Developing Marine Reserves for Biodiversity Conservation and Sustainable Fisheries in Rodrigues

Impacts of Marine Reserves in Rodrigues: Report of a training visit to Shoals Rodrigues, September 2005

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Executive Summary

1. The author made a visit to Rodrigues under the Darwin Initiative project *Developing marine reserves for biodiversity conservation and sustainable fisheries in Rodrigues* during September 2005. Local support was provided by Shoals Rodrigues.

2. Monitoring fish size changes associated with the introduction of marine reserves was identified as one key skill where local expertise was lacking. Training of staff from Shoals Rodrigues and the Fisheries Protection Service (FPS) to monitor live fish sizes was carried out using wooden models of known sizes. All participants showed marked improvements in size estimation over a series of in-water training sessions. Recommendations for further action are made, including continued snorkel training for FPS staff, continued size estimation training for all potential fish surveyors, and minimum standards for surveyors. A provisional list of fish species suitable for size monitoring is presented.

3. A list of apparent new records of fishes for Rodrigues was compiled from fishery and reef monitoring reports produced by Shoals Rodrigues. Recommendations are made for further development of the scientific checklist of fishes of Rodrigues.

4. The potential for other biodiversity documentation is discussed, and recommendations made.

5. There appears to be particularly good potential for Shoals Rodrigues to conduct a cetacean survey in the waters around Rodrigues. This is beyond the scope of the current Darwin Initiative project, but it is recommended that Shoals Rodrigues staff continue to document all incidental records of cetacean sightings and strandings and investigate further funding options.

Impacts of Marine Reserves in Rodrigues: Report of a Training Visit to Shoals Rodrigues, 17 to 30 September 2005

1. Background

This report summarizes discussions and training carried out during a visit to Rodrigues by Dr. Charles Anderson under the Darwin Initiative project *Developing Marine Reserves for Biodiversity Conservation and sustainable Fisheries in Rodrigues*. This project is funded by the UK Department for Environment, Food and Rural Affairs (DEFRA) from February 2005 to January 2008.

The background to the project and summaries of work carried out to date are given by Edwards (2005) and Gell (2005). In brief, the government of Mauritius and the semi-autonomous region of Rodrigues recognise the problems associated with habitat degradation and overfishing in the nearshore waters of Rodrigues. In response, the Rodrigues Regional Assembly plans to declare four marine reserves in the northern Rodrigues lagoon. The purpose of the Darwin Initiative project is to assist with that process, helping to develop a management strategy, building local capacity in marine science, and raising environmental awareness.

In Rodrigues the project acts mainly through the local marine environmental NGO, Shoals Rodrigues. One key element is the provision of training in research methods to staff of Shoals Rodrigues, as well as to the Fisheries Protection Service (FPS) and the Fisheries Research and Training Unit (FRTU). This will support their monitoring of fisheries and habitats both within and outside the new reserves, allowing the effectiveness of the reserves to be assessed.

The main aim of this visit in September 2005 was to develop a programme of fish monitoring designed to show the effects of marine reserve establishment on fish populations, and to provide training for host country partners in these techniques.

2. Underwater Estimation of Fish Lengths

A major aim of the proposed marine reserves will be to allow overexploited fish populations to recover within the newly protected areas. It is anticipated that, in time, 'excess' fish will move out of the reserves, providing increased catches to fishers even though the area open for fishing is reduced. It will be important to monitor the effectiveness of the marine reserves, not only to justify their cost and continued existence to all stakeholders, but also to identify any weaknesses in their structure and management and to formulate appropriate remedial measures.

Monitoring which is designed to demonstrate the effects of marine reserves on fish populations should at the minimum cover two likely types of change:

a. Changes in fish population **abundance** (exploited fish species might be expected to become more abundant within the marine reserves once they are fully protected there).

b. Change in fish **size** (exploited fishes might be expected to become larger within the marine reserves once they are fully protected there).

Shoals Rodrigues already has in place a standard protocol for recording fish abundance. Selected species are counted along 50m transects as part of a wider coral and marine life monitoring programme. Therefore during this visit, efforts were concentrated on training for monitoring changes in fish size.

At present Shoals Rodrigues carries out length frequency sampling of commercial catches from the Rodriguan reef and lagoon fisheries, with much emphasis placed on the important artisanal seine net fishery. It is likely (and desirable) that this on-going catch sampling will remain the major source of fish size data. However, there are two reasons why this should be supplemented by non-fishery data:

a. Most importantly in this case, there should in the future be no fishing within the new marine reserves. Therefore the monitoring of fish sizes within the reserves will require a fishery-independent methodology.

b. More generally, catch sampling provides data on just the exploited subset of any fish population. Changes in fishing practice (e.g. the proposed increase in mesh size for the artisanal seine net fishery) will produce changes in size frequency of the catch, which do not necessarily reflect changes in population. Again, a fishery-independent means of monitoring sizes will be required if the effects of the marine reserves are to be isolated from the effects of any other changes in the fisheries.

Thus, if fish sizes are to be monitored in the new marine reserves, it will have to be done without catching them. There is no easy and entirely accurate means to do this. However, experience elsewhere has shown that divers and snorkelers can be trained to estimate fish lengths underwater to within acceptable levels of accuracy. The key is in the training.

The Training Programme

Potential surveyors were trained to estimate fish lengths underwater using fish-shaped models cut from plywood. Details of the training procedure, and the results obtained, are given in Annex 1. In summary, 20 models were prepared, in the shapes and covering the full size range (11-48 cm total length) of fishes exploited in the lagoon and shallow reefs of Rodrigues. These models were painted either black or white (10 of each) and clearly marked with individual numbers. The models were set out underwater to either side of a 50m tape/transect. Participants (2 from Shoals Rodrigues and 5 from the Fisheries Protection Service completed the course) were required to snorkel along the transect, and record their estimates of model length on an underwater writing slate. After each open water session, at a debriefing session, feedback was given on the true lengths of the fish models so that participants could judge their own performance and (hopefully) improve during the next session.

Four open water snorkelling sessions were completed. (Due to poor weather, planned diving sessions were cancelled). The main outcomes may be summarized as follows:

a. The ability of all participants to estimate fish model lengths accurately and without bias was initially poor but clearly improved over the course of four training sessions.

b. Participants from Shoals Rodrigues were more efficient at locating models and were better at estimating their sizes than participants from FPS. This was a reflection of the higher level of snorkelling experience of those from Shoals Rodrigues.

c. For Shoals Rodrigues participants the training demonstrated that it is possible to estimate fish lengths underwater to an acceptable level of accuracy, but that that it is not a straightforward exercise, requiring practice and concentration.

d. For FPS participants, most of whom had very little previous in-water experience, the main outcome was undoubtedly their increased interest and confidence. Most are still some way from reaching a standard suitable to carry out actual monitoring, but all demonstrated and voiced an enthusiasm to improve their skills in order to do so.

Recommendation: Fisheries Protection Service personnel should continue snorkel training with Shoals Rodrigues on a regular (weekly) basis to further improve their water skills.

Recommendation: All Shoals Rodrigues and FPS staff who will be involved in fish monitoring should continue regular training to improve their underwater size estimation skills.

Recommendation: Anyone who will be carrying out actual fish size monitoring should achieve a set standard of performance with fish models of known size before carrying out live monitoring. It is suggested that a bias score of less than ±10, an (in)accuracy score of less than 40 and an 'efficiency' score of at least 39 (in each case based on estimates for 20 models averaged over 2 trials, see Annex 1 for details) would be sufficient.

Species to be Monitored

During the course of this visit, poor weather (i.e. consistent strong E-SE winds) limited the amount of open water snorkelling and diving that could be carried out. As a result I was not able to visit many sites, and was not able to gain a full idea of the species of fish that would be most suitable for size monitoring. As a result, the list of species for size monitoring presented below should be treated as provisional. The final choice should be made by those senior Shoals Rodrigues staff actively involved in fish monitoring, perhaps with further input from a Darwin Initiative project consultant on a future visit.

Species chosen for monitoring should have ideally have (individually or collectively) the following attributes:

- Be easily identified to species underwater
- Be regularly seen underwater (The commonest species caught, the Rabbitfish *Siganus sutor*, is apparently never seen by snorkelers or divers)
- Include a range of ecological types (e.g. predators, herbivores, coral grazers, territorial, roving, etc)
- Include both reef-associated and lagoon-associated species
- Include some species that are targeted by Rodriguan fisheries and some that are not targeted ('controls'). Lists of species caught by the three main artisanal fisheries (seine net, basket trap, and line) are presented in Annex 2.

The total number of species to be monitored for size should not be too large, otherwise the work-load may become too great, and the possibility of confusion increases. A dozen, carefully chosen species should provide a good indication of size changes associated with the introduction of marine reserves. Potential species include the following:

Crown Squirrelfish	*Sargocentron diadema*
Four-saddle Grouper	*Epinephelus spilotoceps*
Black-saddle Coralgrouper	*Plectropomus laevis*
Whitemargin Lyretail Grouper	*Variola albimarginata*
Blacktail Snapper	*Lutjanus fulvus*

Blackspot Emperor	*Lethrinus harak*
Spangled Emperor	*Lethrinus nebulosus*
Two-saddle Goatfish	*Parupeneus trifasciatus*
Bluefin Jack	*Caranx melampygus*
Blackback Butterflyfish	*Chaetodon melannotus*
False-eye Sergeant	*Abudefduf sparoides*
Bullethead Parrotfish	*Chlorurus sordidus*
Bridled Parrotfish	*Scarus frenatus*
Convict Surgeonfish	*Acanthurus triostegus*
Picasso Triggerfish	*Rhinacanthus aculeatus*

Recommendation: The list above should be reviewed by senior Shoals Rodrigues staff who are involved in fish monitoring, and a final selection made of fish to be monitored for size.

Length Measurements

It is noted that Shoals Rodrigues staff record fish lengths as **total lengths**, i.e. length from tip of snout to tip of tail (with the exception of the Surgeonfish *Naso unicornis*, which has extended tail filaments). This is a perfectly acceptable practice, although it is more common to measure **fork length**, i.e. length from tip of snout to centre of tail. Shoals Rodrigues staff sample commercial catches for weight, at which time they also record total length, fork length and standard length. In order to facilitate comparisons with other studies (most of which use fork length) it would be useful to calculate the statistical relationships between each of these parameters, at least for all the more abundant species.

Recommendation: Relationships between total length, fork length and standard length for all the commoner fish species should be calculated and published.

3. Biodiversity Documentation

The proceedings of the First International Marine Biodiversity Workshop for Rodrigues held in 2001 (Oliver and Holmes, 2004) provide an excellent introduction to a number of groups of marine organisms. However, not all marine life groups are covered, and even for those that are, the listings are not complete. Updating knowledge of Rodriguan of marine biodiversity should be an on-going activity for Shoals Rodrigues. Accurate and comprehensive listings of selected components of marine biodiversity are of great value for ongoing monitoring activities, as well as providing important inputs to broader studies of taxonomy, biogeography and conservation.

Fishes

Heemstra et al. (2004) have provided an updated checklist of the fishes of Rodrigues, listing a total of 493 species. This list is certainly incomplete. Heemstra et al. (2004) themselves suggest that there may be a total of about 600 coastal fish species at Rodrigues, while the total fish fauna, including pelagic and deep water species, might approach 1000 fish species.

A good number of fish species not recorded by Heemstra et al. (2004) have been recorded by Shoals Rodrigues staff during the course of their on-going fish monitoring activities, particularly from the seine net fishery (Lynch et al, 2003-2005). These records are summarized in Annex 2. They cannot be considered as confirmed, definite records, but they do demonstrate that many ‘new species’ do await adequate documentation. In most cases it will be necessary to obtain a specimen to confirm identification. This is especially the case for

fish families where field identification is not always straightforward (e.g. parrotfishes and barracudas). Useful website: www.fishbase.org

Recommendation: Shoals Rodrigues staff involved in fisheries monitoring and reef monitoring should keep an active look-out for fish species not included in the checklist of Heemstra et al. (2004). Whenever possible, specimens should be obtained, otherwise photographs may suffice to substantiate records in some cases.

Recommendation: Voucher specimens should be deposited at an appropriate international institution (e.g. the Natural History Museum, London).

Recommendation: Shoals Rodrigues should continue to cultivate collaboration with big game fishermen, with divers and others to source specimens or photos of new fish species.

Other Groups

While fishes are perhaps the most obvious component of the marine fauna, many other groups are present and play key roles in the Rodriguan reef ecosystem. The study of any group would undoubtedly pay dividends. However, creatures that are conspicuous but are rare (in space and time) are particularly suited to this type of on-going documentation. Their rarity means that an outside expert on a relatively short visit is unlikely to record more than a small fraction of the total fauna. On the other hand, their conspicuous nature means that a local researcher is likely to come across many species over the course of a few years. Obvious examples of such animals include the sea slugs (Opisthobranch Molluscs) and the marine flatworms (Polyclad Platyhelminthes). Useful website: www.seaslugforum.net

Recommendation: Individual Shoals Rodrigues staff should be encouraged to 'adopt' particular faunal or floral groups for on-going study, ideally in collaboration with an acknowledged international expert.

4. Cetaceans

The cetacean fauna of Rodrigues appears to be completely unstudied. The most recent regional review (de Boer et al., 2002) makes no mention of Rodrigues, while Payet (2005) alludes to the general dearth of cetacean research in the Mascarene region. Nevertheless, inspection of bathymetric charts, and discussions with Shoals Rodrigues staff, Fishery Protection Service staff and fishermen suggests that there are likely to be good numbers of whales and dolphins in the waters immediately around Rodrigues.

Cetaceans are an important component of most marine habitats, and particularly nearshore pelagic areas such as those surrounding Rodrigues. Furthermore, Rodrigues lies within the International Whaling Commission's (IWC's) Indian Ocean Sanctuary (IOS) (Leatherwood and Donovan, 1991). Within the IOS, which includes all waters of the Indian Ocean as far south as 55°S, all great whales are protected from commercial exploitation, and benign research is encouraged. Furthermore, there is an acknowledged need to expand and diversify income-generation from tourism, and cetacean-watching may provide one such opportunity.

Shoals Rodrigues is in a good position to initiate a basic research cetacean programme. As a first step this could document the occurrence, relative abundance and seasonality of cetaceans in the waters around Rodrigues. A few records of cetaceans from Rodrigues are listed in Annex 3.

The numerous game fishing boats operating from the island would provide suitable platforms for any proposed cetacean research programme. Major constraints will include the weather and funding. For much of the year, Rodrigues is subject to strong E/SE winds, which would make an offshore cetacean survey almost impossible. Offshore studies are likely to be limited to the calmer summer months of November to March (although cyclones do occur at this time of year). Cetaceans do occur within the deeper parts of the proposed marine reserves, but their impact there is likely to be minor, and any future cetacean research will be outside of the scope of the existing Darwin Initiative project.

Recommendation: Shoals Rodrigues should continue to document all incidental records of cetacean sightings and strandings.

Recommendation: Shoals Rodrigues should investigate the possibility of obtaining funding to conduct an offshore cetacean survey.

5. Other Issues

a. A separate marine reserve project, funded by UNDP, is developing a fifth marine reserve in the south of the island. It would be advantageous to all to develop further links with that project.

b. At present the issue of policing the marine reserves once they have been declared does not appear to have been fully addressed. The success or failure of the marine reserves will depend in large part on the nature and effectiveness of any policing and enforcement. While this is outside the direct remit of Shoals Rodrigues, advocacy of preferred options should continue.

6. Acknowledgements

This visit was funded by the Darwin Initiative and facilitated by Dr. Al Edwards of Newcastle University. I am most grateful to the Director of Shoals Rodrigues, Eric Blais, and all the Shoals staff, particularly Scientific Coordinator Dr. Emily Hardman, Research and Training Officer Jovani Raffin and Technical and Training Assistant Sydney Perrine for their hospitality and support.

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Annex 1

Summary of Results from Fish-length-estimation Training Sessions

The proposed declaration of several Marine Reserves around Rodrigues should provide some opportunity for overexploited reef fish populations to recover. Any recovery should be apparent in two ways: (1) and increase in fish abundance, and (2) an increase in fish size.

Changes in abundance can be monitored relatively easily by making regular counts on standard transects. Monitoring changes in fish size is less straightforward, simply because it is not possible to actually measure live, free-swimming fish. Therefore it is necessary to make estimates of fish length underwater. This introduces many potential sources of error, and it is necessary to complete training to improve size estimation skills before any monitoring can be started.

Training Programme

During an initial briefing session, participants were informed of the purpose of the training, the likely errors inherent in underwater size estimation, and the training technique to be used. The apparent magnification of objects underwater when viewed through a diving mask was emphasized.

During each of four open-water training sessions, some initial instruction was given in snorkelling procedures. Then participants were required to swim along a 50m tape transect, set out on the bottom, near which 20 wooden fish models had been deployed. Each fish model was of different size and had a number painted on its side. Participants recorded their estimate of length for each model on an underwater writing slate. After each session, in a short debriefing session back at the Shoals Rodrigues office, the true lengths of each model were revealed so that each participant could assess their own performance, and make appropriate improvements during the following session.

During a final debriefing session, summary results for the whole training period were presented, and each participant's performance was discussed.

Training Schedule

Wednesday 21 September (afternoon)
    Introductory briefing session at Shoals Rodrigues office
Thursday 22 September (afternoon)
    First snorkel training session, Grand Baie
Friday 23 September (morning)
    Second snorkel training session, Ile Hollandais
Monday 26 September (afternoon)
    Third snorkel training session, Ile Hollandais
Tuesday 27 September (afternoon)
    Fourth snorkel training session, Ile Hollandais
Wednesday 28 September (afternoon)
    Final debriefing session at Shoals Rodrigues office

Participants

Dr. Charles Anderson, training consultant, for Shoals Rodrigues
Mr. Eric Blais, Director, Shoals Rodrigues
Mr. Jovani Raffin, Research and Training Officer, Shoals Rodrigues

Mr. Marcelin Raffaut, Ag. Senior Fisheries Protection Officer, FPS
Mr. Marclay Peermamode, Fisheries Protection Officer, FPS
Mr. George Eric Jolicoeur, Fisheries Protection Officer, FPS
Mr. Johnson Ah Kang, Fisheries Protection Officer, FPS
Mr. Wendy Grandcourt, Fisheries Protection Officer, FPS

In addition the following participated in the initial briefing session:

Mr. Fleuriot Meunier, Principal Fisheries Protection Officer, FPS
Mr. François D'Assise Speville, Fisheries Protection Officer, FPS
Mr. Sylvio Perrine, Technical Office, Fisheries Research and Training Unit

Results

Results are summarized in Tables 1-3. Table A1-1 summarizes bias in size estimation by each participant during each of four training sessions. A negative number indicates that on average the participant underestimated the size of the models, while a positive number indicates that model sizes were overestimated. The larger the number, the larger the bias in estimation. The main point to note is the very large bias during the first training session and the improvement in every case by the fourth training session. A second point to note is that initial bias was mainly negative, i.e. most participants had overcompensated for magnification due to use of a diving mask underwater.

Table A1-1. Summary of estimates of bias in underwater fish length measurements during four training sessions by eight participants

Bias	Training session				Final
	1	2	3	4	average
Jovani	-10	-36	0	3	0.2
Charles	-16	3	8	8	0.4
Eric Blais	-22	-16		17	0.9
Raffaut	-85	-101	-148	18	0.9
Peermamode	252	-83	1	30	1.5
Ah Kang	-162	-89	45	32	1.6
Eric Jolicoeur	-261	-68	32	38	1.9
Wendy		-190	-87	-50	-2.5

Figure A1-1 gives two examples of biased size estimation from the first training session. One participant (Peermamode) consistently overestimated sizes, while the other (Eric Jolicoeur) tended to underestimate sizes. Both participants improved greatly in their abilities, with the training given, and in particular with the feedback on performance after each training session. By the fourth and final training session both had greatly reducde the bias in their estimates (Figure A1-2).

Figure A1-1. Examples of results from two participants from first training session, showing low accuracy and both large positive and large negative bias in model fish length estimation

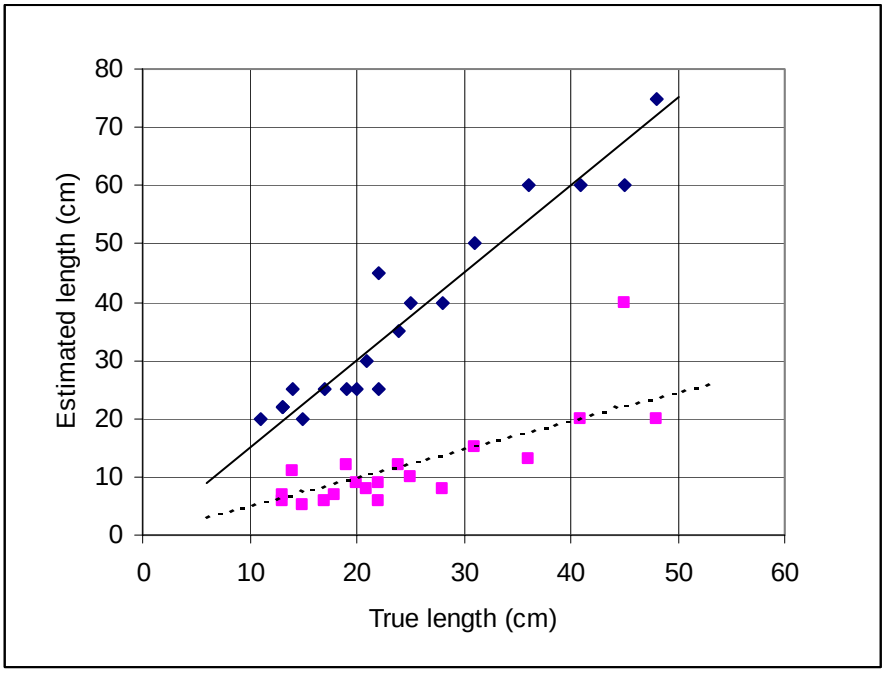

Figure A1-2. Results from the same two participants as above (Figure A1-1) from fourth and final training session, showing increased accuracy and much reduced bias in model fish length estimation

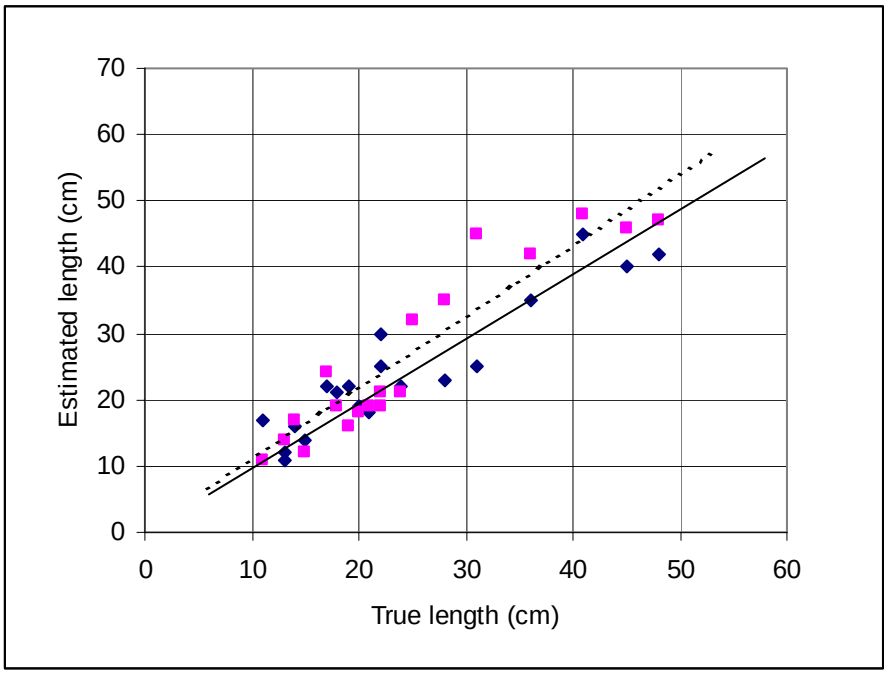

Table A1-2 summarizes accuracy of size estimation by each participant during each of four training sessions. The larger the number, the less accurate the estimation. The main point to note is again the poor level of accuracy during the first training session and the improvement in every case by the fourth training session. Comparison of Figures A1-1 and A1-2 illustrates this graphically.

Table A1-2. Summary of estimates of accuracy in underwater fish length measurements during four training sessions by eight participants

Accuracy	Training session 1	2	3	4	Final average
Jovani	50	42	46	31	1.6
Charles	54	41	42	32	1.6
Eric Blais	48	40		41	2.1
Peermamode	252	90	70	50	2.5
Eric Jolicoeur	261	96	120	75	3.8
Wendy		216	104	81	4.1
Ah Kang	162	118	97	83	4.2
Raffaut	108	112	162	103	5.2

Table A1-3 summarizes numbers of fish model lengths recorded (out of 20) by each participant during each of four training sessions, and as such provides an index of 'efficiency'. The larger the number, the more effective the participant was in locating and recording the fish models. (To facilitate comparison between participants, numbers were raised for those who took part in less than four training sessions). The main point to note here is the greater 'efficiency' of participants from Shoals Rodrigues compared with those from FPS. This is largely a reflection of the greater experience of the Shoals Rodrigues participants with both snorkelling and underwater monitoring. The Shoals Rodrigues participants also showed less bias and greater accuracy in fish model length estimation than the FPS participants, for the same reasons.

Table A1- 3. Summary of 'efficiency' in underwater fish length measurements during four training sessions by eight participants

Efficiency	Training session 1	2	3	4	Total
Jovani	20	20	20	20	80
Charles	20	20	20	20	80
Eric Blais	20	20		20	[80]
Ah Kang	18	18	20	18	74
Peermamode	19	18	19	18	74
Wendy		17	18	18	[71]
Eric Jolicoeur	19	10	19	19	67
Raffaut	12	15	17	16	60

Of the 20 fish models, 10 were painted white and 10 were painted black. Underwater, contrast is often reduced, but can play an important role in perception of size. However, in this series of training session there appears to have been no significant difference in sightability or size estimation of black or white models.

Sightability: during all four training sessions, the five FPS participants between them missed a total of 27 black models and 21 white models. Although more black models were overlooked than white ones, the difference between the numbers missed is not statistically significant (chi-squared = 0.75, df = 1, NS).

Size estimation: during the fourth and final training session, data from all eight participants produced the following relationships between estimated length and true length for the black and the white models:

Black models: Estimated length = 0.981 x true length
$r^2 = 0.74$
n = 75

White models: Estimated length = 1.038 x true length
$r^2 = 0.88$
n = 74

Although the black models were on average estimated to be slightly shorter in length than the white models the difference was again not statistically different (Z test). The implication is that hue had little impact on size estimation.

Annex 2

Fish Species caught by Different Fisheries

Table A2-1. Importance of different fish species within the artisanal seine net fishery ranked by number of individuals landed, for the three years, 2002-04 (after Lynch et al., 2005b)

Species	2002	2003	2004
Siganus sutor	1	1	1
Lethrinus nebulosus	3	4	2
Caranx melampygus	5	7	3
Gerres longirostris	4	3	4
Acanthurus triostegus	7	9	5
Valamugil seheli	18	10	6
Mulloidichthys flavolineatus	2	2	7
Upeneus vittatus	-	15	8
Scarus sordidus	-	12	9
Mulloidichthys vanicolensis	9	5	10
Naso unicornis	6	16	11
Acanthurus spp.	-	29	12
Scarus ghobhan	19	19	12
Lethrinus mahsena	27	38	14
Sphyraena jello	-	14	15
Siganus argentus	8	6	19
Myripristis murdjan	-	8	-
Mugil cephalus	17	11	38
Valamugil robustus	-	13	-
Parupeneus barbarinus	13	18	20
Chanos chanos	12	20	53
Rhinecanthus aculeatus	11	21	26
Scarus spp.	10	26	-
Fistularia commersonii	14	40	35

Table A2-2. Importance of different fish species within the artisanal basket trap and line fisheries by numbers of individuals sampled, for the year 2002 (after Lynch et al., 2003)

Species	Basket Trap	Species	Line
Siganus sutor	479	*Epinephelus spilotoceps*	568
Parupeneus rubescens	130	*Siganus sutor*	55
Epinephelus spilotoceps	54	*Mugil* spp.	41
Acanthurus triostegus	42	*Mulloidichthys flavolineatus*	40
Mulloidichthys flavolineatus	39	*Epinephelus melanostigma*	24
Siganus rivulatus	38	*Sphyraena putnamae*	17
Scarus ghobhan	33	*Gerres longirostris*	12
Acanthurus spp.	31	*Ctenochaetus striatus*	9
Calotomus carolinus	25	*Epinephelus* sp.	8
Caranx melampygus	23	*Apogon* sp.	7
Naso unicornis	21	*Sphyraena flavicauda*	6
Ctenochaetus strigosus	19	*Epinephelus merra*	6
Naso brachycentron	11	*Naso unicornis*	5
Lethrinus nebulosus	7	*Lethrinus nebulosus*	5
Scarus enneacanthus	6	*Lutjanus kasmira*	2
Scarus spp.	6	*Naso brachycentron*	1
Scarus russelli	5	*Scarus psittacus*	1
Parupeneus barbarinus	5	*Rhinecanthus aculeatus*	1
Zanclus cornutus	5	*Gnathodentex aurolineatus*	1
Acanthurus mata	4	*Naso lituratus*	1
Chaetodon auriga	4	*Cheilinus chlorurus*	1
Scarus rubripinne	3	*Lethrinus harak*	1
Caranx sexfasciatus	3	*Lethrinus mahsena*	1
Acanthurus nigrofuscus	3	*Zanclus cornutus*	1
Acanthurus tennenti	3	*Chaetodon trifasciatus*	1
Kyphosus spp.	2		
Epinephelus tauvina	2		
Echidna nebulosa	2		
Scarus pyrrhurus	2		
Cheilinus trilobatus	2		
Rhinecanthus aculeatus	2		
Siganus argentus	2		

Annex 3

Fishes of Rodrigues – potential updates to checklist of Heemstra et al. (2004)

Heemstra et al. (2004) presented a checklist of coastal fishes known from Rodrigues up to 2003. They recorded a total of 493 species, most on the basis of specimens or photographs, but a few on the basis of sight records. During the course of fisheries and reef monitoring (particularly sampling of seine net catches), Shoals Rodrigues staff have recorded a number of fish species not reported by Heemstra et al. (2004). There are 26 potential new records, which are listed below (and marked with an asterisk, *; more doubtful records are marked with a question mark). In addition a number of recent nomenclatural changes are noted.

Carcharinidae (Requiem Sharks)

**Carcharhinus amblyrhynchos* (Bleeker, 1856)
One Grey Reef Shark reported caught off the north coast on 23.9.05 by big game fishing boat *Black Marlin* (Yann Colas, skipper, pers. comm. to RCA, 25.9.05).

Belonidae (Needlefishes)

Tylosaurus crocodilus (Peron and LeSueur, 1821)
Recorded by Lynch et al. (2004a, 2005b). Heemstra et al. (2004) recorded *Tylosaurus* sp. As noted by Heemstra et al. (2004: Table 2), specimens are required to confirm identification.

Holocentridae (Soldier and Squirrelfishes)

**Myripristis violacea* Bleeker, 1851
Recorded by Lynch et al. (2005a). Not recorded by Heemstra et al. (2004).

[*Sargocentron cornutum* (Bleeker, 1853)
Recorded by Lynch et al. (2004a). This is a western Pacific species, and was not recorded by Heemstra et al. (2004). Probable misidentification.]

Syngnathidae (Pipefishes and Sea Horses)

*Seahorse
One unidentified seahorse recorded by Lynch et al. (2005a: Table A12), from lagoon algal/seagrass sampling site L1. Not recorded by Heemstra et al. (2004).

Fistulariidae (Flutemouths)

Fistularia commersonii Rüppell, 1838
Heemstra et al. (2004) recorded *Fistularia* sp. This species recorded by Lynch et al. (2003, 2004a, 2005b). This is a shallow-water species, and is characterized by the presence of blue markings; the only other species likely to occur is *Fistularia petimba*, which lives in deepwater and has red markings.

Serranidae (Groupers)

**Epinephelus melanostigma* Schultz, 1953

Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004).

**Epinephelus spilotoceps* Schultz, 1953
Recorded by Lynch et al. (2003, 2004b, 2004c, 2005a). Not recorded by Heemstra et al. (2004).

Pseudochromidae (Dottybacks)

Chlidichthys foudioides Gill and Edwards, 2004
Recorded by Heemstra et al. (2004) as *Chlidichthys* sp.

Haemulidae (Sweetlips)

**Plectorhinchus gibbosus* (Lacepède, 1802)
Recorded by Lynch et al. (2005b). Not recorded by Heemstra et al. (2004).

Lethrinidae (Emperors)

**Lethrinus lentjan* (Lacepède, 1802)
Recorded by Lynch et al. (2004a). Not recorded by Heemstra et al. (2004).

**Lethrinus olivaceus* Valenciennes in C. & V., 1830
Recorded by Lynch et al. (2004a, 2005b). Not recorded by Heemstra et al. (2004). Note that this species is easily confused with *Lethrinus microdon*.

**Lethrinus rubriopercularis* Sato, 1978
Recorded by Lynch et al. (2004a, 2005b). Not recorded by Heemstra et al. (2004).

**Lethrinus xanthochilus* Klunzinger, 1870
Recorded by Lynch et al. (2004a, 2005b). Not recorded by Heemstra et al. (2004).

Mullidae (Goatfishes)

**Parupeneus rubescens* (Lacepède, 1801)
Recorded by Lynch et al. (2003, 2004b, 2005b). Not recorded by Heemstra et al. (2004).

Parupeneus trifasciatus (Lacepède, 1801)
Recorded in several Shoals Rodrigues reports, and by Heemstra et al. (2004) as *Parupeneus bifasciatus*, a junior synonym (Randall and Myers, 2002).

Carangidae (Jacks)

**Caranx sexfasciatus* Quoy and Gaimard, 1825
Recorded by Lynch et al. (2003, 2004a, 2005b). Not recorded by Heemstra et al. (2004).

**Gnathodon speciosus* (Forsskal, 1775)
Recorded by Lynch et al. (2004a, 2005b). Not recorded by Heemstra et al. (2004).

**Scomberoides lysan* (Forsskal, 1775)
Recorded by Lynch et al. (2003 in family Scombridae, 2004a). Not recorded by Heemstra et al. (2004).

Priacanthidae (Bigeyes)

?Priacanthus blochii Bleeker, 1853

Recorded by Lynch et al. (2004a). Not recorded by Heemstra et al. (2004), who did record *Priancanthus hamrur*. *P. blochii* is a deepwater (and round-tailed) species, while *P. hamrur* occurs in shallower waters (and is crescent-tailed). *P. hamrur* seems more the likely of the two to have been caught in the seine net fishery.

Chaetodontidae (Butterflyfishes)

Chaetodon interruptus Ahl, 1923

Referred to in various Shoals Rodrigues reports as *Chaetodon unimaculatus*. For many years the Indian Ocean and Pacific Ocean varieties of this Butterflyfish have been considered 'forms' or subspecies of one Indo-Pacific species (*Chaetodon unimaculatus* Bloch, 1787). Current opinion is that the two forms should be considered as two valid species (Allen et al., 1998; Heemstra et al., 2004).

Pempheridae (Sweepers)

?Pempheris vanicolensis Cuvier, 1831

Recorded by Lynch et al. (2004a). Not recorded by Heemstra et al. (2004); however, they did record two other species of *Pempheris*, with which this species may have been confused.

Pomacentridae (Damselfishes)

**Abudefduf vaigiensis* (Quoy and Gaimard, 1825)

Recorded by Lynch et al. (2004b, 2004c). Not recorded by Heemstra et al. (2004).

Chrysiptera brownriggii (Bennett, 1828)

Recorded by Lynch et al. (2004b) as *Chrysiptera leucopoma*, a junior synonym.

[*Pomacentrus semicirculatus*

Recorded by Lynch et al. (2005a). No such species known. Possible mis-recording of Angelfish *Pomacanthus semicirculatus*?]

?Stegastes punctatus (Quoy and Gaimard, 1825)

Recorded by Lynch et al. (2004b, 2005a) as *Stegastes lividus*, a species now regarded as a Marquesan endemic (J.E. Randall, pers. comm.). Not recorded by Heemstra et al. (2004). Confusion with other species of *Stegastes* possible.

Labridae (Wrasses)

**Anampses geographicus* Valenciennes, 1840

Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004).

**Thalassoma quinquevittatum* (Lay and Bennett, 1839)

Recorded by Lynch et al. (2005a). Not recorded by Heemstra et al. (2004).

Scaridae (Parrotfishes)

Calotomus viridiscens (Rüppell, 1835) / *Calotomus carolinus* (Valenciennes, 1840)

Recorded by Lynch et al. (2003, 2004a) as *C. carolinus*. Recorded by Heemstra et al. (2004) as *Calotomus viridiscens*. These parrotfishes are generally considered to be sibling species, *C. carolinus* being widespread in the Indo-Pacific species, while *C. viridiscens* is confined to the Red Sea. However, the differences between the two are limited to colour

pattern, and as pointed out by Heemstra et al. (2004: Table 2) both forms occur in South Africa, so *C. calotomus* is likely a junior synonym of *C. viridiscens*.

**Calotomus spinidens* (Quoy and Gaimard, 1824)
Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004).

Chlorurus enneacanthus (Lacepède, 1802)
Chlorurus sordidus (Forsskal, 1775)
Chlorurus strongylocephalus (Bleeker, 1854)
Recorded in various Shoals Rodrigues reports under the generic name *Scarus*. Several parrotfish species, including these ones, were split from the genus *Scarus* by Bellwood (1991).

[*Scarus dimidiatus*
Recorded by Lynch et al. (2005b). *S. dimidiatus* is a Pacific species, and this record is likely a misidentification for the Indian Ocean species, *S. scaber* Valenciennes, 1840. The latter was recorded by Heemstra et al. (2004).]

**Scarus prasiognathos* Valenciennes, 1840
Recorded by Lynch et al. (2005b). Not recorded by Heemstra et al. (2004). If confirmed, this record would constitute a significant range extension from the central Indian Ocean.

[*Scarus pyrrhurus*
Recorded by Lynch et al. (2003). *S. pyrrhurus* is a junior synonym of *Chlorurus japanensis* (Bloch, 1789), a western Pacific species. Therefore this record is likely a misidentification.]

[*Scarus rubripinne*
Recorded by Lynch et al. (2003). *Scarus rubripinne* is a junior synonym of *Sparisoma rubripinne*, which is an Atlantic species. Therefore this record is likely a misidentification.]

**Scarus viridifucatus* (Smith, 1956)
Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004).

Mugilidae (Mullets)

**Crenimugul crenilabis* (Forsskal, 1775)
Recorded by Lynch et al. (2005b, as *Crenimugul crenilabrus*). Not recorded by Heemstra et al. (2004).

Sphyraenidae (Barracudas)

**Sphyraena flavicauda* Rüppell, 1838
Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004).

**Sphyraena jello* Cuvier, 1829
Recorded by Lynch et al. (2004a, 2005b). Not recorded by Heemstra et al. (2004).

**Sphyraena putnamae* Jordan and Seale, 1905
Recorded by Lynch et al. (2003, as *S. putnamiae*). Not recorded by Heemstra et al. (2004).

Gobiidae (Gobies)

Amblyeleotris fasciata (Herre, 1953)

Recorded by Heemstra et al. (2004) as *Amblyeleotris wheeleri*, which is apparently a junior synonym of *A. fasciata* (J.E. Randall, pers. comm.).

Gobiodon prolixus Winterbottom and Harold, 2005
Recorded by Heemstra et al. (2004) as *Gobiodon* sp. A.

Acanthuridae (Surgeonfishes)

?Acanthurus mata (Cuvier, 1829)
Recorded by Lynch et al. (2003). Not recorded by Heemstra et al. (2004). Note that this is an open water species that normally feeds on zooplankton, up above the reef. It seems less likely than most other *Acanthurus* species to be caught in a basket trap, as reported by Lynch et al. (2003).

Ctenochaetus truncatus Randall & Clements, 2001
Recorded in several Shoals Rodrigues reports as *Ctenochaetus strigosus*. *C. truncatus* is an Indian Ocean member of the *C. strigosus* species complex, *C. strigosus* itself now being considered an Hawaiian endemic (Randall and Clements, 2001; Heemstra et al., 2004).

**Naso brachycentron* (Valenciennes, 1835)
Recorded by Lynch et al. (2003, 2005b). Not recorded by Heemstra et al. (2004).

Naso elegans Rüppell, 1829
Recorded in various Shoals Rodrigues reports and by Heemstra et al. (2004) as *Naso lituratus*. Randall (2001) demonstrated that the Pacific (*lituratus*) and Indian Ocean (*elegans*) forms are distinct, and treated them as separate species.

Siganidae (Rabbitfishes)

**Siganus rivulatus* Forsskal, 1775
Recorded by Lynch et al. (2003). Recorded by Heemstra et al. (2004) as possibly occurring (see their table 2 for discussion of Rodrigues record). Note that this species occurs in the Red Sea, in some western Indian Ocean locations, but several western Indian Ocean records are apparently unconfirmed (Smith and Heemstra, 1986).

Istiophoridae (Billfishes)

Makaira nigricans Lacepède, 1802
Recorded from Rodrigues by Heemstra et al. (2004) as *Makaira mazara*. Blue marlins have long been considered to belong to two geographically separate species, the Indo-Pacific blue marlin, *Makaira mazara*, and the Atlantic blue marlin, *M. nigricans*. However, genetic analysis has demonstrated that there is but one circumtropical species (Graves and McDowell, 1995; Buonaccorsi et al., 1999). This position is followed by the Indian Ocean Tuna Commission, but not by Fishbase.

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Annex 4

Cetacean Records

It is likely that over 20 species of whale and dolphin regularly inhabit the waters around Rodrigues. However, to date there has been no survey of cetaceans in this area. Below are five records of cetaceans collected incidentally during September 2005.

Bottlenose Dolphin (*Tursiops truncatus*)
A group of about three bottlenose dolphins seen by RCA and Shoals Rodrigues staff off Port Mathurin (at about 19°40'S 63°26'E) on 21.9.05. According to Yann Colas, (game fishing boat skipper, pers. comm., 25.9.05), dolphins which he thinks are bottlenose dolphins occur regularly in large numbers over the drop-off to the east of the island. It seems likely that some Bottlenose Dolphins are resident around Rodrigues.

Sperm Whale (*Physeter macrocephalus*)
One large sperm whale washed up dead at Petite Gravier (SE side of Rodrigues) in about 2000. It was buried on site, and there are apparently plans to displayed the skeleton in a proposed island museum. Some further information is likely to be recorded in local newspapers.

Humpback Whale (*Megaptera novaeangliae*)
It seems likely that Humpback Whales are uncommon but regular austral winter visitors to Rodrigues (as they are to other parts of the subtropical SW Indian Ocean). I am aware of three recent sightings:

1. Four individuals seen by Shoals Rodrigues staff off the NW side of the island in August 2001 (Eric Blais, pers. comm.).
2. One individual seen by game fishing boat off NW side of island (at about 19°39'S 63°14'E) in June 2005 (Yann Colas, skipper, pers. comm., 25.9.05).
3. Two individuals (an apparent mother and calf) present off Port Mathurin for 4-5 weeks, from late July to late August 2005 (Emily Hardman and Eric Blais, pers. comm.).

Annex 5

Itinerary

Sat 17 Sept	Depart Newmarket by coach 0920. Depart London Heathrow (LHR) 1400 on Emirates (EK002) for Dubai. Arrive Dubai 2355.
Sun 18 Sept	Depart Dubai 0255 on EK701. Arrive Mauritius 0940. Depart Mauritius 1425 on Air Mauritius (MK131). Approach Rodrigues 1600; weather too bad to land; return to Mauritius. Arrive Mauritius 1745. Depart Mauritius 1945. Arrive Rodrigues 2115. Late arrival not expected; taxi to guesthouse (Residence Foulsafat at Jean Tac).
Mon 19 Sept	Full day at Shoals Rodrigues office. Orientation meeting with Shoals Rodrigues Director Eric Blais and Scientific Officer Dr. Emily Hardman. Briefing to Shoals staff on purpose of visit. Read relevant Shoals documents.
Tues 20 Sept	Morning at Shoals Rodrigues office. Continue orientation, reading reports. Finalize preparation of plywood fish models. Afternoon visit to sites of two proposed marine reserves (Riviere Banane and Anse aux Anglais). Coral cover at first site (Aquarium) impressive, but lack of large fish, and predatory fish in particular, very obvious.
Wed 21 Sept	Morning at Shoals Rodrigues office. Presentation and briefing for Shoals Rodrigues staff plus officials from Fisheries Protection Service (7) and Fisheries Research and Training Unit (2). Afternoon visit site of proposed marine reserve (Anse aux Anglais). Dive on outer reef slope with Eric Blais and Emily Hardman.
Thur 22 Sept	Morning at Shoals Rodrigues office. Midday meeting with Yann Colas, skipper of game fishing boat to discuss options for Shoals Rodrigues to charter boat for survey work beyond reef. Afternoon (first) training snorkel at Grand Baie (sheltered, shallow site). Snorkelling and reef fish monitoring training session for officers of Fisheries Protection Service (5) and Shoals Rodrigues (2). Evening discussions with Shoals staff on problems relating to implementation of marine reserves.
Fri 23 Sept	Morning (second) training snorkel at Ile Hollandais (shallow reef flat). Snorkelling and reef fish monitoring training session for officers of Fisheries Protection Service (6) and Shoals Rodrigues (2). Afternoon at Shoals Rodrigues office. Compilation of data; radio interview given by Eric Blaise and Charles Anderson to Mauritius Broadcasting Corporation. Residence Foulsafat pre-booked for weekend and full; transfer to Hotel Les Cocotier, Anse aux Anglais.
Sat 24 Sept	Morning walk along coast to Port Mathurin then inland to Mont Lubin, and return. Afternoon preparation of list of potential revisions to checklist of fishes of Rodrigues.
Sun 25 Sept	Visit to Ile aux Cocos, island seabird sanctuary. Return late afternoon. Evening meeting with Yann Colas, skipper of game fishing boat to continue discussion of options for Shoals Rodrigues to charter boat for survey work beyond reef.
Mon 26 Sept	Morning at Shoals Rodrigues office. Updating checklist of fishes of Rodrigues.

	Afternoon (third) training snorkel at Ile Hollandais (shallow reef flat) with staff of Fisheries Protection Service (5) and Shoals Rodrigues (1). Evening transfer from Hotel Les Cocotiers to Residence Foulsafat.
Tues 27 Sept	Morning at Shoals Rodrigues office. Data compilation and analysis. Afternoon (fourth) training snorkel at Ile Hollandais (shallow reef flat) with staff of Fisheries Protection Service (5) and Shoals Rodrigues (2).
Wed 28 Sept	Morning at Shoals Rodrigues office. Data compilation and analysis. Afternoon final debriefing for trainees from Fisheries Protection Service. Preparation of final report. Late afternoon visit to Oyster Bay to see endemic Rodrigues fruit bats.
Thur 29 Sept	Morning at Shoals Rodrigues office. Presentation of results and recommendations to Shoals Rodrigues staff. Report writing. Depart Shoals Office 1500. Depart Rodrigues by Air Mauritius (MK131) 1645. Arrive Mauritius 1815. Depart Mauritius (EK702) 2340.
Fri 30 Sept	Arrive Dubai 0615. Depart Dubai (EK001) 0845. Arrive London Heathrow 1245. Depart Heathrow by coach 1515. Arrive Newmarket 1805.