewed at the audience's leisure. From experience, we also know that one of the most popular pastimes of commercial industry members on vessels is watching DVDs, and that many younger fishers regularly uses social websites such as Facebook. If the information is conveyed at an appropriate level, and the video is made somewhat entertaining, this approach could be very effective. This was the approach taken for this project.

Script

The DVD is of 1 hour 38 minutes duration but is divided into 11 chapters, each with a specific topic: introduction; fish stocks; recruitment; age and growth; mortality; selectivity; catch rates; data collection; stock assessment models; model fitting; and harvest strategies. Although there is some obvious overlap between the topics, the chapters were used to ensure that each topic could be viewed independently in a relatively short space of time.

As mentioned previously, development of the DVD script was an iterative process and during post production, various chapters were shown during a number of different forums to fishing industry members of the East Coast Tuna and Billfish Fishery (ETBF), Northern Prawn Fishery (NPF), Great Australian Bight Industry Association (GABIA), Melbourne Seafood Centre and SESSRAG and as hyperlinks through the South East Trawl Fishing Industry Association (SETFIA) web-based newsletters. Through this process, hundreds of people viewed the chapters and we received numerous suggestions for improvement. We also realised that there was significant interest in obtaining the DVD and using it to educate a much broader group (government agencies, universities schools, and various non-government organisations) than the initial target audience of commercial and recreational fishers. This development required further modifications to the script and footage to make the DVD appropriate for a more general viewing audience and distribution.

The final script for each chapter is provided in Appendix 3.

Evaluation

Evaluation was undertaken of the draft final version of the DVD to three different groups of commercial fishers, participants of two different Eastern Tuna and Billfish Fishery (ETBF) workshops and NPF Industry Association members. Quantitative feedback was obtained from participants who were asked a series of questions after viewing the DVD:

1. Did the stock assessment DVD improve your understanding of the science behind stock assessments?

1a. Do you think the stock assessment DVD would improve your crew's understanding of the science behind stock assessments? (NPF workshop only)

2. Do you think that a DVD is a good way to get this information across?

3. How would you rate the technical level of the information contained in the DVD?

4. Do you have any suggestions on how we can improve the content or information delivery?

5. What were the main topics you learnt from the DVD?

Results of this questionnaire are shown in Table 1, Table 2 and Table 3. All respondents agreed or completely agreed that the DVD improved their understanding of the science behind stock assessments, and that DVD was an appropriate format to get the information across. Most respondents thought that the technical level of information was "just right", however there was 1 response of "too simple" and one of "too technical". This is to be expected because participants had different levels of education and exposure to stock assessments and RAGs. Qualitative responses were also positive, and it was suggested that it could be tailored for specific fisheries. This could be particularly appropriate for the chapter on harvest strategies.

Table 1. Results of feedback from 11 participants at the October 2012 ETBF workshop.

Question	**Do not agree**				**Agree**				**Completely agree**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1					2	1	1	3	1	3
2							2	5	1	3
	Too simple		**Just right**		**Too technical**					
3	0		9		0					
4	11 returns with no comments									
5	Importance of good data					11 returns with no comments				

Table 2. Results of feedback from 12 participants at the December 2012 ETBF workshop.

Question	**Do not agree**				**Agree**				**Completely agree**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1							1	5		6
2								4	1	7
	Too simple		**Just right**		**Too technical**					
3	0		11		1					
4	3 returns "adequate or just fine" 9 returns with no comments									
5	5 returns "Stock Assessments"					7 returns with no comments				

Table 3. Results of feedback from 13 participants at the December 2012 NPF RAG meeting.

Question	**Do not agree**				**Agree**				**Completely agree**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1					1		1	6	3	1
1a							4	6	2	1
2								4	5	4
	Too simple		**Just right**		**Too technical**					
3	1		12							
4	"great concept", "just fine", "would be great to tailor to fishery", "keep it simple", most deckies and fishermen could understand this format", "very good presentation", "great educational tool", "concise", "keep it short"									
5	"about fish distribution", "how fish are aged"									

Conclusions

- Various methods of information delivery were assessed, and video was considered the most appropriate format because it was preferred by the target audience, can be distributed to a wide audience for low cost, does not require a high level of reading ability, is a medium that is frequently used by the commercial and recreational fishers on board boats and at their home / office.
- The content of the video was decided in consultation with co-investigators, and comprised 11 short chapters, each with a specific topic: introduction; fish stocks; recruitment; age and growth; mortality; selectivity; catch rates; data collection; stock assessment models; model fitting; and harvest strategies.
- The script was written to convey technical material in a style and language to suit the target audience, and used interviews with "case study" fishermen to help convey the subject material.
- The video is 1 hour 38 minutes duration, and is distributed as a DVD commercial and recreational fishers and is also available on You Tube (www.youtube.com/FishwellConsulting).
- Various chapters of the DVD have been used in a number of industry and government training workshops on stock assessment and harvest strategies. .
- Evaluation of the DVD reveals this media is an effective method for delivering this type of information and that the technical level of information provided was appropriate for the intended target audience.

Further Development

Publicity around this project has generated significant interest, including from Universities, schools and fisheries management agencies and other government departments.

Dedicated promotion of the series on the You Tube channel and distribution of DVDs to commercial and recreational industry associations as well as other stakeholder groups is being planned and is expected to result in a far greater dissemination to a broader viewing demographic than was originally intended – particularly in Australia but also overseas.

Extension and Adoption

The DVD has been used during two ETBF workshops titled "*Improved Environmental Work Practices*" held in Marcoola and Ulladulla during October and December 2012 respectively. It replaced the power point presentation that had been presented in "*Improved Environmental Work Practices*" workshops that had been held for the Commonwealth Trawl and Gillnet, Hook and Trap sectors. Chapters of the DVD will be shown in future *Improved Environmental Work Practices* workshops. During May 2013, all chapters were uploaded to You Tube (www.youtube.com/FishwellConsulting) and have already received over 1000 views. The series was made available for AFMA's recent RAG induction workshop and the chapter on harvest strategies was presented at the Indian Ocean Tuna Commission workshop on Management and Allocation Workshop held on 17-18 June 2013.

Project Coverage

The planned outcome was that commercial and recreational fishers will have better understanding and more effective input into the stock assessment process. In turn, it is expected that this will promote and encourage industry members to be involved in the RAG and MAC process, leading to improved stock assessments and harvest strategies. It is too early to evaluate this outcome, but access to the You Tube videos for all participants at the recent AFMA RAG workshop has begun this process. The key outcome form this project to date is an increase in the knowledge that a small subset of commercial and recreational fishers has of stock assessments and harvest strategies. As the DVDs get distributed to a wider group of stakeholders, and viewing of the You Tube channel continues to increase with publicity, the effectiveness of the project in improving stakeholder knowledge of stock assessment and harvest strategies will be able to be better gauged. In time, this increased knowledge will be widespread throughout the commercial and recreational and hopefully this will influence future MAC and RAG succession planning.

References

Boag, S., Koopman, M., Stott, R., Knuckey, I. and Owen, R. (2011). SETFIA accreditation of Commonwealth Trawl Sector skippers toward improved environmental operation. FRDC Project 2009/330.South East Trawl Fishing Industry Association.

Burst, J. and Skrobe, L. (2000). Fisheries Stock Assessment User's Manual, Special Report No. 69 by the Atlantic States Marine Fisheries Commission, 2000.

Cooper, A. B. (2006). A Guide to Fisheries Stock Assessment from Data to Recommendations. Edited and designed by Kirsten Weir, NH Sea Grant College Program Kingman Farm, University of New Hampshire Durham, NH 03824. NOAA grant #NA16RG1035.

Haddon, M. (2011). Modelling and Quantitative Methods in Fisheries, Second Edition. CRCPress, Taylor and Francis Group, Florida.

Hilborn, R. (1992). Current and future trends in fisheries stock assessment and management. South African Journal of Marine Science. Volume 12: 975-988.

Hilborn, R. and Walters C. (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York.

ICES (2012). Report of the Training Course: Opening the box: Stock assessment and fisheries advice for stakeholders, NGOs and policy-makers (TCSAFAS), 9-11 October 2012, ICES Headquarters, Copenhagen. 19 pp.

King, M. (2007). Fisheries Biology, Assessment and Management, Second Edition. Blackwell Science, Victoria.

Knuckey, I.A. and C.J.T. Ashby. (2009). Effects of Trawling Subprogram: Maximising yields and reducing discards in the South East Trawl Fishery through gear development and evaluation.. FRDC Project 1998/204. Fisheries Victoria – Fisheries Research Branch 279pp.

NHT project 44144. Sylvia G. (2009). Improving Participation in Fisheries Management: Stock Assessment Training for Stakeholders (2006-2008).

Quinn, T. and Deriso, R. (1999). Quantitative Fish Dynamics. Oxford University Press, 1999.

SPC (2011). http://www.spc.int/oceanfish/en/publications/cat_view/116-ofp-publications-a-documents/124-meetings-and-workshops/133-tuna-stock-assessment-workshops.

Stewardson, C. L. and Knuckey, I.A. (2006). South East Trawl Fishery: Seal Bycatch–Guidelines for Reporting and Data Collection. Bureau of Rural Sciences, Canberra.DVD/Video production, Andrew Marriott, Images Online Pty. Ltd., Canberra.

Appendix 1 - Intellectual Property

The Copyright on the final DVD is held by FRDC, Fishwell Consulting and Biomedia. The copyright on the raw footage (or rushes) remains with Biomedia, where the footage will be archived. If FRDC or Fishwell needs access to raw footage obtained during this project Biomedia has agreed to provide it at only the cost for time to assemble the footage, compress and deliver. There will be no charge for a stock footage fee.

Appendix 2 - Staff

Name	Organisation	Project Involvement
Ian Knuckey	Fishwell Consulting	Principle Investigator
Matt Koopman	Fishwell Consulting	Scientist
Matt Woods	Biomedia	Video Production
Sandy Morison	Morison Aquatic Sciences	Co-Investigator
Malcolm Haddon	CSIRO	Co-Investigator
Neil Klaer	CSIRO	Co-Investigator

Appendix 3 – DVD script

TITLE: Introduction
DESCRIPTION: Overview of DVD, meet the case study fisherman and general introduction to modelling.

VOICE OVER	VISION/QUESTIONS
Fisherman talking about the importance of a sound industry and making a good living. For a fisherman to be successful and have an ongoing business, he must fish in a sustainable fishery. The best way to be sure of this is to have a good understanding of the status of the fish stocks - this is gained through stock assessments. Stock assessments and a sustainable fishery. Passing business onto the next generation.	Q: What do you need to have a successful fishing business? Q: Is having a sustainable (both economic and environmental) fishing industry important to you? Q: Would you like to be able to pass your business onto your kids and why?
Australian fisheries are amongst the best managed in the world. This is because their sustainability is underpinned by sound stock assessments and harvest strategies. The quality of stock assessments and management are continuously improving to ensure a sustainable and viable industry for the future. This process isn't just about scientists and mangers; it relies heavily on contribution from fisherman. Without your input they can't develop accurate stock assessments. The aim of this DVD is to help you understand how stock assessments and harvest strategies work. We also want to demonstrate just how important a fishermen's knowledge, information and participation is in the stock assessment and harvest strategy process.	General footage of fishing industry and scientists working on boats. Measuring fish, taking ear bones out.
Ian Knuckey is a fisheries scientist who's been working in stock assessment for over 20 years. With world wide experience, Ian explains where Australia sits in terms of fisheries management.	Footage of XXXX working on a boat.
Scientist: Australians should feel pretty proud of how our fisheries are managed. It's fair to say that Australian fisheries are some of the best managed in the world and this benefits all Australians now and into the future. A big part of the success in this area is the support and information we get from commercial fisherman. *But things haven't always been so good. A few years ago, some Australian fisheries had too many fishers for them to be either sustainable or profitable, and faced year after year of dropping TACs. Big decisions had to be made to turn things around before it got too bad.* *There are examples from around the world where the hard decisions were not made and as a result, thousands of fishermen have lost their jobs and coastal fishing communities have collapsed. A good example is the collapse of Canadian Cod fishing industry. In the early 1990s, over 35,000 fishers lost their jobs and the fishery still hasn't recovered.*	Q: Are Australia's fisheries well managed and how do we compare to the rest of the world? Do you get a lot of support from commercial fisherman? What happened in the Canadian Cod fishery?
We'll use practical information from five different case study fishermen and – as with all fishermen - their businesses rely on well managed fisheries.	General shots of case study fisherman. 4 way split screen.
So lets meet our fisherman. Tony is a trawl fisherman in the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark Fishery. Tony fishes out of Bermagui and Ulludulla. Like most of our case study fisherman, Tony's been involved in stock assessment meetings for years.	Google Earth and general shots of XXXX at work.
Interview with Tony…..	• *How long in the industry and how did you get into it?* • *Description of boat.* • *What do you catch?* • *What sort of gear do you use?* • *What market do you sell into?* • *What are the challenges for you in the industry at the moment?* • *How have the catches been over the past few years?* • *How important is commercial fishing to your town?*
Moving south is Wayne who fishes out of Lakes Entrance. Wayne's also in the Commonwealth Trawl Sector, but uses Danish seine gear to target Tiger	Google Earth sequence and general shots of Tony at work.

Flathead and School Whiting.	
Interview with Wayne	• *As above*
Down on the south coast is Frosty at Apollo Bay. He operates in the gill net, hook and trap sector of the Southern and Eastern scale fish and shark fishery, and also Victoria's rock lobster fishery. Frosty's main catch is gummy shark and southern rock lobster.	Google Earth sequence and general shot of XXXX at work.
Interview with Russell…..	• *As above*
Next we have Russell. He runs an auto-longline vessel in the Gillnet, Hook and Trap sector, and fishes throughout south-east Australia. His main catch is Pink Ling and Blue-eye Trevalla.	Google Earth and general shots of Dodgy at work.
Interview with Russell…..	• *As above*
Our final case study fisherman is Dodgy, a Charter Boat skipper out of Portland. During autumn and winter he's taking customers offshore game fishing to catch Southern Bluefin Tuna.	Google Earth and general shots of Dodgy at work.
Interview with Dodgy…..	• *As above*
So, that's our case study fisherman and as you can see they come from a variety of fisheries and use a range of different gear. In each of these fisheries, stocks are assessed using a similar process. In essence this process relies on the collection of information by fisherman recording details of their catch and scientists measuring fish populations. Now, obviously scientists can't count all of the fish in a fishery, so instead they rely on computer models to estimate fish stocks. Computer models are used for a wide range of applications, not just fish stock assessments. For example in weather forecasting, meteorologists gather a range of information including air pressure, sea temperatures, humidity and satellite imagery. This information is plugged into a computer model and the computer generates a weather forecast. In a similar way, stock assessment scientists collect information from the fishery and put that information into the computer model. The computer model then generates predictions about fish populations.	Scientist doing presentation to a group. Fisherman filling out log book. Crazy scientist gearing up and scuba diving counting fish. Port Philip survey footage. BoM footage of meteorologists at work. • Air pressure • Sea temps • Humidity • Satellites General scientists at work.
Here's a diagram that illustrates how the stock assessment model works and represents a fish population over time. It's important to point out that unlike a weather forecast, our stock assessment models not only tell us what will happen in the future but also, what has happened in the past. The model predicts the fish population every year from when fishing started and up-to twenty years into the future. So, let's have a brief look at the important information used to predict a fish population.	Stock Assessment Diagram. Start with whole diagram on screen. Reduce model component to demonstrate that process is taking place each year. Highlight the time sequence on our graphic.
Here we see more detail of what is happening between each year, quite naturally the population is either going up, down or remaining unchanged. Now, just the same as humans, fish populations change and this depends on the number of births and number of deaths. Scientists call this recruitment and mortality. If we know how many fish we have to start with, how many are being recruited and how many die, we can work out how many will be there next year. That's the basis for a stock assessment model. The only difference is that just like commercial fishermen usually talk about their catch in weight rather than numbers, scientists also usually talk weight and not numbers, this is called biomass. Biomass refers to the weight of fish. So for the purposes of this DVD, we'll use biomass from now on to talk about the size of fish populations.	Continue with stock assessment diagram. Image of hospital maternity suite or crèche & image of cemetery? Words replace from 'population' to 'biomass'.
Now, like people, as fish grow older they get heavier. So, to properly account for biomass we need to add another component to our stock assessment diagram – growth. Because we're now talking about total weight of a stock rather than numbers, the rate at which fish grow is going to affect biomass change.	Growth gets added in as another variable in the diagram. Animation of the fish in the population increasing in size.
So, our diagram now represents how a simple stock assessment model works. Using a model, we can predict how biomass changes based on recruitment, growth and mortality. These are the fundamental parts of a stock assessment model, scientists call these parameters. Often the level of information required to fully understand each parameter isn't always available so very simple assessments are used. However, to help explain the detail of stock assessments, the examples used in this DVD will assume there is enough information available to estimate each parameter. Fisheries managers use the predictions provided by stock assessment to manage the fishery, guided by rules called a harvest strategy. The harvest strategy sets out the ways to work out how much fish can sustainably be	Animated images of recruitment, growth and mortality. Each with the words BIRTH, GROWTH AND DEATH, fading to RECRUITMENT, GROWTH AND MORTALITY. Animated trawler catches fish in the net.

caught, depending on the health of the fish stock. A good harvest strategy means that Tony, Wayne, Frosty, Russell and Dodgey will have sound industries and a good living long into the future.	
This DVD is divided into different sections which look in more detail at the different components of stock assessments and harvest strategies. Throughout this DVD we'll use our diagram and relate the information back to our case study fisheries. So, settle back, grab a coffee and enjoy the show.	Showing graphic again. Fisherman on boat taking porn out of DVD player and putting on stock assessment DVD. Coffee in hand sits back and watches.

TITLE: 'Schools of Fish'
DESCRIPTION: The Stock Concept and Distribution.

VOICE OVER	VISION/QUESTIONS
In this section we'll look at what a fish stock is and the boundaries that are important to its management.	Text: What is a fish stock? Stock boundaries
So, what is a fish stock? The first thing to look at is boundaries that affect how, when and where fish are distributed. In most cases these boundaries fall into three main categories: physical, chemical and biological.	Google Earth image starting close and pulling out to reveal South East Australia.
Physical boundaries are often easy to see and understand; some examples are land separation, water temperature, and water depth. Other boundaries are not so obvious. A chemical boundary might be the interface between fresh and salt water or oxygen levels. Biological boundaries might come about from predators or competition for food. The important thing to remember is that these boundaries may change over space and time.	Image of arctic water compared to tropical water and bathymetry chart. Ocean and river. Sharks and feeding.
So, to help illustrate the concept of boundaries, let's look at one of our case study fisheries. *Tony: Talking about where he fishes for Pink Ling and the standard depths that he's working.*	Q: Where do you fish for Pink Ling and what depths do you catch them? Do the hotspots where you find Pink Ling change? What do you think causes this change?
Tony only works in a small area of the Pink Ling's range which are also found in New Zealand, and South America. In Australia, their distribution extends from central New South Wales around Southern Australia to the south west coast of Western Australia. Beyond this range, we assume the conditions are not suitable for Pink Ling because they are not found there. The depth boundaries for Pink Ling are about 40–900 m. In terms of chemical boundaries, Pink Ling are restricted to salt water only and won't travel up a river. The biological boundaries restricting Pink Ling are hard to define but may include competition with similar species at the edges of their range. OK, so that's a bit about boundaries and the factors that may explain the distribution of a species; let's now look at the concept of a fish stock.	Google Earth with highlights for the boundaries. Net cam footage of Pink Ling
In Australia, the population of Pink Ling is split into two different stocks. The two stocks are separated at about longitude 147 degrees. The pink ling in these two areas don't mix or interbreed and so are considered biologically separate. For these reasons we call them different stocks. Within a stock's boundary however, the fish are assumed to easily mix with few limitations. So, for example, Pink Ling to the west of longitude 147 will not breed to any great extent with Pink Ling from east of 147. This means that fishing on one stock will have almost no effect on the size of any other stock. Also, within a stock, fish can be expected to have similar biological characteristics like birth rates and growth rates. What this means is that to ensure sustainable fishing, these stocks need to be managed separately.	Map of Australia showing location of the Pink Ling stocks. Zoom into the boundaries and discuss. Tony fishing.
Dodgy: My main fishing grounds for Southern Bluefin Tuna extend from….. to …… I guess the main depth I catch Tuna is around…..	Q: Where do you fish for Southern Bluefin Tuna and what depths do you catch them?
The Southern Bluefin Tuna that Dodgy's catching are part of a massive fish stock that ranges throughout the oceans of the Southern Hemisphere; it's known as a high seas straddling fish stock. This means the Southern Bluefin tuna stock crosses management boundaries, and is managed jointly between Nations. So, in essence a fish stock is a single species of fish that breeds, grows and moves within boundaries – and that is how it should be managed.	Blow up to a map of the distribution of Southern Bluefin Tuna. Google Earth again.
Now we understand what a stock is, in the next section we'll be looking at how fish stocks grow.	Stock assessment diagram, highlighting recruitment.

TITLE: New Recruits
DESCRIPTION: Reproduction and Recruitment.

VOICE OVER	VISION
A fish stock is like any other population, to maintain numbers there needs to be new births or "recruitment"- the addition of young fish to a stock. Balancing numbers going out – deaths – with numbers coming in – recruits – is a critical process for managing fish stocks. In this section we'll examine reproduction and recruitment and the key information scientists require for their stock assessment models. Obviously, not all eggs that are spawned end up growing into fish that will recruit into a fishery - many die on the way.	Stock Assessment diagram showing dying fish and new recruits. Crazy scientist has two fish in lab and uses one to hump the other. Looks up at camera and then down to notepad and writes some notes. Back to stock assessment diagram and see young fish dying before being recruited.
So in our diagram, breeding and recruitment are inputs into biomass change. It's important to remember that for most fisheries, there's no way scientists can count all the eggs or offspring produced by a fish stock; it's just physically impossible. So, how then do they go about measuring it?	Hold on stock assessment diagram Over the side of a boat showing net coming up and then panning over to reveal the expanse of the ocean.
Scientists usually assume that the number of eggs produced by a fish stock is directly related to the total weight of all of the mature spawning fish. It makes sense, the more adults there are, the more eggs that can be produced. The starting point then, is to work out when a fish becomes mature. Like all animals, fish species vary in the length and age they become sexually mature and can breed. In our case study fisheries, Tiger Flathead and Gummy Shark all mature at about four to five years old, Southern Bluefin Tuna and Blue-eye Trevalla at 10-12 years old and Southern rock lobster at about 7 or 8 cm carapace length.	Underwater of fish being caught in nets. Case study boats.
Frosty… "The minimum length for snapper is 38cm in South Australia, and by the time they get to that size, they are mature and have had a chance to breed. *You can tell when snapper are about to spawn, can see the eggs under the tail.*	Q: What's the minimum size limit for southern rock lobster and how does that compare to the size at maturity. Q. Is it obvious when crays are spawning? What can you see?
Working out the age of fish is very time consuming and expensive, and for Southern Rock Lobster, it can't even be done! So instead scientists look at the relationship between sexual maturity and length; this is much easier to measure. The most efficient method of doing this is to examine a commercial fish catch and work out which fish are sexually mature and what their length is. From this, scientists can estimate at what length the average fish of that species is sexually mature.	Scientist measuring a fish and examining gonads to see if they are mature or not. Obvious difference between mature and immature gonads.
So, why is length at sexual maturity important? The answer is that with information on the distribution of fish lengths in the stock, and knowing the average length at which they begin to breeding then, scientists can work out the amount of breeding individuals in that stock – the spawning biomass. Working out the length of the fish in the stock is not as hard as it sounds and is covered in more detail in the section on Age and Growth.	Graphic showing a fish population, a certain percentage then change color to demonstrate which are available for breeding.
The relationship between the weight of the breeding stock and recruits into the fishery is usually estimated by the stock assessment model. This "Stock – recruitment relationship" or "spawning stock – recruitment relationship" is one of the key bits of information that describes how recruitment varies in response to changes in fish stocks. Having said that, this relationship is one of the most difficult things to directly measure so scientists make certain assumptions about how the relationship works.	General fishing.
Scientist: Over the last 100 years, a lot of different types of fish stocks have been heavily fished down to low levels. When this happens, we get an understanding of the relationship between the spawning stock biomass and recruitment. Some stocks can be fished heavily before there is any effect on recruitment while in others you can see an effect on recruitment from even light fishing. Based on this understanding, we know that certain types of fish have certain stock-recruitment relationships and we can apply this to the stocks we are investigating and include it into the stock assessment model with certain assumptions. Throughout the assessment process, this assumption and other assumptions are continuously tested and evaluated to gauge accuracy.	
Now, length at sexual maturity isn't the whole story because the bigger the fish, the more eggs it produces. A good example of this is the Southern Bluefin Tuna. On average, a 115 cm Southern Bluefin Tuna produces about 870,000 eggs, but a 130 cm tuna produces over 2 million eggs. It's a similar story with Gummy Shark.	Southern Bluefin Tuna being caught.
Russell: "we don't want to catch sharks any bigger than about 1.4 metres. The reason is that bigger sharks can produce 10 times more offspring than smaller sharks. If we leave the big ones then we will have more sharks next year".	Q: Why is it best to leave the sharks that are bigger than 1.4 metres?
Fish have an incredibly diverse range of breeding strategies. Tiger Flathead,	Eggs and sperm being mixed in the

Blue-eye trevalla and Southern Bluefin Tuna for example are broadcast spawners; this means that eggs and sperm are mixed together in the water and grow into larvae. Gummy Shark internally fertilise the females and give birth to live young. Southern Rock Lobster on the other hand use a totally different strategy; they fertilise eggs externally, and hold the fertilised eggs under the tail of the female, and after they hatch, they swim off into the plankton. Because scientists can't measure the number eggs or larvae, the first time they begin counting most fish is when they're recruited into the fishery.	water column Rock lobster in berry
Recruitment into a fishery occurs when the fish reach a certain size and are available for catching. The length at which they are recruited is determined by the selectivity of the fishing gear, the growth rate of the fish and sometimes, the behaviour of the fish.	
So, that's about it for Recruits. In summary this section looked at the importance of finding out at what age and size fish start breeding, what recruitment is and the assumptions used to describe recruitment. In our next section we'll be looking in detail at how scientists age fish and measure growth.	Text: Age at Maturity Recruitment Assumptions

TITLE: Growth
DESCRIPTION: Age and Growth.

VOICE OVER	VISION
You may have noticed fisheries observers measuring fish and cutting into their heads and wondered what the hell they're up to. This process is like opening a window into a fish's life. In this section we'll be looking at the process of measuring and ageing fish and estimating growth rates with the aim of building an understanding of the size and age structure for the fish stock.	Measuring fish and cutting into fish heads.
Going back to our diagram, age and growth fit here; we want to understand the size and age structure for the fish stock at any point in time. So, why's this important? The answer is that if we know the size structure of the stock then we can estimate how many new fish are in the population, which ones will get caught, which ones are breeding and which ones are dying.	Zooming in on the fish stock from last year and seeing more detail of the size of the fish. As each category is mentioned it gets highlighted or caught.
Have you ever wondered how scientists measure the age of fish? Many people think it's as simple as looking up the fish's date. Well, as it turns out, looking up a fish's date isn't really that helpful. The process of measuring and aging fish is the first step in the understanding of the size and age structure of the fish stock.	Crazy scientist looking at fish a bit confused and then gets a magnifying glass and begins to look up fish's date. Give fish a bit of a squeeze.
Wayne: *Before selling our catches into the market we sometimes grade the fish into different lengths. This usually happens out at sea as we put different grades of fish into separate fish boxes.*	Q: When did you last notice a big pulse of young Tiger Flathead entering the fishery? Are you seeing them in your catch now? What is the grading process for fish before you sell them into the market?
A good way to demonstrate this is looking at the fish unloaded by Wayne at the Co-op. Wayne grades the fish for market because he gets a different price for different size fish. Here we see fish bins filled with fish of the same grade, from small to extra large. In a normal shot Wayne usually gets a few bins of smalls, a few bins of extra large but mainly bins filled with medium and large. Believe it or not, what we're creating here is a frequency distribution graph and it's much the same as graphs created by scientists to explain the size structure of a fish catch. Frequency distributions show counts of things in different categories. On this line we have the sizes of the fish caught by Wayne and on this line we have the numbers of bins of fish caught. If we draw bars over the top of our bins here, this is what scientists call a frequency distribution graph. Scientists use graphs a lot to represent relationships between two different measurements, also known as variables. In this case the measurements, or variables are length along the bottom and number of bins along the side.	Lakes Entrance Co-op unloading. Fish bins being swung up out of hull and stacked on wharf by grade. Need a clean profile shot that can then be turned into a graph in post. Smalls through to Extra Large. Draw in the X and Y axis and then the distribution curve over the top.
Scientists do basically the same thing as Wayne, except rather than grading the fish in to S, M, L and XL, they grade them in to 1 cm size-classes. Let's see how scientists obtain a length-frequency distribution. The first step is to measure the length of heaps of fish. We'll use Tiger Flathead. You may well have seen this happening on your boat, it's a common practise. After all this measuring, scientists end up with an understanding of the size range of fish that get caught in the gear. We can represent these length measurements visually. Our scientist has been very busy and collected a lot of measurements into one centimetre categories. Looking closely at these measurements you can see that the fish are falling into different sizes, little ones down this end of the scale and the biggest up this end of the scale. As you can see, they're not all big or all small, instead what we get is a range of fish lengths which together form the length-frequency distribution curve.	Scientist on a boat using a measuring board. Show clearly that scientist measure fish on scale and marks tail with marker. Speed up footage so scientist does over 50 samples. Restrict length. Once 50 samples done, roll measuring board up so fills screen. Need to take a still shot of board.
For some fisheries, length information is all we know about the structure of the population. With most fish however, we can get age information in addition to	Measuring Pink Ling.

length. The advantage of having age information is that we can tell what year the fish were spawned.	
So, how do you age fish and what do ear bones have to do with the process. A fish's ear bone - or otolith - can be aged much the same way as people age trees. If you take a chainsaw to a tree and cut through its trunk, you'll see the stump is made up of rings. Each ring represents one year of the tree's life, and by counting the rings you can age the tree. Now, if you take a chainsaw to a fish then you won't see much at all. So instead, scientists use a knife and then tweezers to pull out the otolith. They embed the otolith in resin, cut it into a thin slice and count the growth rings to get a measurement of age. The problem with aging fish is that it's expensive and time consuming to collect large numbers. Instead, scientists age a small number of fish of known lengths and use the length frequency distribution from the stock to estimate ages for the entire population.	Scientist on boat cutting into fish head. Chain sawing through a tree and then counting the rings. Crazy scientist taking chainsaw to a fish and getting blood splatter on the lens. Scientist taking out ear bone and slicing through it to start counting growth rings. Footage from microscope and computer screen.
After aging the fish, the next step is to establish the relationship between length and age. This is known as a Von Bertalanffy curve, named after the bloke who developed it. Much easier though to remember it as a, VB curve. Let's have a look at how it works. Here we have our length measurement and here we have age from youngest to oldest. In the first few years the fish grow very quickly, as the fish get older this growth tapers off to the point where the fish have virtually stopped growing. And here, is what the VB curve looks like. What we're representing here is another graph, a bit like the graph we had before of length distributions. In this case, we have the length of fish on the side and the age of the fish along the bottom (youngest to oldest). So here you can see the relationship of length against age.	Fisherman laying Tiger Flathead out on fish cleaning table at boat ramp with youngest first and working up in age. Fish length sticker laid out. Need to get exactly the right size fish so it forms a VB curve. Have a tinny of VB nearby so they remember. Or can you stretch a can into the shape of a VB curve? Over the top of the noses, draw in the curve. Convert jetty graph to real graph and highlight the two variables.
So, now we've established what a VB curve is, what's the point of it? In essence if you know how long a fish is, then you can work out roughly how old it is. In our example here this fish is three years old. Unfortunately though, it isn't quite that simple. The complication is that, like children, fish of the same length aren't necessarily the same age; or alternatively, fish of the same age aren't necessarily the same length. So, how do we deal with this?	Fisherman taking a Flathead out of esky, measuring length and using the curve to work out the age. Fish grouped by size, all the same. Then, fish grouped by age, different sizes.
Well, the next step in the process is to establish the age range of fish at a specific length. So let's take 37 cm Tiger Flathead to start with. Here are ten fish at 37 cm, we know from their otoliths that they are of the following ages. One of these fish is only three years old, four are four years old, two are five years old, two are six years old and one is seven years old. Now, let's look at this in terms of percentages for the whole Tiger Flathead stock. At 37 cm, 10% of Tiger Flathead are three years old, 40% are four years old, 20% are five years old, 20% are six years old and 10% of Tiger Flathead are seven years old. This process is repeated for fish of all lengths to develop what scientists call an age-length key. For Tiger Flathead, the age length key looks something like this.	Scientist laying fish out in order of age. Grouping together the ages. Laying out one column of the age length key. Age length key.
OK, we're now up to the final step; pulling all this information together so we can understand the age distribution of the whole Tiger Flathead catch. Firstly, let's turn our length frequency distribution graph into a bar graph. This will help us merge the two together. So, from these two figures, we know how many fish of each length were in the catch, and the percentage of fish at each age in each 1 cm length category. If we simply merge our table here into the length frequency distribution, we can clearly see that each length has a range of different ages. What we now want is to group all of our ages together and create a distribution that represents ages on the bottom with numbers of fish on the side. This is our final result, the age frequency distribution of the Tiger Flathead catch.	Take the one column from age length key and distribute it into the appropriate column of the length frequency distribution curve. Move ages around so grouped together and create an age frequency distribution.
That was a fair bit to take in, so let's have a bit of a re-cap. Here we have fish of a whole lot of different lengths. From aging of the otoliths, we know that each of these lengths has fish of different ages. By combining these two bits of information, which are length frequency distribution and the age-length key we can see the percentage of fish at each age for each length category. Now, rather than grouping the fish by length, if we group them by age we get an age frequency distribution.	Measuring board graph (with bars). Age length key, highlighting 37cm then age and percent. Animation combining length frequency and age length key. From length at age to age frequency animation.
Wayne: *In 2005 we had a whole lot of new fish enter the fishery. They were small and most of them escaped through the net. We've seen them grow over the last five years and they're now a big part of our catch.*	Interview
So, that's about it. To understand age and growth we've looked at the process for collecting length and age measurements and then converting these to the final outcome, an age frequency distribution. Importantly, a Tiger Flathead age frequency distribution shows us how many fish for each age are in the catch. If this is done over many years, we can then see how the distribution changes over time to better understand key characteristics of the stock, such as strong and weak recruitment events and the effect of fishing on the fish population.	Text: Length frequency distribution Age frequency distribution VB curve

In the next section, we'll discover how we can use the age structure of a stock to estimate fish mortality and why an understanding of mortality is so important.	Footage from next section.

TITLE: "RIP"
DESCRIPTION: Natural mortality, fishing mortality and measuring mortality for a whole stock.

VOICE OVER	VISION
Even without humans catching fish, fish die from a whole range of different causes. Old age, predation, disease, lack of food; these are all examples of things that cause "natural mortality" or deaths that would happen without fishing.. Typically, all of these things are very hard to measure out in the ocean, but luckily there are some general relationships between how old animals get and their natural mortality rates. Scientists often represent natural mortality by just using the letter M. Scientists estimate natural mortality based on how long the fish live; longer living fish have lower natural mortality. Some level of natural mortality is occurring all the time, but once you start harvesting a fish population, the fish you catch or kill become one of the major sources of mortality – this is termed "fishing mortality", and is represented with the letter *F*. Going back to our diagram, you can see where natural mortality and fishing mortality fit; the combination of these two gives us "total mortality", represented by the letter Z. Total mortality is a measure of the proportion of fish that die each year; which is obviously important to understand for stock assessments.	Fishing. Underwater of fish, sharks, fish eating. Stock Assessment Diagram.
XXXXX: My target species live for a maximum of about ?? years.	Q: How long does your species live for?
Knowing how long a fish species lives and their mortality rate is critically important to managing a fishery. We've already discussed measuring fish age so, how do we measure mortality? Building on what we already know about the age frequency distribution in Tiger Flathead and extending this over a number of years, we can track the change in population for each group of recruits. Let's follow this through and look at an example starting in 2002. Here we see a graph of the age structure for the whole fishery, along the bottom line is age in years and along this line is the number of fish. This column represents the number of new recruits for 2002. Moving to 2003, our new recruits are now four years old and as you can see, there numbers have gone down – due to a combination of natural and fishing mortality. Again, in 2004, our recruits are a year older and there numbers have dropped even further. This continues each year until they all die.	Scientists measuring fish. Age frequency graph. Highlight the vertical line. Graph columns move along to demonstrate how as the different year groups age their numbers decline.
If we isolate the 2002 recruits and look at the change in their population over the following years, our graph looks like this. Here we have total number of fish at each age and as you can see over the period the number of each age class falls. This is called a catch curve, and represents the total number of fish dying each year. But what we really want to know is the proportion of the stock dying each year, this is the important figure. Now, we're not going to bore you with the maths on this but this curve can be straightened by squashing down the graph; scientists call this a log transformation. The gradient of this line is the total mortality, or Z. The steeper the line, the higher the total mortality rate. Scientists do this with a number of year groups and get an average which represents the mortality rate for the whole stock. This is a good example of another assumption made for the model, that mortality is the same across a number of different year classes.	Catch curve graph showing only the 2005 cohort over 3 years. Show the line tilting for different fish species. Show a range of catch curves for a stock and then show them merging to form the average.
Scientist: Mortality rates vary a lot between species and largely relate to how long a fish species lives for. So for a fish like Orange Roughy that can live to 160 years old the natural mortality rate is very low. Whereas a fish like Squid that only live for a year, their natural mortality rate is very high.	Q: How does maximum age affect mortality in species as diverse as Orange Roughy and Squid?
Lets look at examples using species that our case study fishermen catch. Blue-eye trevalla are one of the longest living of our species, reaching at leach 40 years old. Its catch curve looks like this. Gummy Shark live for around 16 years and their catch curve is much steeper. The steeper the curve the higher the mortality rate.	Split screen with three case study fish, enlarge for Flathead and show curve. Same for Gummy Shark and Tuna.
Lets go back to the catch curve for our Tiger Flathead example. If we only took into account natural mortality, our curve would look like this. If we take into account fishing mortality as well, then the curve changes to this; the whole curve gets lower and its angle changes, because the stocks mortality rate increases. If we further increase fishing mortality you can see the line getting steeper and steeper. You can also see that there are relatively fewer old fish in the population. This is one of the indicators that a stock is under considerable fishing pressure.	Show Tiger flathead curve and demonstrate how it adjusts to include fishing mortality.
XXXX Cray Fisherman: Cray stocks have been a bit down in the past few	Q: Cray stocks have gone down over the

years.	last few decades, how is this affecting the size of the cray's your catching?
Going back to our stock assessment diagram, fishing mortality is directly affecting biomass change. Looking at the stocks from last year, if we know how many are dying from both natural and fishing mortality and how many are being recruited this year then we can estimate the stocks, or biomass, for next year.	Stock Assessment Diagram.
That brings us to the end of our section on mortality, just to re-cap on this section we covered the difference between natural mortality and fishing mortality and the process for estimating total mortality across a whole fish stock.	Text: Natural Mortality (M) Fishing Mortality (F) Total Mortality (Z)
In our next section we'll be looking at how the gear we are fishing with and how discards affect the information scientist collect to estimate recruitment, age and growth and mortality.	

TITLE: Heads or Tails
DESCRIPTION: Availability and Gear Selectivity.

VOICE OVER	VISION
When your boat comes back to the wharf after a trip there'll be two main things that will have affected the size of the fish you're about to sell; these are: fish availability, and gear selectivity. Obviously the quality of the skipper has an effect too, because their decisions as to where to fish and how deep to fish will also affect what gets caught, but we might leave that for another section series.	Boat returning to harbour and unloading fish bins. Crazy scientist either in the wheelhouse ejecting our DVD and puts in another DVD 'Being a Better Skipper'. Or crazy scientist landing crap fish (eg 1 mullet in a fish bin)
Referring back to our diagram we're now going to look at fish availability and how the selectivity of our fishing gear affects what size fish you catch. Then, we are going to look at how these two things affect the information being collected.	Stock assessment diagram.
Fish availability refers to which fish are available in the area you're fishing. Put simply if fish aren't there – you can't catch them – that's availability. There are many examples of this in fishing, so let's hear again from our case study fisherman.	GPS and sounder and then pan across to skipper for response to below Q.
Tony: Big gemfish are mainly caught during winter at depths of around 420 metres as they do their spawning run up the east coast. You do get a few fish at other times and other depths but they're mostly small to medium size and scattered around.	Q: Tell us about catching Gemfish and where you might find them?
Gemfish provide a good example of availability. During the winter months large spawning gemfish are travelling up the East Coast at a very specific depth as part of their breeding cycle. This makes them very easy to catch, or very available, if you know where to look and what to do. Other times of year you can't find them – they have low availability.	Google Earth with text coming up 420 metres.
Dodgy: Tuna turn up off Portland in about March each year, and we get them up until July. You get a few fish outside of those times, but mostly, they just aren't there.	Q: Can you tell us about the seasonality of the tuna fishery?
Wayne: We tend to find that the availability of flathead changes with depth. On our inshore grounds we get many more of the little ones but if we go further out on the shelf we get the good-sized ones we are looking for. The availability of large flathead increases with depth.	Q: How does the size of flathead change with depth.
So how do scientists deal with availability? Because the size and type of fish you can catch change over space and time, the best way to deal with availability is to collect samples from broad areas of the fishery over a long period of time. By doing this we get an understanding of where and when fish become available to different gear types.	General fishing
The type and size of gear used on boats obviously plays a big part in what fish are being caught. Not only is the species being caught affected by gear but also, the size of the fish. So in essence, fishing gear is selective in the size of fish it catches. This is all pretty obvious to fisherman but it can create complications for scientists when working with information collected from a fisherman's catch. Ideally, scientists want to measure the length and age of the fish population in the water. But, because fishing gear is selective, scientists don't get to see the full size range of fish. For example, in a trawl, they might not see as many of the small fish as are really out there, because they escape through the meshes of the trawl nets. There may not be as many large gummy sharks in catches from gillnets because bigger sharks can tend to bounce off the meshes.	General fishing gear on boats. Underwater footage of fish escaping. Crazy scientist takes a sledge hammer to his computer in obvious anger.
To get a more accurate picture of fish populations, scientists take into account gear selectivity and adjust fish measurement counts taken from the catch accordingly. In this way, scientists use information that is easily measured to estimate the population that they can't see.	General fishing and fish escaping nets.
Scientist: An important contribution to the stock assessments comes from the measurements made on the fish caught by commercial boats. A problem here, as fishermen understand, is that commercial gear is	Q: What affect does fishing gear selectivity have on measuring fish stocks?

selective in what it catches and the catch won't necessarily be representative of all parts of the natural populations in the fish stock. To account for this, we need to estimate fishing gear selectivity.	
Let's have a look at our case study fish and see how fishing gear selectivity affects the size of the catch.	Case study footage.
Russell: Our cray pots have to have an escape hatch that's a minimum of ??? High. This lets out the undersize crays, but retains all of the legal size crays. My shark mesh is………	Q: What sort of gear do you use on your boat and how does that affect the size/length of the scallops you catch?
Tony: Our boat is a trawler and we use a 90mm double braid diamond codend with a panel of larger mesh to let undersize fish through. We catch very few ling less than ?? cm but once they are above ?? cm none of them can escape through the codend..	Q: What sort of gear do you use on your boat and how does that effect the size/length of the fish you catch?
Very small Tiger Flathead that enter a net can easily pass straight through the codend. As they get bigger, the chance of them getting through the codend gets smaller. Looking at it the other way, the bigger the Tiger Flathead, the more chance of it getting caught. This doesn't mean however that there is a definite "knife-edge" size cut off, so for example all Tiger Flathead from 30cm up get caught. It's a percentages game, some 30cm Tiger Flatheads will get caught and some will escape through the net. Scientists describe this with something called L50. L50 is the fish length at which 50% of fish get caught in the gear, and 50% get away. So for example with Tiger Flathead, as they grow, the chance of being caught increases. We can use our measuring board again to represent how this works. When fish are small there's only a small chance of them being caught. When they get to a length of about 30 cm, they have a 50% chance of getting caught if they enter Wayne's Danish seine net. In other words, half the fish of this length get caught and half escape. By about 35cm, nearly 100% of Tiger Flathead that enter the net are caught.	Section of tiger flathead escaping codend to cover (from Danish seine stuff) Graph of selectivity, building the graphic as it is described. Curve gets drawn as it gets described. In the background, show section of flathead escaping codend.
How do scientists measure selectivity? Well, the stock assessment model usually does that for them, but, it can be measured through experiments on fishing gear. Using gill nets as an example, scientists went out on a shark boat with 2, 3, 4, 5, 6, 7 and 8 inch net and measured the sizes of all sharks caught in each of the nets. The 2-inch net showed us how many really small sharks were in the population while the 8-inch net showed us how many really big sharks were there. From this information, we could work out what a 6-inch mesh wasn't catching and therefore determine its selectivity. A similar process can be used to determine hook selectivity. Trawl selectivity can be worked out a bit differently. Because most of the larger fish eventually tire and get caught by the trawl, we are more interested in the small fish that can escape through the trawl net. To measure selectivity in this instance we surround the commercial codend with a much smaller mesh and measure the fish that have escaped through into the small mesh.	Footage if different mesh net sizes. Graphs of Terry's gill mesh net selectivities. Someone on board holding up a big mother gummy shark and a piddler. Footage of covered codend experiments and results.
So, how is selectivity used to adjust fish measurement counts? Let's bring back our length frequency distribution collected by the scientists. This shows the lengths of fish that were brought onto the boat by the Danish seine net. Now we overlay selectivity and can see that only 50% of 30cm Tiger Flathead are caught by the net. If only 50% are caught then it means the real population is double that, so we double it. For fish of 28 cm, you can see that only 25% get caught, the real population then must be four times this. We can keep doing this for fish of all sizes and what we end up with is a good understanding of the fish population length frequency.	Show l/f graph of Tiger Flathead that we had earlier, then overlay selectivity curve as it is described. As it is mentioned, build the graph – add fish to account for selectivity.
So, that's about it for availability and selectivity. Just to re-cap, in this section we have covered the availability of fish to fishing gear and the effect of selectivity on the information that scientists collect. In our next section, we'll be looking at the importance of fishing log books for helping scientist's measure changes in fish populations.	Text: Availability Selectivity

TITLE: 'Making Every Shot Count'
DESCRIPTION: Catch Per Unit Effort (measure of abundance)

VOICE OVER	**VISION**
Remembering back to our diagram, we want to be able to understand how the fish populations are changing over time. The reason is to assess if fish stocks are going up or down, and to see how healthy the stock is now compared with the past. Ideally, we'd know each year how many fish were in the water but, obviously, that's impossible. Fortunately we have another way of tracking changes in fish populations and it relies totally on fishermen. The measure is catch per unit effort, better known as CPUE or catch rates. In this section, we'll examine how catch rates are calculated and how scientists take into account the factors that cause differences in catch rates, such as boats and locations.	Stock Assessment Diagram. Animated boat moves through diagram and catches fish. General fishing shots. Nets landing on decks.

Most fisheries use logbooks to report what gear was used, how much fish was caught, and how much fishing effort it took for the fisherman to catch those fish. Combining this information together gives us a catch rate.	Fisherman filling out log book.
Frosty: On most trips we get about ???? kg of cray per pot, but get as much as ???? per pot on a good trip.	Q. What sort of crayfish catch rates do you normally get?
Lets use Frosty as our example and show how catch rates are calculated. During this trip, he checked 50 pots, and caught 15 kg of Southern Rock Lobster. To get the catch rate, scientists simply divide 15 kg by 50 pot lifts and get 0.3 kg/pot-lift. If there was more Southern Rock Lobster around, and Frosty had of caught 50 kg for the 50 pot-lifts, the catch rate would be 1 kg/pot-lift. If there was less fish around, catch rates would be lower, and if there were no fish around, obviously the catch rate would be zero.	Footage of Scott fishing, blur and put catch rate calculations over the top.
Sometimes it's not just the amount of gear you set but also how long you set it that is important for catch rates. For Frosty's gillnet for example, you would expect that you would by leaving your net for a few hours, rather than for 30 minutes. In this case both gear length and amount of time are multiplied together to measure effort, called kilometre hours. Gillnet catch rates are measured that way. If a fisherman caught 500 kg of shark from 4 km of net soak of 5 hours, his catch rate would be 500 kg divided by 4 km divided by 5 hour, which turns out to be 25 kg per km hour.	Footage of shark net being run out over the roller. Footage of shark being pulled from gillnet. Calculation on screen
Now, if you set the same amount of gear in an area where there are lots of fish, you will get higher catches than if you set the exact same gear in an area where there are not may fish. In this way, catch rates can be related to the amount of fish in the area where you set your gear. This is a really important concept for fisheries science because it means that catch rates can give you some indication of abundance. We'll spend some time going through this.	
Here's an example of how catch rates can reflect abundance. We've put 200 goldfish in a tank, and here's our trawl net. What were going to do is look at how catch rates change as the population decreases. So, our fisherman takes his first shot. Counting them out, he got 19 fish in the first shot. Speeding things up a bit, he's now taken four shots and caught fifty fish. Now he's reduced the population to 150 fish, which is 75% of the original population. Catch rates have been pretty high so far. Let's get the fishermen to keep fishing and see if catch rates change. Now, the population is down to 60% of its original level, and you its getting harder to catch fish; catch rates have dropped right off. This example demonstrates that catch rates can provide some index of abundance.	Bathtub full of goldfish, someone dressed as a fisherman holding a butterfly net (or something?) Tows net through bathtub, putting catch in a bucket. Scoreboard keeps track of catch and effort. Tally catch rates after 80%, 60% and 40%.
This is pretty simple right? Not in real life! As you'd expect, catch rates don't only change with fish population size, but, among other things, with fisherman, gear types, seasons and depths fished. All of these things need to be accounted for. This is called catch rate standardisation. And to show you how this works, we'll compare our first fisherman with a new entrant.	Show the crazy scientist with a much smaller net dragging through bathtub. Catches only 1 fish.
Our first fisherman has been in the industry a long time and had pretty good catch rates. His gear is set up right and he knows just the right speed to tow. Let's see how the crazy scientist does. It looks like his gear isn't as good and his tow speed is much slower. Eventually he catches the same amount of fish as the fisherman, but it takes twice as long. So the crazy scientist ends up with less than half the catch rate.	the crazy scientist, dressed in wet weathers, using much smaller net, towing slowly catches less. Speed up section until he reduces the population to 40%
Now, it's obvious that comparing catch rates between fishermen won't tell us anything useful about population size or changes in population size. So what we need to do is compare catch rates of the same fisherman over different years. So, let's get them both back onto the fishing ground. Because the population had decreased, both fisherman have lower catch rates. If we do the maths on the this what we discover is that although their catch rates are very different, they have both experienced the same fall in relative catch rates; in each case they both experienced about a 50% drop in catch rate.	Simple catch rate calculations to compare between fishermen.
The next step is to standardise the results which means to even out the differences between high catch rates of one fisherman and low catch rates of another. Going back to our fish tank results, in the first year our first fisherman had a catch rate of 7 fish/shot and the crazy scientist had a catch rate of 4 fish/shot. In the second year abundance has fallen, so our fisherman only had a catch rate of 3.5 fish/shot and the crazy scientist only 2 fish/shot. We know the major reason for the catch rate difference was that the crazy scientist had a smaller net, and scientists need to even out the differences caused by the different nets to make the results comparable. Remember, we're not interested in the comparisons between fisherman, but the comparisons between years so we can understand changes in abundance. The process of standardisation then means that in our fish tank example, we want to make the first years catch rates the same, in this case we'll use round numbers and make the first years catch rate 1. To achieve this we divide the first fisherman's catch rate by 7 and the crazy scientist's catch rate by 4. Now going to the second year we do the same thing, divide our fisherman 's catch rate by 7 and the crazy scientist's by 4. What we've done here is standardised both their catch rates and therefore adjusted for the fact the crazy scientist had a smaller net. Result; even though	Calculations.

the catch rates were very different, by standardising them we can clearly see that the changes in catch rates were the same. The catch rates could now be combined to get an average catch rate for the fishery for each year.	
Applying this process to a commercial fishery is exactly the same but, over a much larger number of fisherman and more variables. Those variables being things like gear type, depth, season and area. Looking at standardised catch rates over a number of years, scientists can tell if a fish stock is going up or down. The large number of logbook records provided each year across a whole fishery helps to show the bigger picture that might be hard to see in the catch returns of any one fisherman.	Commercial fishing boats. General fishing.
XXXX: We have to put a whole heap of information in our logbooks, like where we are fishing, depth of water and what net we are using.	Q: Apart from catch, what other information do you put in the logbook?: Apart from catch, what other information do you put in the logbook?
Now, scientists acknowledge that using catch rates to measure changes in fish populations isn't perfect because there are so many factors involved, many of which can't be measured. Examples of variable that are difficult to account for are market price and quota availability. But for many fisheries, it's the best information available. To get a more accurate measure of changes in fish populations, scientists sometimes use Fishery Independent Surveys. These surveys use standardised gear and trawling methods, and are designed to take out many of the factors that might cause unaccounted variability in catch rate calculations. We'll look at them in more detail in the next section.	General fishing. Port Phillip trawl survey.
In summary, what we've looked at in this section is how catch rates are measured and the process of using catch rates to estimate changes in abundance of fish populations. A really important point to remember from this section is that the accuracy of catch and effort information from fisherman greatly affects scientist's abilities to monitor population changes of fish stocks. In our next section we'll be looking at the process of how scientists collect data for stock assessments.	Text: Standardisation Calculating catch rates.

TITLE: Measuring Stuff
DESCRIPTION: Data Collection (fisheries independent and dependent)

VOICE OVER	VISION
So far, we've talked about the different information that scientist's need to understand fish stocks. In this section, we're going to look at how scientists collect this information. A index of abundance is probably the most critical measurement feeding into stock assessments. Without good a good index of abundance and data on age and length, it's impossible to have quality assessments. People refer to this as 'shit in = shit out'; meaning if your data is crap to start with then the results are also going to be crap.	Highlight footage from previous sections. Scientists collecting data. Stock Assessment Diagram Crazy scientist puts rubber dog turd into the CD-Rom. Dog turd then appears on the screen and scientist gives big thumbs up.
There's two different categories of fishing data; Fisheries Dependent Data and, Fisheries Independent Data. First, let's look at Fisheries Dependent Data. This is information that's either collected by the fisherman or, by observers sampling commercial catches.	Title: Fisheries Dependent Data Fisheries Independent Data Commercial fishing, general footage.
Most commercial fisheries record catch in logbooks. These logbooks have information on location, depth, date and time, and how much fishing effort was used to take the catch. From this we learn about distribution and boundaries, depth range and how much the species moves around. In fact, most of our knowledge of fish distribution over space, time and depth has come from logbooks. Scientists also use log book data to calculate catch rates, which they use as an index of abundance.	Fisherman using logbook.
Tony: We don't have scales on our boat so we estimate the catch on the boat for each species. We have to write down the catch of each species for each shot that we do.	Q: Tell us about how you record your catches in your logbooks?
Scientists are aware of other inaccuracies in logbook data and often adjust for these. A common inaccuracy is position information, which is pretty easy to detect because it stands out from the rest of the fleet. There are many other examples of scientist being able to correct for inaccurate logbook data by deleting individual records that are well outside the expected range.	Maybe a graphic of a distribution of catch rates with some outliers. Or, crazy scientist looking at effort information with positions over Canberra.
Logbooks provide really useful information on fish with commercial value, which fishermen keep. Fish that are thrown away however don't usually make it into the logbook and this is one reason why scientific observers are important on boats	Discarding, or catch on the deck – spilling from net.
Russell: *I catch a few small fish that people don't want to eat so there's no market. There's always a few sharks to that get damaged and I can't sell.*	Q: What sort of stuff do you catch that you don't keep and why don't you keep them?
An important role for observers is to estimate the discarded catch which is usually made up of lots of small non-commercial species. This is important information, because it gives managers a better idea of the full impact of	Observer working on a boat. •

fishing across all species. But it's not only non-commercial species that are discarded, sometimes commercial species are discarded because there is no quota available or the fish are too small to market. In this case, good information on discards is needed so scientists can add them to the retained catch to calculate the total quantity of fish that the fishery has caught. In most fisheries it's too expensive and impractical to put observers on every boat, so only a small percentage of trips have observers. It's important to ensure that observers are distributed across the boats in the fleet to match the effort in the fishery. So, observer coverage should be highest in the areas with most fishing effort. That way, the observers' discard data can be combined with the fisherman's log book data to provide information about the entire catch of the whole fleet.	• Trash fish getting pushed over the side • Measuring fish • Observing catch and writing in clip board • Observer watching fishermen sorting fish. Fleet of boats in port. Log book image being merged with an observer data sheet.
That's pretty much it for fisheries dependant data, the information collected on commercial fishing boats. Next, we'll look at fisheries independent data. This is information collected outside of normal commercial fishing operations. There are a variety of fisheries independent activities but the main one we'll focus on is fishery independent surveys.	Commercial fishing boat steaming along. Port Phillip trawl survey.
Scientist: For some of the data we collect, sometimes we need to go outside normal fishing operations. An example of this is the Great Australian Bight trawl survey. This survey has been going since 2005 and utilises a commercial boat, the Explorer S. The aim of this survey is to monitor the change in fish stocks over time and has greatly contributed to improving the assessments for Deep Water Flathead and Bight Redfish.	Q: Why use trawl surveys and tell us a bit about the importance of the Great Australian Bight survey?
Fishery Independent Surveys are often conducted with research vessels. In this way, scientists can control all aspects of the fishing trip, including location, depth, gear, fishing duration and season. Commercial fishing vessels are sometimes used, but are usually chartered so scientist can control all these variables. The main aim of these surveys is to measure a catch rate that is not influenced by market price, quota availability, targeting and avoidance. In this way, scientists get catch rate data over a number of years that can be a better measure of abundance than data collected from commercial log books. As mentioned at the start, a good index of abundance is a critical piece of information for stock assessments. Fishery Independent Survey data becomes another input into our computer model which helps to improve its accuracy.	General shots from Port Phillip trawl survey.
Tony: Trawl surveys have been done in our fishery for the last couple of years. Personally I think commercial catch rates are a bullshit indicator of abundance these days; fishery independent surveys give us a better idea of whether the stocks are going up or down.	Q: Are trawl surveys done in your fishery and what do you think of them?
Unlike commercial fishing, fishery independent surveys need to cover the whole area of the fishery, so they can supply useful information even if the fish, or fishermen, move around from year to year. Most importantly, they need to be conducted very consistently, year - after year - after year. This is because their main value is in providing a relative measure of abundance that can be compared from one year to the next. Scientists have very strict rules they apply to fishery independent surveys so they can meet these goals.	General fishing, catch spilling on deck.
That's pretty much it for data collection. In review we've looked at recording commercial catch information, fisheries observing and fisheries independent trawl surveys. In our next section we're going to tie it all together and show you how the stock assessment models predict fish populations and changes in fish populations.	Text: Commercial catch information Fisheries observers Fisheries independent trawl surveys.

TITLE: The Black Box
DESCRIPTION: Stock Assessment Models

VOICE OVER	VISION
Now we're getting to the guts of it; pulling it all together. We're going to look at how stock assessment models work. But before doing that, let's just reinforce one very important point and it goes to the central question of why do we use stock assessments, what's the point of them? Well, the main reason to use stock assessments is that scientists can't directly count all the fish in a stock and as a result, they need as much information as they can get to estimate how much fish can be sustainably harvested. This information includes, length, age, catch, discard and catch rate information collected every year, combined with what is known about stock-recruitment, growth rates, maturity, reproduction and mortality. There is simply no way anyone can analyse this amount of information in their head. So, scientists plug all this information into a computer model that's customised for each species. From this, they work out how the stock is responding to the fishing pressure and provide a prediction of what catches can be sustainably taken in the	Stock Assessment Diagram with different elements of harvest strategy being highlighted. Review of data collection footage. General fishing. Crazy scientist head expanding and blowing up. BoM footage. Fishermen checking forecast.

future. Remember, weather forecasts aren't always right but they're still much better than having no forecast at all. Even though weather forecasts aren't perfect, many people still rely on them as the best use of all the information we have to estimate what is going to happen.	
Let's go back to our diagram and see how it all fits together and how a model might work. First, let's re-cap on the variables we've already discussed that go into the model. Reproduction and recruitment were first and they tell us how many new fish are entering the fishery. Up next was age and growth which tells us how quickly fish grow, how many fish of each age there are and at what age reproduction begins. Mortality rates were the next cab off the rank, with natural mortality and fishing mortality estimated from age and growth data with catches in logbooks and observer data helping with the estimation of fishing mortality. Availability and gear selectivity was next and they work across the whole diagram because they affect how we interpret and adjust much of the other data collected to better represent the entire population. Finally, commercial catch per unit effort (CPUE) data and fishery independent surveys inform us about abundance and population change, whether the stocks are going up, down or remaining steady.	Stock Assessment Diagram. Different elements highlight and animate.
So, now we've collected all this information lets see how this all goes into a stock assessment model. We could pretend that in this section we'll be able to explain everything about how stock assessment models work; the truth though, is they're bloody complex and only specialised scientists actually fully understand all the details. So in this section, we're going to treat it a bit like a black box, that is, feed the information in, press the go button and get the results. But we'll also have a little peek inside the black box to look at how it works and how small adjustments in the way scientists use and interpret the data can affect the results.	Stock assessment meeting
Let's go back to our diagram and start with the factors that increase population size; recruitment and growth.	Stock Assessment Diagram.
We'll start with recruitment. Because of availability and trawl net selectivity, Tiger Flathead are recruited to the fishery at about 25 cm length or 3 years old and this is when we can start measuring them to get information about the stock. Flathead of 3 years and older are represented in green. We know from length measurements and ageing data that the age frequency of the Tiger Flathead population looks something like this. We also know that the Tiger Flathead mature at about four years old. Putting this together, we can see here in 2005, the proportion of the fish stock available for breeding; this is called the mature or spawning stock biomass. A good way to demonstrate the relationship between spawning stock biomass and recruits is to show age frequency graphs for a number of years. So, going back to our 2005 graph, we can see the spawning stock biomass includes all of this. The number of fish spawned by the spawning stock biomass is estimated in the following year, 2006; represented here. The point is that the biomass of these very young fish are estimates; because they're not caught by the fisherman, the model estimates their biomass based on the spawning stock biomass from the year before. Moving into 2007, our year zero fish are now one year old and we have a new population of year zero fish. As you can see, we've lost a few of the year zero population through natural mortality. Moving into 2008 our original year zero fish are now 2 years old and getting close to becoming recruits and as would be expected all the others have moved on a year and we have a new year zero population. Now into 2009 and much to their proud parent's delight, our year zero fish have graduated into the fishery. The point here is that recruitment levels are usually dependant on spawning stock biomass and the recruits we see in 2009 were produced by the spawning stock biomass of 2005. If the spawning stock biomass in 2005 had of been bigger then we might have seen more recruits, and if it had been smaller we might have seen less recruits; recruitment is naturally variable because of the high mortalities that the eggs and larval fish can suffer.	Using the age frequency graph. Zoom in on 2005. Time series of age frequency graphs, showing recruits coming from spawning stock biomass. Colour up the bar which shows TF available for breeding. Highlight the actual number.
Remember that when it comes to stock assessment models and commercial fishing, we aren't interested in fish populations but the biomass of the stock. So the other factor, apart from recruitment, that leads to an increase in the stocks biomass is fish growth. It's obvious that a 4 year old Tiger Flathead will be 5 years old next year. From our VB curve we know that on average, a 4 year old Tiger Flathead will be 35 cm long, and at age 5 it will be 37 cm long. On average, a 37 cm Tiger Flathead will be heavier than a 35 cm Tiger Flathead. So, in addition to the year's recruitment, the model calculates increase in weight due to growth of the biomass already present to end up with a biomass for each year group and a total biomass for the stock. But we're getting a bit ahead of ourselves in estimating the total biomass for the stock, this is the most complicated part of the process and the final step we'll look at in this section.	Fish landing on deck. Laying flat heads out on deck in order of size. VB curve. Balance scale with a 4yo and 5yo fish on either side. Show the weights getting added together on our age frequency graph and the totals.
So, factors that lead to an increase in the biomass of the Tiger Flathead stock	Stock Assessment Diagram and move to

are recruitment and growth. Let's now look at the factors decreasing the stock biomass: mortality - both natural and fishing.	mortality.
We've previously discussed natural mortality which is caused by things such as ageing, predation, disease and lack of food; these aren't calculated separately, but as a single variable. Fishing mortality is pretty easy to understand and to calculate. We know how much Tiger Flathead was caught from logbook records of landed catch, we know what size and age they were from our length-frequencies and otoliths, and we have estimates of how much was discarded from observer programs. Together, they account for fishing mortality.	Fish landing on deck, logbooks and observer data sheets. Stock Assessment Diagram and show mortality decreasing the population.
Combined, recruitment, growth and mortality each describe different factors that act to change the Tiger Flathead biomass each year. We've also talked about how catch rates or fisheries independent surveys show us how much the biomass changes each year. Now, pretty much all that's left is to work out how big the total biomass for the Tiger Flathead stock is and how much we can sustainable take. This is the hard bit.	Stock assessment diagram
Estimating the biomass in each year is complicated so without going into too much detail we'll explain a few things. There are a couple of facts about a fish stock biomass that we already know. Firstly, it must be bigger than the annual catch. Now this might seem obvious, but it's important information as it sets a minimum possible biomass for our fish stock. We also know that fish biomass is not endless, and that there is some limit that the ocean can handle. Biomass then is going to be somewhere in between; but working it out is a bit like the process of triangulation when navigating. Without a compass or a landmark (and no GPS) you are lost at sea. With just a compass and one landmark, you might know roughly where you are, but you don't know your position, because you don't know how far away from the landmark you are. If you know the compass bearing of two landmarks, however, you can work out your approximate position. But, if you are unsure about the landmarks or can't get a precise reading from the compass then you are less certain about your position. By using more landmarks and improving the precision of your compass reading you become more confident that you know your exact position. In a similar way, a stock assessment model is lost without any information. Also, the model can use more than one type of information at the same time to estimate the abundance of a fish population. The more information it gets and the more precise that information is, the more certain you are in the estimations that come out of the model. By using all of the past and present information that scientists have on a fish population, the model can calculate the vital missing bit of information – stock abundance or biomass. The most important information that gets estimated by the model is the current biomass and the biomass before the fishery began – termed the "virgin biomass". These are the critical numbers that feed into the harvest strategy that go to set the total allowable catches. We'll cover this in more detail in the final section. What's more, if you provide even further information to the model, you can also use the model to predict the biomass, recruitment, age structure and sustainable catch levels. Now, no one is saying that these model predictions are perfect, and the further out they predict the more imprecise they get, but they are the best tool we have to make sense of all the information we have. Remember weather forecasts, they're not perfect and they become less accurate the further out they predict. We still use them though. All important information that we can turn into a number or "quantify" that helps us to estimate the biomass should be in the assessment model.	Have a chart and show how triangulation works. Stock Assessment Diagram, numbers/equations start filling in on variables and they combine to answer next years Biomass which has a ? and then gets a number. Continues on down the diagram into other areas. Finally calculates virgin biomass Model starts filling in forward The model filling forwards should have expanding confidence intervals Some weather type footage
That brings us to the end of the Black Box. Just to re-cap, in this section we combined all the different components of the stock assessment model and showed you how they work together. At this point you may be thinking, but how does the model actually use all the information, how do we know the model works, how do you know that the results make sense? Well, it's called model fitting and sensitivity testing, and we'll talk about that in our next section – opening the black box.	Stock Assessment Diagram animating and making more numbers and filling in detail.

TITLE: Opening the Black Box
DESCRIPTION: Model Fitting and sensitivity testing

VOICE OVER	VISION
It's all well and good to plug all of the information into the model, run it and produce lots of nice numbers and graphs. But, it's essential to understand roughly how the model is processing all of that information and check that those numbers make sense. How can scientists know that the biomass predicted five	Scientists working on computers and generating graphs, printouts etc.

years into the future is right? Well the truth is they can't, but they can get an idea if it's on the right track. They do this by comparing the models results with the things that they can measure.	
What you haven't been told yet is that when the model is estimating things that we don't know, it's also estimating things that we do know — because we've measured them — such as age structure, length structure, and catch rates. What this means then is that scientists can compare the models estimates to the real data – the observations; if the models estimates are close to the real data then it gives them confidence in the results. If the estimates aren't close, then scientists can change some of the parameters and re-run the model. They keep doing this so that the match between the models estimates and the observations improves. This is called, model fitting. Let's look at a simple example of how this might work.	Stock Assessment Diagram predicts numbers but also fills in and predicts numbers we already do know. Scientists working on computers. Stock Assessment diagram goes again and this time predictions are closer to the known numbers.
Here's a snapshot of a fish stock in each year between 2005 and 2010. In real life we can't see all of the fish in the stock, but we do know that they are made up of juvenile fish that have just been spawned, young fish that are newly recruited into the fishery and the adult spawning fish. For the purpose of illustration, we'll pretend that we can see the population structure of the fish stock in each year. Now, here's some of the data collected by observers and fishermen. It represents the age structure of the commercial catch showing the proportion of young and adult fish that were caught, and the catch rates. Catch rates are shown as yellow bars; the higher the bar, the higher the catch rate. We'll put these two types of data into the model and see what happens. Here, the model tries to estimate the fish stock in each year, and as you can see it doesn't do a very good job, because it shows the fish stock disappear. We know that's obviously not the case because fish were caught in the years after 2008. Now, let's compare the age structure and catch rates predicted by the model with the age structure and catch rates that were observed. You can see that the two different sets of information aren't even close. In the predicted data, a lot more adult fish are caught in the first year, and expected catch rates are initially much too high, and then drop off more quickly. Whereas in the observed data, an even mix of juvenile and adult fish are caught, and catch rates fluctuate a little but remain stable over the years. The word that scientists use to describe how different the predicted values are from the observations is the likelihood; this literally means "how likely is it that the model represents the observed data well". If the model's predictions are very different from the observations, the likelihood will be very low. In this case, we'll give the likelihood a 0. Fitting involves adjusting the parameters until the likelihood of the model representing the observed data is as big as you can get it.	Images from Neil's ppt. Age structure and catch rates. Run the model and do the comparisons. Compare graphs and show likelihood low. Compare another two graphs and show likelihood high.
Lets change the model parameters a bit and see what happens. This time the results look more like the observations, but are still a bit different because there are more juvenile fish in the catch than what was observed, and the catch rates are a bit too high. You can see that the likelihood is better than the first go, but the predictions are still not that close to the observations. Let's have another go.	Compare graphs again and show likelihood has gone up.
This time the results look a lot like the observations, and the likelihood is high. The model is said to fit the data well. When scientists get a model with high likelihood, and a good fit to the data, their confidence in results from the model increases. That means, with the information they have, they believe that they are modelling the fish population as well as they can, and have confidence in the model's predictions.	Compare real graphs again and show a high likelihood.
Scientists then check models by adjusting the parameters and testing the assumptions. This is called sensitivity testing, and really means they are testing how sensitive the models outputs are in response to these adjustments. For example, when modelling the Tiger Flathead population, scientists do things like make their estimate of natural mortality 50% higher or lower, they might change the relationship between the spawning stock biomass and recruitment, or change the growth rate. The other thing that sensitivity tests do is to highlight the parts of the information that need to be looked at more closely. For example, if the results are very sensitive to changes in growth, then it might mean that more growth information needs to be collected.	Crazy scientist dressing a blow up doll. Scientists having a RAG meeting with fisherman with somebody taking notes. Further RAG meetings.
Now we have seen how the stock assessment models work, and how we can tell if they make sense, how do they get turned into TACs? That's where managers apply harvest strategies, and we'll look at that in our final section, fishing for the future.	General fishing footage.

TITLE: Fishing for the Future
DESCRIPTION: Harvest Strategies

VOICE OVER	VISION
If you remember the start of this DVD, the fisherman were talking about the importance of a sound industry and making a good living. For a fisherman to be	Wayne on the boat with his son – in the wheelhouse of sorting fish.

successful and have an ongoing business, he must have future access to fish in a sustainable fishery. The only way to have a sustainable industry is through an understanding of the state of fish stocks – gained through stock assessments.	
Wayne: My eldest son skippers the boat at the moment, and I hope that there are still fish around for his son to catch.	Q: What do you have planned for the future of your business??
XXXXX: If a fishery isn't profitable then it isn't a real business and if it isn't ecologically sustainable then it won't be around very long. So all Industry wants is a stable fishery that is both economically and ecologically sustainable.	Q: What is important to the future of the fishing industry? Is an economic and ecologically sustainable fishery important to you and why?
XXXXX: The management of our fisheries needs to be transparent. If changes are made, we need to know why.	Q: How can management of your fishery be improved? Is it important to have transparency in the fisheries management process and do fisherman need to know about changes?
The Australian Fisheries Management Authority, or AFMA, manages all commonwealth fisheries in line with the Commonwealth Harvest Strategy Policy. Harvest strategies provide the tools required to sustainably manage a fish stock to ensure that it is not only available long term but also provides good economic yield. The primary aim of managers under the harvest strategy is to have healthy fish stocks achieved by controlling the level of fishing mortality. Both stock biomass and fishing mortality are estimated in stock assessments.	General fishing footage and selling fish. Markets, co-ops, processing, fish shops.
Before we jump right into harvest strategies, we need to describe a few of their key elements. Firstly, harvest strategies need an "indicator", something that you can measure such as catch rate, biomass or fishing mortality. Another critical element of a harvest strategy is a goal or "target" against which its success is measured. This is called a "target reference point" and is the optimal state of the fishery in terms of economic returns and sustainability. A harvest strategy should also have a defined limit reference point: usually a critical stock biomass below which the stock is at an unacceptable risk of collapsing. Once the limit is breached, targeted fishing is supposed to stop to allow the stock to recover. As their names suggest, the target reference points are places where managers want the fishery to be, whereas limit reference points are where they don't want the fishery to be. A harvest strategy will specify what management action is required to move the fishery towards the target reference points.	Text: • target biomass, • limit biomass, • target fishing mortality • limit fishing mortality All text with general fishing blurred in the background. Maybe to show the biomass reference points, show two pools of fish representing the virgin biomass and the target biomass
To help explain how the harvest strategy policy works, we're going to use a graph. To start with, lets lay out our graph and put in some components of the policy. Along here is biomass as a percentage of the virgin biomass. Now, we'll overlay some of the reference points and rules that the harvest strategy sets out. The default target reference biomass for most Commonwealth fish stocks is 48% of the virgin biomass, and that's here. Now let's add the limit biomass reference point. It's at 20% of the virgin biomass, here. If the biomass is below 20%, it's unacceptably low and is called overfished; the risk to sustainability is too high to continue targeting that stock. If it's between 20% and 48% it's not considered overfished, but needs to rebuild to the target. If the stock is in the green and above 48% there might be the potential to increase fishing. Managers aim to keep the stock at the target reference point level of 48% biomass.	Build the harvest strategy graph.
So, how do they do this? Well, the next component to look at is fishing mortality and we'll put that along here, the higher it goes the higher the fishing mortality. The primary tool that managers use to get fish stocks to the 48% target reference point is by controlling the fishing mortality on the stock. This is done by setting total allowable catches or effort levels that control fishing mortality so that the stock moves towards the target biomass. If the biomass is below the limit reference point, the aim is to set the fishing mortality as close to zero as possible to allow the stock to recover, including stopping targeted fishing. If the biomass is between the limit and target reference points, then fishing mortalities are set to increase the biomass to the target. If the biomass is much greater than 48%, fishing mortality can be higher to reduce the biomass to 48% over time. But a fishing mortality above this line will lead to overfishing and is not sustainable. It's important to note that the target fishing mortality is set to reach the target biomass over many years; it's not set to achieve the target biomass in a single year.	Build the harvest strategy graph.
There are a couple of other points about harvest strategies that we haven't mentioned. Firstly, why is the default target reference point for biomass set at 48% of virgin biomass? Well, we're glad you asked! The target biomass is the 'sweet spot' where we get the most profit in the long term; otherwise called the maximum economic yield. If biomass falls below this, it costs you more to catch the fish; if the biomass is higher, then you're not taking enough. Based on analysis of fish stocks from around the world, the point of maximum economic yield usually occurs at 48% of virgin biomass. This is the default target biomass for Australia's commonwealth fisheries. For some fish stocks however, there's information that indicates the maximum economic yield occurs at other biomass levels. For example Tiger Flathead has a maximum economic yield that occurs at 42% of virgin biomass.	General fishing with text.
The second point to cover is how the harvest strategy is used to set a total	Stock Assessment Diagram.

allowable catch, or TAC? Well, when the model calculates the target fishing mortality required under the harvest strategy, it can easily be converted into a Recommended Biological Catch or "RBC". This is the total catch from all sources that can be taken from the fish stock in the following year to achieve the required fishing mortality. But, the TAC may not be equal to the recommended biological catch if there are catches from outside the fishery (for example by recreational fisheries or fisheries from other jurisdictions). Let's use a real example and demonstrate how this works for Tiger Flathead in 2010. From the Recommended Biological Catch of Tiger Flathead, scientists take away the expected catch from State fisheries and discards from commonwealth fisheries; what's left is the commonwealth fisheries TAC for Tiger Flathead. This ensures that all sources of catches are taken into consideration before setting the TAC, ensuring that the total fishing mortality is not exceeded.	Do calculation
The whole stock assessment process is great for fish species we know a lot about, but for species where there is limited information, then the harvest strategy sets out a different set of rules for the management of those species, and that's a whole other story. So far we've described fish stocks that have a lot of information, these assessments are pretty much as good as it gets. For species with less information, assessments are simpler and harvest strategies should be more precautionary. If for instance we only have catch and effort data, then our assessment might only analyse catch rates and a harvest strategy might simply be to maintain catches and catch rates at historically sustainable levels.	Footage of other fish getting caught i.e. Dory etc.
Scientist: For the species that we know most about, you can generally fish them at a higher rate. One of the aims of the resource assessment groups is to increase our knowledge of fish species to improve the stock assessments and allow a less precautionary management controls.	Q: Tell us about the precautionary principle and what that means to quotas?
So, that's pretty much it for the whole series. If you're still watching this DVD, then it means you've got all the way to the end and hopefully stayed awake. If there's one message to take away from this DVD it should be don't take a chainsaw to a fish. No, the key take home message is that the stock assessment and harvest strategy process is critical to establishing sustainable fisheries and the long term viability of fishing businesses. To do the job properly, scientists need the help and support of fishermen in carrying observers, recording accurate data and, most importantly, in participating and bringing your special understanding of fisheries into the stock assessment process. Thanks for taking the time to watch this series. Hopefully, now that you understand the basics of stock assessments and harvest strategies, leaving your boat and joining into this process won't seem so daunting.	Fisherman sleeping in a chair and spills his coffee and wakes up. People in white coats grab crazy scientist who has chainsaw and take him away. Fisherman going to push observer off boat then thinking twice. Data recording. Stock assessment meetings.
	Credits.