Sustainable Management of the Black Land Crab, Gecarcinus ruricola, Colombia (162/11/015)

Final Report, April 2005

Darwin Initiative for the Survival of Species

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Final Report

1. DARWIN PROJECT INFORMATION

Project title	*Sustainable management of the black land crab (Gecarcinus ruricola)*
Country	Colombia
Contractor	Heriot-Watt University
Project Reference No.	162/11/015
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Staring/Finishing dates	April 2002 – March 2005

2. PROJECT BACKGROUND/RATIONALE

The Archipelago of San Andres, Old Providence and Santa Catalina is located in the Western Caribbean. Part of the West Indies, these islands are Colombia's only oceanic and historically English-speaking department. Declared the Seaflower Biosphere Reserve in November 2000 by the Man and the Biosphere (MAB) Programme of the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), this archipelago is one of the most isolated island regions in the Americas. It is made up of three small inhabited islands - San Andres Island (SAI), Old Providence and Santa Catalina (OPSC), and several uninhabited cays. The terrestrial area is 57 km^2, while the marine area is approximately 300,000 km^2 covering about 10% of the Caribbean Sea. Maritime borders are shared with Jamaica, the Cayman Islands, Honduras, Nicaragua, Costa Rica and Panama. The largest island, SAI, is 800 km north-west of Colombia's north coast, 200 km east of Nicaragua, and 725 km south of Grand Cayman at 12° 32' N and 81° 43' W. The islands of OPSC, which are separated by a 150m channel and connected by a footbridge, are located in the middle of the archipelago 80 km north of San Andres at 13°20' N and 81°22' W.

In the San Andres Archipelago, the black land crab, or 'Cangrejo Negro', is a symbol of cultural identity as well as a major source of protein and economic subsistence. Despite the conspicuous presence of the black land crab and its role within the socio-economic structure of the local demography, it has until recently attracted surprisingly little attention, with the species largely being known to science as a "museum piece" (Richmond 2003). In 1999 at a series of community meetings in the western Caribbean Archipelago of San Andres, Old Providence, and Santa Catalina (Colombia), participants were asked to rank 15 coastal and marine resources according to value. Over 60% ranked the black land crab first, over 90% placing it in the top five. Although these crabs are a major local food source, a figure in folklore, and a symbol of cultural identity (San Andres natives are known as 'black crabs', and sociologists have coined the term "crab antics" to define West Indian cultural behaviours), this ranking was not anticipated. Consequently, a literature review found that although a certain amount of research has been undertaken on several American tropical and subtropical land crabs, the lack of information on *Gecarcinus ruricola* was striking. In the Archipelago, this crab is under increasing pressure. Harvested by many islanders for subsistence, there are also families who survived solely from marketing black crab products (e.g. out of a total of 1,100 families in Old Providence, the number rose from 15 in 1997 to over 60 in 1999) with many more supplementing their income exploiting this resource. Other threats included a proliferation of vehicles, inadequate waste management and habitat loss, as this tropical land crab depends upon forested areas. Given the demand for this species, the local environmental agency CORALINA identified that developing management initiatives and education tools to conserve, recover, and promote sustainable use, would aid in the conservation of a significant tropical species and provide a viable economic alternative to alleviate growing poverty in these islands. This proposal was then developed with Heriot-Watt

University, Scotland who has worked with CORALINA on other marine resource management initiatives.

3. PROJECT SUMMARY

The logical framework for this proposal is provided as Appendix 5. The general objective of the project was to conserve and ensure future sustainable exploitation of the black land crab by developing management initiatives education tools, and studying the potential for terraculture of this species, to help eliminate growing poverty, while serving as a model for regional action. Specific objectives were identified in 4 key work areas:

1. Information gathering
   The information base on the black land crab would be improved by carrying out the biological and socio-economic research needed for management planning and to determine the validity of terraculture as a possible management option.
2. Management planning
   Management planning would be developed towards conservation and sustainable use of the black land crab. This would be developed alongside socio-economic analyses, including a feasibility study of the potential for terraculture in the Archipelago.
3. Implementation
   Initiatives defined in the management plan would be put into place, including strengthening of the policy and regulatory framework, initiation of a monitoring program for species conservation and recovery, establishment of a Black Crab Conservation Unit if supported, and the design of a model terraculture project, if proved viable.
4. Training and education
   CORALINA personnel/local community groups would be trained in resource management techniques, with the simultaneous development of a public awareness campaign.

Article 7 (Identification and Monitoring) of the Convention on Biological Diversity perhaps best describes the main component of the project, as the basic necessity was to gather biological and socio-economic information which would aid in the development of management planning. Article 10 (Sustainable Use of Components of Biological Diversity), however, also featured high on the project's priorities, with the promotion of proactive co-operation between scientists, regulating agencies and communities in future management of the black land crab as a resource.

With respect to achieving the objectives, the project team note the following:

1. Information gathering
   There is now an improved understanding of the biology and ecology of the crab, including reproductive and migration behaviour, population structure, growth, mortality, size frequency distribution, sexual dimorphism, weight-length relationships, fecundity, recruitment, distribution, and abundance. The results of a comprehensive biological monitoring programme are published in MSc theses, the black land crab management review, and are in the process of being printed by or submitted to peer-review journals.

   There is also an improved understanding of the characteristics of the black land crab catchery including levels of catch and effort, catch areas, and the socio-economics of local communities dependent upon this resource. The results of a comprehensive catchery monitoring programme are published in the black land crab management review, with one paper submitted to a peer-review journal. The prospects for terraculture of this species have also been examined in both an MSc thesis and a professional appraisal (appended to the management review).

2. Management planning
   In the latter half of year 3, a combination of management workshops and follow up meetings with crab catchers has resulted in a significant level of participation of local communities in

the assessment and development of future management planning. A management review has been produced, which is strongly based on the results of this proactive approach, and recommendations have been made for future management. Many aspects are backed by catchers, including the formation of a Black Crab Conservation Unit (BCCU), and the implementation of various management measures, such as minimum size limits for captured crab.

3. Implementation

The management review was produced in March 2005. At this stage it is anticipated that the formation of the BCCU will occur in mid-2005. It is expected that the regulatory recommendations will be considered by both CORALINA and the BCCU for implementation this year. Continued biological and catchery monitoring recommendations form part of the management review. The degree to which they are followed, however, will depend upon human and financial resources available. The development of terraculture initiatives for stock enhancement on the islands will not happen soon, as there are many constraints with respect to costs and technical support. There are also questions of methodology to be resolved. This will need further investigation. Terraculture for grow-out to market size is not considered to be a viable prospect for the islands. It was not deemed necessary to produce a terraculture manual.

4. Training and education

CORALINA personnel and representatives from the local communities have successfully completed training programmes on crab biology, ecology and monitoring; and community based resource management. Considerable on the job training in biological survey techniques also took place for both CORALINA personnel and crab catchers. As part of the project an education programme on black crab was developed and implemented. For children this included the formation of crab clubs; and the conduct of fun activities, vacations and festivals. For the general communities, initiatives included workshops and talks. Perhaps the more visible and outstanding achievements have been the production of a professional educational documentary on the project; the production of a pop song and video; the integration of black crab studies into the school's curricula beginning this year; and the production of a black crab lore book and children's activity book.

4. SCIENTIFIC, TRAINING, AND TECHNICAL ASSESSMENT

4.1 Biological and Ecological Research

The biological and ecological research was led by Dr Richard Hartnoll, the UK's leading land crab expert. All CORALINA personnel, funded through the project, took an active part in the monitoring programmes. Crab catchers also played a major role in locating crab for biological analyses. Two students from Heriot-Watt University also travelled to the San Andres Archipelago to undertake dissertations on specific aspects. The following sections provide the main approaches and findings of the biological research programme.

Stock Assessment

It is difficult to assess the numbers of black crab. Firstly because they live in burrows, or under rocks, so that it is hard to count their refuges. Secondly they are generally only active at night, and their activity varies greatly with environmental factors such as moonlight and rainfall.

Two approaches to stock assessment were considered. One was mark and recapture, based on capturing active crabs on the surface by night, and marking them. Then on a later occasion the number of marked and unmarked crabs was counted, enabling a population estimate. This approach was not used for three reasons. Firstly, the number of recaptures of marked crabs was generally too low to give reliable estimates. Secondly, the level of surface activity was so variable, depending on rainfall and moon phase, that results were unreliable. Thirdly, it was logistically difficult to mobilise work teams by

night for a comprehensive survey. This method will almost certainly overestimate numbers, due to crab mobility.

The second approach was to work by day, determining the number of crabs in marked quadrats by searching refuges and excavating burrows. This method is not affected by the level of activity of crabs, and is logistically simpler (and safer) to organise. It will tend to underestimate the number of crabs. This was the method used, a detailed account of which, and the analysis of data and results obtained, are presented in Atkin (2004). To briefly summarise the methods, use was made of existing GIS land use maps of each island. Each island was divided into watersheds, and within each watershed areas of 'forest' and 'crop' were identified (these being the habitats likely to support black crab). A number of sites were selected in proportion to area, and five 5 m by 5 m quadrats worked at each site, to estimate numbers of black crab. The results of the 2003-4 stock assessment are summarised by watershed and habitat in Table 1 for SAI and Table 2 for OPSC. Total numbers on each island are given in Table 3.

Table 1 Crab Abundance on SAI, 2003-4 Survey

Watershed	Mean Crabs per $25m^2$	Mean Crabs Forest ($25m^2$)	Mean Crabs Crop ($25m^2$)	Estimated Total Population	Total Pop in Forest	Total Pop in Crop
South	1.6	1.94	1.05	133,000	100,000	33,000
East	0.9	1.2	0.4	130,000	116,000	19,000
West	2.95	3.8	0.84	415,000	369,000	37,000
Cove	0.9	1.1	0.3	65,000	64,000	4,000
North	0.88	0.88	-	30,000	30,000	-

Table 2 Crab Abundance on OPSC, 2003-4 Survey

Watershed	Mean Crabs per $25m^2$	Mean Crabs Forest ($25m^2$)	Mean Crabs Crop ($25m^2$)	Estimated Total Population	Total in Forest	Total in Crop
Bailey	0.3	0.33	-	16,000	15,000	-
Bowden	2.6	3	1.1	293,000	258,000	29,000
Fresh Water	11	10.9	11.5	818,000	734,000	81,000
Gamadith	4.4	4.4	-	406,000	406,000	-
Gareth	-	-	-	-	-	-
Lazy Hill	3.9	3.9	4.4	308,000	290,000	20,000
McBean	1.8	2.3	0.85	83,000	77,000	11,000
SC South	10.7	10.7	-	178,000	161,000	-
SC North	8.7	8.7	-	67,000	67,000	-
Smooth Water	6.1	7.8	1.05	188,000	181,000	7,000
South West	13.8	14	13	558,000	453,000	105,000

Table 3 Estimated Total Crabs for Each Island and Habitat

Island	Total Crabs on Island	Total Crabs in Forest	Total Crabs in Crop
SAI	772,000	678,000	94,000
OPSC	2,895,000	2,642,000	253,000

The following conclusions can be drawn:

- On both islands the density of crabs in 'crop' areas is generally lower than in 'forest' areas.

- On both islands the great majority are found in forest areas, which cover a greater area (859 Ha forest, 350 Ha crop on SAI: 1200 Ha forest, 190 Ha crop on OPSC), especially in OPSC.
- Both density and total number of crabs vary greatly between watersheds. On SAI the 'West' watershed has the densest crabs and the highest total. On OPSC this is so for the 'Freshwater' and 'South West' watersheds.
- The overall density of crabs on SAI is about 650 per hectare. On OPSC it is much higher, about 2050 per hectare.
- The total population estimates are of the order of 800,000 for SAI and 3,000,000 for OPSC. These are minimum values, but the degree of underestimate cannot be evaluated.

The results of the stock assessment exercise also indicated that there were roughly equal numbers of each sex in the populations.

Population size data are extremely important inputs to management strategies, but what we have is limited in scope. The relative differences in density and abundance between SAI and OPSC can be accepted with some confidence: they were completed using the same methods at the same time. However, the absolute values may be considerable underestimates. We have no reliable time series, which would indicate whether the population size was changing. The other problem is that only the larger crabs are assessed – relatively few specimens below 40 mm CW are recorded. This may be because they are rare, or because the survey methods are size-sensitive – again we do not know. Consequently, this lack of juvenile data, combined with the intermittent and unpredictable recruitment years, makes predicting the effects of different exploitation levels very difficult.

Growth and Age of Land Crabs

The growth rate and age of land crabs have both been poorly studied, because they are difficult topics. However, there is a general consensus that they grow slowly and live a long time (well over ten years). They must moult by shedding their shells, and at this time they are very vulnerable and hide in their burrows. As a result there are few observations of moulting, but it tends to occur during the wet seasons. For mature crabs, at least, it is thought that they only moult once a year. This slow growth and long life have major management implications. If the stock is over-exploited, then replacement by growth of juveniles will be a slow process. If cultivation is considered, then the return on investment will not be rapid.

Breeding Migration

The migration monitoring programme had the following aims:

1. *To determine where the migration occurs*. For the purpose of monitoring, the migration zones were divided into sections. Activity was recorded in each section.
2. *To determine when migration occurs*. Surveys were carried out regularly, normally in the evening at around 20 00. When there was little activity these surveys were carried out every second day. When migration was active, they were completed daily. Records were kept of the weather conditions, especially of rain at the time, or in the previous 24 hours.
3. *To determine the type of crabs migrating*. Crabs were measured (carapace width), and classified as: males; females without eggs; females with early eggs; females with late eggs. Where crabs were very numerous it was deemed sufficient to examine a sub-sample of 50 crabs. It is difficult to distinguish early and late eggs by torchlight, so a sample of eggs from each female was placed in tubes with alcohol for the egg stage to be examined the next day.
4. *To estimate the number of crabs migrating*. It is not possible to estimate the number of crabs migrating in the course of a night: with the resources available the project team could only obtain a relative estimate of the intensity of migration by counting the crabs on the road at a specific time. Counts/estimates were, for consistency, limited to crabs actually on the road, but note was also made of very large congregations seen on the roadsides. If the number of crabs in a section was small (<50), a total count was made. If more, then an estimate was required. Usually the dense numbers of crabs were limited to part of a section. To estimate the number, an estimate of

the length of road with dense crabs was made, alongside the number of crabs on 1 metre length of road

The breeding migration is a regular annual event, but it varies in timing and intensity from year to year. On SAI in 2003 it extended from 22 April to 5 July, with peak migrations in early and late June. In 2004 it lasted from 14 April to 12 July, with a major peak in mid May. On OPSC in 2003 it lasted from 19 May to 10 June (probably longer, but records unavailable), with no prominent peaks. In 2004 it was from 25 April to 7 July, with a large peak in mid May. The peak migrations show some correlation with moon phase, but are more strongly influenced by rainfall, though not in a consistent way. The lengthy migration season, with its unpredictable peaks, makes the framing of protective legislation difficult. If framed too broadly, they will cause unnecessary disruption, and become largely ignored.

Another feature of the migration is that it is composed predominantly of females – roughly 90%. In some other land crabs (e.g. *Gecarcoidea*) the sexes migrate in roughly equal numbers, and they mate near the sea. This is not the case in the black crab, mating in most cases occurs earlier, and few males migrate to the sea. Project data was collected from migrating crabs crossing the coast roads. Particularly later in the season, the majority of specimens consisted of females carrying eggs which were near to hatching. Each female produces only one batch of eggs per year, and makes only one annual migration to the sea. The result of this female domination during the migration is that the females will be put under particularly heavy exploitation pressure at this time.

The migrations do not occur randomly, but are concentrated along particular stretches of the western sides of both SAI and OPSC. Within these stretches of coastline, migration is not evenly distributed. The control zones, where traffic flow and catching are regulated during the migration season, are designed to encompass the main migration areas. On SAI, this was proven not to be the case, with reconsideration required for future management.

Size Frequency Distribution and Growth

There are several data sets on size-frequency distribution. One is from market sampling from the processors. A second is from measurements made of migrating crabs. For diverse reasons both of the above will provide biased estimates of population size structure. The most reliable estimate of population size structure is from the stock assessment exercise, though this will underestimate small size classes as they are less likely to be captured. There are two clear results. Overall, males are larger than females: either they grow faster, or they live longer because they do not undergo the same risk during the breeding migration. Secondly, crabs are larger on OPSC: this may be because conditions for growth are superior, or because they are subject to lower mortality due to less catching pressure. The market sampling data indicates that the catchery is concentrated on the larger specimens within the population.

For management purposes an understanding of age and growth rate is extremely important, but it a major gap in our knowledge for not only the black crab, but for land crabs in general. This is because age is very hard to determine in crustaceans, because every time they increase in size they shed their skeleton, losing all record of their previous growth history (in contrast fish can be aged by their scales, tortoises by their shell, and so on). Nevertheless, the project team made a best estimate. The limited data available indicated that adult black crab moult only once a year, and increase in width by about 5%. It is assumed that a crab is five years old when it reaches maturity at 50 mm CW – this matches assumptions for other similar species. With a 5% moult increment, a crab >100 mm CW (the largest found in this study) will be 20 years old; with a more generous 10% increment assumed, it will still be 13 years old. So the mature (and exploited) population is comprised of many year classes. If it is seriously depleted by over-exploitation, it will take many years to replenish from the juvenile population, assuming that the latter is present in adequate quantity.

Fecundity

It is necessary to know how many eggs (and thus how many larvae) females of different size produce, so that the effects of demographic change on potential recruitment can be estimated. During the migration

period, a sample of females was captured for analysis (removal of eggs and microscopic counting). The majority of females captured carried late stage eggs, near to hatching. It is believed that after laying eggs, females shelter in refuges until the eggs are ripe, and then emerge and migrate the final leg to the sea (during which time they were captured crossing the coast road). Some eggs are lost during incubation, but the number of ripe eggs is the biologically relevant variable, since it dictates the number of larvae released. Results indicate that a female may carry between 28,000 and 120,000 eggs, and that fecundity increases rapidly with size. Doubling the width increases the fecundity eightfold. So from the management standpoint, to ensure good recruitment means conserving a stock of large (and thus old) females.

Seasonal Ripening of Gonads

Reproduction is a highly seasonal phenomenon in the black crab, so it is to be expected that this will result in seasonal changes in gonad condition. This was examined by inspecting monthly samples of crabs of reproductive size (>60 mm CW) from November through to May. In males there was a high proportion of small vas deferens in November, but this had increased considerably by March. It is assumed that the main mating season is around the start of the migration period in April-May. In females the ovaries were nearly all immature, on the basis of both size and colour, from November through to January. From February onwards they began to mature, and by May they were ripe in the majority of females in time for the breeding migration and the production of eggs. The management implication is that the migrating females are not only easy to capture, but they are also in the optimal condition for eating, with large ovaries and maximum 'meat' content. Once they have laid eggs they are less desirable. Hence there may be resistance from catchers to proposals seeking to delay capture until after the breeding females have released larvae.

Size at Sexual Maturity

In males the size at sexual maturity was estimated by examining the size of the vas deferens. A clearly enlarged vas deferens is evidence that sperm are being produced and stored, though it may not be proof that crabs of that size are actually mating. The data indicated that males become sexually mature at about 50 mm CW.

For females there are more criteria that indicate maturity, e.g. the size and colour of the ovaries as they ripen, changing from pale yellow to green-brown. The presence of sperm in the spermathecae is evidence that they have mated. Finally, eggs carried underneath the abdomen provide proof that they are actually breeding. All observations again indicated a size at maturity of about 50 mm CW. Catchery data show that few crabs below 50 mm are caught, either because they are difficult to find, or more probably because they are not acceptable to the processors. From the management aspect this 'protection' of immature specimens is good. However, they probably live for over 10 years after maturity, breeding annually, with large females producing the most eggs and larvae. So although they probably all live to breed once, heavy exploitation will nevertheless seriously threaten the overall reproductive potential.

Weigh/Length Relationships

This relationship is important, since it is simple to collect data in the field on number and size of crabs, but weighing is more difficult (especially at night with live crabs). However, weight provides a better index of potential yield, and gives a means to evaluate the possible benefits of allowing crabs to grow to a larger size before capture. Weight/length relationships have been determined for each sex on each island, but only the results for males on OPSC are considered here (the others are not greatly different). This relationship shows that a specimen of 50 mm CW weighs roughly 40 g, whilst one of 100 mm CW weighs around 270g. So if the size doubles, the weight increases about seven times. This suggests that it is better to let the crabs grow before catching them, as long as natural mortality is not so great as to reduce the final yield. The information on population structure, with large numbers in the upper size classes, does suggest a low natural mortality.

Recruitment of Young Crabs

The reproductive effort of the black crab is in vain if it does not result in effective recruitment. Due to the

relative isolation of the populations on SAI and OPSC, it is probable that they depend predominantly on self recruitment. This means that the larvae released into the sea must drift and develop for about twenty days, and then if the currents have been favourable, be brought back to land. When this happens successfully the result is a very obvious mass landing of juvenile crabs, though smaller and less obvious returns might occur in other years (but there are no data to support this suggestion). There are no reports (anecdotal or otherwise) of mass larval returns on SAI. On OPSC a mass return was observed by project team members in 2004, and there are anecdotal reports of similar events in 1998, and in 1992. This very intermittent recruitment poses serious management problems in terms of modelling population changes in the face of different levels of exploitation. During the 2004 mass return on OPSC it was estimated that some 500 million megalopas and first crabs crossed the coast road. This seems a vast number in relation to the assessed population of about 3 million, but we have no idea of the mortality patterns affecting these juveniles. The megalopa stage has been described (Hartnoll and Clark, in submission), which will enable its positive identification in any future studies of the pelagic larvae.

Genetic studies of crab stocks

Samples of adult crabs from SAI and OPSC have been collected, as well as of the returning juveniles to OPSC in 2004. Genetic studies are in progress to determine whether the stock on the two islands can be discriminated, and if so, whether the returning juveniles can be attributed to a specific source.

4.2 Catchery Research

The catchery research was overseen by Dr Mark Baine, with assistance from Dr Richard Hartnoll, and involved the participation of the CORALINA project manager, technicians and biologists in the collation of data.

Baseline Socio-economic Survey

In 2003, a series of questionnaires was developed aimed at catchers (sample size of 50), sellers (57) and crab consumers (37 in SAI only), to learn more about the social and economic factors that influence and/or drive the catchery. The following interesting observations were made from subsequent analysis of the data:

(a) Catchers

- The majority of SAI catchers are active 1-16 days/month. In OPSC the majority were active 1-4 days/month. (This apparent low effort in OPSC is not supported by other evidence from catchers)
- Catch amounts ranged from 1 – 18 dozen/trip, though the majority fell in the range 3-6 dozen/trip.
- The majority of catchers in SAI have been active for over 15 yrs, whereas in OPSC the majority have been active for 5-15 yrs.
- 95% of catchers sell their catch in OPSC, 5% selling and consuming. In SAI, 58% sell and consume, 14 % sell only and 28% consume only.
- Crab may be sold as picked crab (meat), claw, live or cooked. In OPSC, there is a concentration on picked crab and claw. In SAI it is on live crab.
- In SAI the major demand for crab, as identified by catchers, is for live crab. In OPSC, it is for meat.
- Some indicative prices from 2003 are: 4,500 pesos for meat per lb (OPSC); 2,230 pesos per dozen crab claws (OPSC); and 1,500–2,000 pesos per dozen live crab (OPSC) and 2,000-3,000 per dozen live crab (SAI). SAI catchers did not provide much information on this aspect of the questionnaire.
- The most productive catching months were identified as March/April in SAI and April/May in OPSC.
- The majority of hunting takes place between 6pm and 11pm.

(b) Sellers

- Sale of crab to consumers is varied with 33% reporting demand on a level of 4 days/month, another 30% reporting daily demand.
- In SAI, the majority sell their crab cooked. In OPSC, the majority is sold as claw.
- In SAI the majority of outlets purchase crab from catchers. The majority purchase once a week. In OPSC the majority of sellers are also catchers.
- In SAI 28% of sellers indicated a weekly spend of 30-60,000 pesos on crab from catchers, 19% less than 25,000 pesos and 12% 90-180,000 pesos.
- Consumers buy more crab in Holy week (Easter)

(c) Consumers

- In SAI 81% of consumers stated that crab was a major part of their diet.
- Interestingly these consumers indicated that in order to obtain crab, 35% sometimes hunted, 32% buy it from catchers, 3% from restaurants, and 8% from grocery outlets/supermarkets.
- The highest demand in SAI is for meat (38%) and live crab (14%), which conflicts with the results of the catcher surveys.
- Consumers would pay around 4-7,000 pesos/lb crab meat.

Catch Areas

Throughout the year, those catchers considered as full-time tend to catch crab in the forest areas of both SAI and OPSC. During the project it has been difficult to gain a complete understanding of the relationship between catchers and catch areas. The indications are that there is no formal division of the islands' forest areas into territories where only some catchers operate. The activity tends to be very much of an open access nature, though at times there appears to be some links between catch areas and residency. Some islanders (non-immigrants), for example, have complained that migration events have occurred in areas where non-islanders are able to collect them quite easily (i.e. outside the closed areas). This appears to relate more to ease of access, the problem also being exacerbated by a general sense of inequity held by islanders when it comes to access to natural resources.

Despite current regulation, migrating crab continue to be easily caught by some catchers, full-time and part-time. The reason for this, particularly in recent years, is that large numbers of crab are now migrating in areas not covered by the regulation. Man-made structures, such as the dam on OPSC, also tend to accumulate large numbers of crab during the migration, their position outside the closed areas (namely > 150m from the shoreline) ensuring a higher level of vulnerability to exploitation.

In an exercise with local catchers in both SAI and OPSC in 2003, maps were developed showing the main areas where catching is undertaken on each island. It is interesting to note that on SAI, the majority of catchery areas are identified in regions considered to have a high abundance of crab. In OPSC, the majority of catchery areas tend to occur in areas considered as having low crab abundance.

Market Sampling

A survey of the sizes of crabs taken in the catchery was carried out by sexing and measuring the crabs of a number of processors. It is assumed that this provides a representative sample of the crabs caught. The survey was carried out from November 2002 to October 2004, and the following totals were measured.

- SAI – 356 males, 346 females.
- OPSC – 223 males and 252 females.

The median values fall in the following size classes:

- SAI males 70-75 mm CW
- SAI females 65-70 mm CW

- OPSC males 85-90 mm CW
- OPSC females 80-85 mm CW

Several points of interest arise.

- The size of sexual maturity is around 50 mm CW. On OPSC no crabs below this size were collected, and on SAI only a very few.
- On each island male crabs collected were larger than females, by about 5 mm CW median size.
- The crabs collected on OPSC were considerably larger than those collected on SAI, in each sex by about 15 mm CW median size.

The sizes were also analysed over time in 3-month bands. Trends were not very clear, but on both islands the smallest median size was found in the May to July period, which covers the migration season. Since most of the migrating crabs are female, and females are generally smaller, this could explain that fact.

The size distribution of the market samples was compared with the size distributions found in the stock assessment exercise. Basically the size distribution in the market samples reflected those found in the stock assessment in two respects: males being larger than females, and crabs on OPSC being larger than those on SAI. However, in both cases the differential was more pronounced in the market sampling. Possible reasons for this are that large males could be bolder, and thus more readily captured. Secondly, that on SAI the greater pressure on the catchery tends towards taking smaller crabs, exaggerating the differential with OPSC.

The other clear difference is that the market sample crabs show a size distribution skewed towards larger sizes, compared to the stock assessment distribution. This is reflected in the lack of small crabs (<50 mm CW), the greater predominance of larger size classes, and a larger median size. There could be two explanations for this. One is a positive selection by the catchers for larger crabs, perhaps driven by the demands of the processors. The other is that larger crabs are bolder, and thus more readily caught on the surface at night. The stock assessment samples were excavated by day in contrast, and thus were hopefully not size sensitive.

Catch and Effort Analyses

During the project CORALINA engaged the help of local catchers in both SAI and OPSC to record the amount of crabs that were caught during each catching trip in the course of 1 year. Approximately 17 catchers took part in this exercise in SAI, and 35 in OPSC. The catchers were provided with log sheets to complete each time they undertook a catching trip. The log sheet requested such information as the date, time, number of hours catching, catch numbers and location. This analysis takes into consideration data gathered between July 03 and June 04. An indication of catch rates in each month over a 12 month period has therefore been provided. This data can be viewed as a useful baseline dataset. Catching trips ranged from 0.5 hrs to 8hrs, but generally a catching trip is approximately 2-3hrs. For all subsequent analyses a catching trip is considered as the Unit of Effort.

From the data collected for SAI it is evident that there are some regular catch locations for some of the catchers. In this instance catch rates per individual location were also examined as well as for the whole island, providing average CPUE for select locations. This was not possible for OPSC.

A detailed analysis of the data is provided in the management review. The following comments are offered on the 2003/04 catch per unit effort data:

- For SAI, the differences in CPUE throughout the year are less pronounced than in OPSC. CPUE is lowest at around 50-56 crabs in January, February, March and then June.
- For the remainder of the year average monthly CPUE varies between 65 and 85, with no obvious consistently high period of the year, though the period July – December does appear to be more productive.

- The average CPUE figures for individual locations do not offer any useful data. They are piecemeal, and at times based on a limited number of catching trips.
- The average annual CPUE for SAI is 62 crabs (22,924 crabs caught during 371 trips).
- For OPSC there is an obvious reduction in CPUE between July and September (40-60), compared with the rest of the year.
- CPUE is highest in OPSC (152) during November though the sample size (catching trips) is lowest. There is no skills bias, however, as the data are supplied by 5 different catchers.
- In general, in OPSC, average CPUE exceeds 100 crabs in October, November, January and then April.
- The average annual CPUE for OPSC is 99 crabs (33,254 crabs caught during 336 trips).
- Annual CPUE in Providence is approximately 160% higher than in SAI.
- Monthly CPUE is higher in OPSC between November and April, compared with SAI data, but lower between July and September

As noted above, a unit of effort is defined as a catching trip. The following data was supplied by CORALINA for catchers operating in SAI and OPSC:

- In SAI, there are 56 crab catchers, 39 considered full-time and 17 who only catch crab during the migration period (part-time).
- In OPSC, there are 124 crab catchers, 56 full time, 43 part-time (mainly catch during the migration period) and 25 unknown. For the purpose of these analyses the 25 unknown catchers will be broken down as full-time (12) and part-time (13). In total therefore, on OPSC it is assumed that there are 68 full-time catchers and 56 part-time catchers.

It is important to note that the definition of full-time, as supplied by CORALINA, encompasses those catchers who catch crab regularly, and sell to processors. A part-time catcher is, by definition, a catcher who catches for personal consumption and/or during the migration period. The following comments on the effort analyses are offered:

- There are a number of catchers in the San Andres Archipelago considered full-time by CORALINA, although their level of effort is more indicative of a part-time catcher. As these catchers have been identified as full-time by CORALINA, these analyses considered them as such in order to ensure consistency with CORALINA's allocation of full-time and part-time definitions to all catchers.
- In SAI individual average effort ranges from 12-16 trips per month.
- In SAI, average effort for full-time catchers appears to increase between March and July compared with the remainder of the year. This coincides generally with the migration season.
- Part-time catchers in SAI range in effort between 1 and 7 trips per month, approximately 50% of whom significantly increase their effort during the migration period, up to 30 trips per month.
- In OPSC average effort ranges from 7-13 trips per month.
- In OPSC, effort seems to peak in November for full-time catchers. Though it is fairly steady throughout the year, there is one noticeable period of reduction between May and July coinciding with the migration period, though observations indicate this as hard to account for.
- Part-time catchers in OPSC generally expend low levels of effort throughout the year or expend considerable effort at specific periods (generally the migration period).

Given the varying nature of the information available for analyses, 2 different approaches were taken to arrive at a total catch figure for each island, related to the full-time or part-time classification. For full time catchers, an estimate of the total catch for all catchers on each island per month was provided, based on average effort and average CPUE. Where there was no average CPUE data for a particular month, the annual average CPUE figure was used as a replacement. The final figures for each month were then summed to provide an estimate of total catch/year. For part-time catchers, the average effort per year for

a catcher was estimated from the available data and then using the total number of part-time catchers and the annual average CPUE, an estimate of total catch for part-time catchers was provided for each island.

Based on the available information for the catchery, and incorporating some large assumptions in the analyses, the indications are that the total annual catch is presently in the region of:

- 500, 000 crabs/year in SAI; and
- 1, 000, 000 crabs/year in OPSC.

These figures should only be viewed as rough indications of the annual level of catching exerted on the catchery. They are not accurate. In light of the figures provided for total population size on each island, however, there is cause for concern.

Also cause for concern, is that these levels of catch are likely to be underestimates. The project team's estimate of numbers of catchers is likely to be much less than the actual number, particularly in SAI where it has been suggested that that there is a significant amount of year round crab catching being undertaken by immigrants from mainland Colombia. The total levels of catch also fail to take into consideration those crabs caught by islanders for traditional island festivities, nor do they cater for what is thought to be a significant subsistence level of catching by those on the island who would not classify themselves as crab catchers in terms of it being an income generating activity.

4.3 Terraculture Research

CORALINA staff member, Mr Arne Britton, undertook an MSc in Marine Resource Management at Heriot-Watt University. An important part of this was the production of a dissertation on the feasibility of black land crab terraculture. An expert appraisal was also undertaken by Dr Richard Hartnoll.

There are two basic options for culture. One is grow-out, which is the culture of crabs in captivity up to market size, when they are harvested and sold. The second is stock enhancement, whereby juvenile crabs are produced within a hatchery/nursery complex, and then released to supplement the natural stock. They grow naturally in the wild until they reach market size.

(1) Grow-out

The project's admittedly limited information indicates that substantial returns of megalopae to the shore are very irregular, and occur only every five to six years or so, on OPSC, whilst there are no records for SAI. This spasmodic and unpredictable recruitment is corroborated by data from other species of land crab. Consequently no grow-out programme can rely on a source of wild caught megalopa/first crab stages, so it is not a practicable option. It was not considered further.

Juveniles of 20-30 mm CW could be caught in the forests, and used to stock grow-out systems. The project has done this on a trial basis. There are two problems. Firstly the availability of such juveniles will be spasmodic, due to the irregular recruitment. In 2003-4 they were present on OPSC, but very difficult to find on SAI. It would seem impracticable in any event to collect them in commercial quantities. A more fundamental problem is that a large-scale collection of wild juveniles would impact the catchery stock. Indications are that natural mortality of black crab is low, so it would make both environmental and economic sense to leave juveniles to grow in the natural environment. This approach was deemed unacceptable.

The grow-out of reared first crab stages would be environmentally acceptable (though land use considerations would apply), and could perhaps be supported by a steady supply of 'seed'. Any arguments for or against must be based on practicality, economic viability, plus consideration of any socio-economic factors. The problems to solve, and the costs, would be two-fold. Firstly, those involving production of 'seed', comprising a hatchery system to produce first crab stages, and of a

nursery system to rear them to a size (around 10 mm CW) suitable for stocking the grow-out system. Secondly, those involving the grow-out system to produce crabs of market size (70 mm CW).

There are several factors to consider in relation to the practicality of grow-out. One is that it is not a rapid process. Most tropical aquaculture systems are based upon a grow-out period of less than six months – e.g. penaeid prawns, mud crabs, milkfish, *Tilapia*. This provides a rapid return on investment, and an ability to quickly recycle capital facilities. In contrast, a very conservative estimate for the growth of black crab from 10 – 70 mm CW would be 5 years. This is similar to the grow-out period for the Atlantic lobster *Homarus*, where despite its high first sale price, its culture has never been considered economically viable. A second factor is the facilities required. These must provide shade, humidity and refuge. These requirements mimic the forest habitat, and mean that enclosures must be roofed, and when necessary watered. They must also provide appropriate shelters, or soil to burrow in: these are essential when the crabs are moulting, and very vulnerable. All of this will increase the cost of the infrastructure. There is also a need for pest control. The project's small scale trials found that both ants and rats caused mortality among the crabs, and would require control measures. In terms of space requirement, the maximum natural density observed in the stock assessment exercise was around 25 crabs per 25 m^2 quadrat (found in some quadrats in several watersheds in OPSC). Thus, a final harvest density of one crab m^{-2} seems an appropriate target: project trials did not suggest that higher densities would be viable. Furthermore, there are still problems of diet and survival to be evaluated. On SAI the annual catch is estimated at ~ 500,000. To culture 50% of this would require an area of 25 hectares.

Ignoring the uncertainties of practicality for the present, let us consider costs. The basic income per hectare would be a maximum of 10,000 crabs over a five year grow out period, namely 2,000 crabs per year. This equates at current SAI prices to 400,000 peso (~200 US dollars) $hectare^{-1}$ $year^{-1}$. Costs cannot be easily quantified, but must include infrastructure (land, fencing, shading), running costs (labour, utilities, maintenance, food, pest control), and seed costs (assuming 20% survival to harvest, this means 10,000 juveniles $hectare^{-1}$ $year^{-1}$). The project team see no way in which these costs could be less than the income, and consider grow-out economically non-viable.

In conclusion, the project team does not consider any of the grow-out options to be viable, from a combination of practical, environmental and economic reasons.

(2) Stock enhancement

The rationale of this approach is an assumption that the abundance of black crab in many areas is below the carrying capacity of the environment. If true, this could be due to lack of recruitment to these areas (we do know that major recruitment events are very irregular, especially in San Andres), or the result of heavy exploitation. There is always the alternative possibility that these areas support fewer crab because they are less suitable. We cannot at present determine which view is correct, both may be true in part. The analysis will continue on the basis (perhaps hopeful) that all 'forest' areas on the islands could support the maximum black crab density recorded within a watershed during the stock assessment.

The aim would be to rear black crab in large numbers to either the first crab stage, or more probably to a small juvenile stage (~10mm CW), and release them into the wild. The basis for calculating potential enhancement levels is as follows.

1. The carrying capacity of the 'forest' environment is equivalent to the maximum value recorded in the stock assessment survey. This was in the South West Watershed of Old Providence, with a density of 14 crabs per 25 m^2 quadrat. Thus, the slightly conservative carrying capacity of 0.5 crabs m^{-2} was adopted. This may be optimistic – SW watershed may be a particularly favourable environment.
2. On this assumption, the number of crabs needed in each watershed to bring the population up to this maximum density was calculated, knowing the estimated number already present.
3. It is assumed that the exploited stock comprises 10 year classes. Thus to attain a stable population

structure, one tenth of the required supplement should be added to each watershed each year. The population would thus be steadily increased over a ten year period.

4. The supplementation could be made by adding small crabs of ~10 mm CW. It is assumed that 20% of these will survive to market size (70 mm CW). There is no justification for this assumption – it is a guess. Alternatively the addition could involve megalopae or first crab stages: the survival rate to maturity would be much lower.

On the above basis the annual requirement of 10 mm CW crabs was estimated in the order of 1,700,000 specimens for each island. This is the annual supplement of ~340,000 multiplied by 5 to allow for 20% survival to harvest size.

There could be various reasons, economic or social, for enhancing the stock on one or both islands, or in all or selected watersheds. These decisions are outside the remit of this analysis, though the most probable scenario is to initially enhance the stock in selected watersheds in SAI, where exploitation pressure appears highest. The following analysis will examine the logistics of the production of 100,000 stocking juveniles per year. Figures could be then scaled up or down as appropriate. There are two requirements: a hatchery system to produce megalopae; a nursery system to grow the megalopae to juveniles of ~10 mm CW. Costs are not considered – realistic estimates would need much more analysis, plus practical trials. However, since the effect would be to supplement a common resource, clearly public rather than private funding would be involved.

There are no precedents for rearing land crab larvae on a commercial scale, but there is the precedent of the Indo-Pacific mud crab, *Scylla*. The hatchery rearing of this commercially important species has been extensively studied in the Far East (Australia, China, Philippines, Viet-nam), and the system has now reached the commercial stage. The larval development of the black crab to the final pelagic megalopa stage is similar to that of the mud crab, and there should be scope for the transfer of technology. However, it must be emphasised that a commercial hatchery would not be a cheap or simple 'back yard' operation. It would have to include not only rearing tanks, but systems for sea water supply, water quality management, live food production, and disease control. The Far Eastern experience has involved years of detailed research. In one respect the black crab hatchery system would be simpler than that for the mud crab. For the latter there is a requirement for maturation/spawning tanks – it is not practicable to collect from the wild females with eggs about to hatch. However, female black crabs with ripe eggs can be easily collected during the migration, and it should be simple to get these to release larvae in the tanks without special holding facilities. However, a few tentative figures are offered. Using commercial methods mud crab larvae can show survival rates of 40% from first crab to megalopa: this would be a target figure for black crab. The initial stocking levels of rearing tanks for mud crabs is 30 larvae litre^{-1} (Field, 2004). So, on this basis the production of 100,000 megalopae could require:

- Initial stocking with 250,000 first stage larvae.
- These could be produced by 3-4 berried females (average 80,000 eggs per female).
- A rearing tank volume of ~8000 litres (8 m^3).

This provides some initial basis for estimating the scale of the hatchery operation required.

It would be possible to release the megalopae into the forest, since it is as the megalopa that the black crab emerges from the sea. However, they are very delicate, so transport would be difficult, and their survival within the forest environment uncertain. Intuitively, it would seem better to rear them to a larger size before release to the wild (as is done in lobster stock enhancement, for example). A size of 10 mm CW could be a target. This size is reached about 5 months after emergence from the sea (Dr Richard Hartnoll, personal observation of cohort emerging in June 2004 on OPSC).

There are no precedents for the nursery rearing of small land crabs, and virtually no data on their life style in the wild. A nursery system would need to be developed as a result of trial experimentation in order to determine the following.

- Optimal stage for removal of megalopae from rearing tanks and introduction to nursery system.
- Habitat conditions and space requirements of a nursery system.
- Optimal feeding regime for juvenile black crab.
- Potential survival rates to 10 mm CW within nursery system.
- Systems for effective introduction to the wild.

There are no data to allow useful speculation on any of these questions.

4.4 Education Programme

A common theme throughout the Darwin research project has been a drive to involve local communities in aspects of the research. This has been complemented with a parallel programme of educational activities. This programme was driven within CORALINA by the project's community promoter, aided by the social researcher and other project staff.

The programme had many components, aimed at catchers, schools and the wider populace, which are summarised below:

- Working with 3 pilot schools (Brooks Hill, Cemed and Rancho), CORALINA established 12 "crab clubs" (with elected presidents, treasurers and secretaries) as a means of teaching children about various aspects of the black land crab, through various modes of entertainment. Over 1500 children involved.
- The development of a number of workshops with schoolchildren on conservation and sustainable use of crab, the cultural importance of the crab, and crab morphology.
- The design and painting of crab murals at schools.
- Participation of children in organised field trips to study crab biology and migratory behaviour.
- Provision of workshops and talks to catchers and processors on black land crab biology, conservation and sustainable management (social cartography, distribution and abundance, capture areas, migration and return of juveniles, and commercialisation).
- Organisation of "fun" evenings with the families of catchers and processors to provide basic knowledge on crab biology and ecology through the making of handicrafts, painting, games and other forms of entertainment.
- The provision of workshops and training programmes for the wider community.
- Working with bus drivers and sewage transporters on possible solutions to the problem of road kill during the migration period.
- The raising of educational awareness on the black land crab at annual festivals.
- The development of "eco-fun vacations" concentrating on the black land crab and including field trips, theatre shows, games, competitions, and handicraft creation.
- The production of a crab lore booklet containing information on crab recipes, songs, stories, legends and other cultural influences of the crab in islander life.
- The production of a children's activity book centred on black crab legends, with various puzzles.
- The production of a pop song and video.
- The production of a professional 15 minute educational documentary on the black land crab.

Considerable progress was made during 2003 and 2004 towards the integration of black crab studies into the "biological and environmental processes" aspects of the school curriculum within the San Andres Archipelago, from pre-school to the 11th grade. A proposal was prepared, reviewed with the Education Secretariat and schools, and is due to be implemented in 2005.

4.5 Training Programme

As part of the project, two major training blocks occurred in year 2, overseen by Dr Richard Hartnoll and

Dr Mark Baine. A total of 17 participants attended these 2 training courses (crab biology, data collection and economics; community based resource management) involving lectures, tutorials and practical on the job training. Christian University students and CORALINA personnel took part in the theoretical aspects; crab catchers and CORALINA personnel in the practical aspects. Theoretical training was undertaken over a 1 week period. Practical training occurred over a 2- 3 week period and included aspects of sampling, measuring and data analysis.

Despite initial intentions to put in place selection criteria for trainees, it was quickly realised that members of the catching community would not attend the theory classes (a possible combination of discomfort, lack of interest and lack of confidence). It was decided that all CORALINA staff and students from the Christian University's natural resource management curriculum would be eligible to attend. Two Christian University students worked extensively with the project but unfortunately other students did not show the level of interest that was anticipated. Although the Christian University contributed the space for the model terraculture studies, efforts to involve the students in these studies did not succeed. Therefore, this work was completed by CORALINA staff, with some support from the two active students.

Mr Arne Britton began an MSc in Marine Resource Management at Heriot-Watt University in October 2003. Because of work commitments Mr Britton required an extension for the completion of his dissertation. His dissertation is currently being assessed by HWU and external examiners, with formal notice of his assessment to be known in April/May 2005. This will be notified to the DI, when announced.

4.6 Management Planning

During the course of the Darwin Initiative funded research project, a number of findings and observations appeared to indicate that the black land crab population on both SAI and OPSC is being overexploited. The health of the black crab populations is also thought to be affected by other activities; the most visible of these being habitat destruction, and road kill during the migration period. Major recruitment events only seem to occur approximately every 6 years (based partly on a mixture of anecdotal information and more recently, direct observation). Furthermore, the problem seems to be exacerbated by a significant level of unawareness or ignorance of existing regulations, a lack of awareness on the potential impacts of overexploitation, and the economic and subsistence importance of catching. There are also political sensitivities with respect to native islanders and resident settlers, which result in feelings of inequity alongside symptoms characteristic of "racing behaviour" so often witnessed in open access fisheries.

It has been estimated that current levels of catch are approximately 500,000 and 1,000,000 crabs in SAI and OPSC respectively. This should be compared with total population size estimates of 800,000 and 3,000,000 crabs for SAI and OPSC respectively. This represents exploitation levels of the background population of around 60% for SAI and 33% for OPSC, which if accurate, are extremely dangerous levels, particularly in SAI, which also suffers from high levels of habitat displacement. There is much anecdotal evidence imparted by local islanders, which suggests that there has been a decline in the numbers of crab present on the islands.

It should be stressed that, with the data at hand, it is impossible to state categorically that "over exploitation" is occurring. There is the anomaly of the very high apparent exploitation levels, yet what appears to be a relatively 'healthy' size frequency structure in the populations. There is an imperative need, as is recommended in the management review, to continue monitoring the catchery, building a time series of data that could stand up more readily to scientific scrutiny. However, it is also impossible to ignore the warning signs inherent in the data at hand, which in itself demands a precautionary approach to future management.

Alongside the interpretation of scientific data, was a need to address the social and economic importance of the catchery. Throughout the course of this research project, efforts had been made to involve local

communities, particularly crab catchers, in both data collection and in subsequent discussions of findings, including the possible implications for management. It was apparent at the beginning of the Darwin project that there was unhappiness with some of the existing approaches to management. There has also been some friction between catchers and CORALINA, the main implementer of the Darwin research programme, often leading to suspiciousness towards proposed collaborations. The project team deemed it essential to work alongside the local community, and the project team hopes this has been achieved to an acceptable degree, although those catchers and processors directly involved in aspects of the project admittedly remain low in comparison with the total estimated numbers of catchers thought to operate on SAI and OPSC. Nevertheless co-operation occurred, and indeed, the level of discussion on management options has been considerable and in many instances thought provoking.

It is important that a high degree of trust is maintained between managers and catchers; the process must be transparent, the adoption of management options must be qualified and open to debate, and if adopted, they must also be respected and adhered to. The recommendations of the management review were circulated among the crab catching and processing community for consultation. This was the next step after 2 public meetings (open discussion on future management) in ensuring such a spirit of openness continued. It is hoped that the final document, including the recommendations, truly reflects the views and opinions of those who reviewed it in its draft form. In summary, recommendations relate to:

- The establishment of a Black Crab Conservation Unit with statutory recognition.
- Further exploration of the establishment of catchers' Co-operatives.
- Stock assessments every 3 years.
- Annual market sampling.
- A logbook scheme for recording catch and effort, with the voluntary involvement of a sample of local catchers.
- Monitoring of the export of crab.
- The organisation of crab processing workshops.
- Widespread distribution of the documentary and books.
- Monitoring of the success of the schools curriculum initiative.
- Catchery management measures including closed seasons, areas, restrictions on size and sex, and enforcement measures.
- Establishment of a working group to explore stock enhancement through terraculture.

- Changes to the regulations.
- The use of wardens during the migration period, and other related measures.

5. PROJECT IMPACTS

There has been a definite improvement in general awareness of issues facing the health of the black land crab populations on SAI and OPSC, particularly among the crab catching and processing community. There has been significant involvement of crab catchers and processors, not only in practical aspects of the research programme, but also in public deliberations of the results of the research, and the associated implications for management. High levels of support were witnessed for the formation of a specialist Black
Crab Conservation Unit and the involvement of the catching community in management decision making. A management review has been completed, involving consultation with local catchers. Such a level of involvement has never been experienced before. There are, of course, many challenges yet to be faced, but there are high hopes that the Darwin project, in the adoption of a novel, proactive and strong approach to black crab management within the San Andres Archipelago, will be remembered as having a pivotal role in the future conservation and sustainable use of this resource. The impact of management recommendations can only truly be realized with continued monitoring of the state of the catchery and the background health of the crab population.

Terraculture does not appear to be a viable economic activity, and will certainly not provide an alternative source of income, though due consideration should be given to its stock enhancement potential.

The National Biodiversity Policy (1995) – which focuses on conservation, knowledge, and sustainable use -- provides the guidelines for meeting Colombia's obligations under the CBD. This project achieved a number of concrete actions recommended in the national policy and laid the groundwork for others. The policy calls for conservation planning for significant species and those of limited distribution, increasing knowledge about these species and their uses, optimising social and economic benefits resulting from exploitation, and strengthening technical and management capacity of both the state and society (*Politica Nacional de Biodiversidad*, 1995).

The project's research greatly increased knowledge of the biology and ecology of the black crab as well as about local patterns of use, exploitation, economic effects, and cultural significance. This information allows the development of new policies, plans, and management actions for biodiversity conservation and sustainable use. Among these are the integrated management plan, which will directly result from the research and management review. Another will be the revised regulation for black crab conservation. This regulation will be enacted immediately following the 2005 spawning season. This timing allows a community-wide education and awareness program about the new regulation to be carried out before the migration in 2006. The feasibility of setting up a crab catchers' co-operative in OPSC will be examined, which would also improve long-term sustainable use. The project successfully trained Colombian scientists, managers, and community members. On-going multiplication of this knowledge and use of the education materials produced in the project will continue to strengthen capacity of both the state and wider society.

Priority activities in the National Biodiversity Policy include managing biodiversity information, collecting traditional knowledge, and combining traditional methods with new technologies to achieve sustainable use. The project databases strengthen information management on a key species and provide a model of how to manage information on other species. The project excelled at working with local communities and gathering traditional knowledge. The booklet of black crab lore, children's activity book (in press), and documentary produced in the project consolidate some of this knowledge and will support on-going education and cultural preservation. Besides providing a forum for on-going discussion of traditional knowledge and new methods, the BCCU will allow managers, catchers, and other stakeholders to work together on long-term management including planning, implementation, monitoring, and community-based education. This unit is being created by a regulation from CORALINA, which is now being drafted, and should be enacted within the next few months. Ultimately, better management of this key resource and source of local protein will also help Colombia achieve the Millennium Development Goals (MDGs) by reducing hunger and poverty.

The project had a substantial training component that was successfully completed and has improved local capacity, at both the community and institutional levels. First the work done with the catchers, schools, and wider community included a variety of creative activities that educated a number of people about this key species. Subjects covered included conservation and sustainable use, identification and reduction of threats, cultural importance, and crab morphology and behaviour. Children's clubs were organized and field trips were realized. The continued use of education materials developed in the project and the introduction of the black crab curriculum into Archipelago schools should impact behaviour for years to come. Although changing young people's attitudes does not immediately affect biodiversity work, the long-term influence on biodiversity conservation can be profound.

Project personnel were extensively trained in technical aspects like biological survey techniques, monitoring methods, and information management, as well as in community-based resource management and crab biology. Most of these people will continue to work with CORALINA and live in the archipelago, which will allow them to both support future crab work and apply their training in other biodiversity programs. The two active Christian University students are still supporting CORALINA in its work with the native community. Training workshops and outreach events with catchers and

processors taught them about crab biology, ecology, and sustainable use and equipped them to play a role in community-based management. The BCCU will provide the forum for a new participatory management style. Building capacity for co-management greatly strengthens biodiversity work, given that empowering local institutions and communities leads to better resource management decisions and improved local resource access, promoting a self-reinforcing cycle of ecological and social sustainability.

Heriot-Watt University and CORALINA have a long history of research collaboration, including the provision of MSc students from degree courses in Scotland, who undertake important research dissertations based in the San Andres Archipelago. This collaborative partnership remains strong.

The degree of co-operation and involvement of the catching communities in the research and management discussions has been excellent, as has been CORALINA's adaptability and recognition of the need to involve the catching communities in the decision making process. Overall, in terms of social impact, the project has benefited the whole community of the Archipelago and in particular both CORALINA and the crab catching communities. This is reflected in the following:

- Collaboration between CORALINA and crab catchers in research and management planning, with an equal role in the proposed Black Crab Conservation Unit.
- Direct participation of catchers and processors, and those related to the industry, in socio-economic surveys, biological surveys, a voluntary log -book scheme and project technical and management workshops (>200 participants).
- Outreaching to schoolchildren (> 1500 children involved in activities).
- 17 trainees in community based resource management; and crab biology, ecology and survey techniques.
- 1 CORALINA MSc qualification under assessment.

6. PROJECT OUTPUTS

All project outputs are tabulated in Appendix II using the coding and format of the Darwin Initiative Standard Output Measures. A full list of publications is provided in Appendix 3.

In general the project fared well in achieving the outputs originally envisaged. In summary the following, main outputs were/were not achieved:

- 1 MSc award currently under assessment.
- The formal training recorded in Appendix 2 (17 trainees for 22 weeks) was supplemented by on the job training throughout the course of the research. There were also a number of additional workshops held with crab catchers, on such aspects as social cartography and crab biology.
- A major output not originally envisaged, was the integration of black crab studies into the "biological and environmental processes" aspects of the school curriculum within the San Andres Archipelago, from pre-school to the 11th grade.
- In addition to the production of a book of crab lore (stories, songs, recipes etc), a children's story-book featuring activity puzzles, has also been published.
- Although a dissertation on terraculture feasibility has been produced, alongside a professional communiqué (assessment), a manual on biological and ecological aspects of terraculture was not produced. The concept of grow-out culture does not appear viable. There are many technical problems to be resolved before a stock enhancement manual could be produced.
- 1 conference paper has been produced and 1 peer-review paper submitted. Three other papers are currently being prepared for submission.
- A reference collection on land crab biology, exploitation, management and terraculture has been completed, comprising over 50 papers, manuscripts and books. It is continually updated.
- Media coverage has been extensive, particularly in terms of local television airplay in the Archipelago.
- The potential establishment of a Caribbean network has not proceeded, as there appears to be a

lack of interest

- Studio Lezard Bleu was commissioned to produce an educational documentary. The result is a wonderful insight into the project and life on the Archipelago, which is beautifully shot, perfectly scripted, and a thoroughly entertaining professional production.
- A lively pop song was produced, accompanied by a video. This has received extensive airplay particularly during the migration season.
- A Black Crab Conservation Unit has received wide support among CORALINA and the catching community. It is hoped that this will be formally established later this year.
- A management review has been completed with the input of local communities, in particular crab catchers and processors. The review makes a total of 37 recommendations, and is based on a comprehensive programme of monitoring and research into (1) crab biology and ecology, and (2) the dynamics of the local catcheries.
- The regulations currently in place for the black crab will be reviewed, taking into consideration the recommendations of the management review.

CORALINA will ensure the dissemination of the management review, the crab lore book, the children's activity book and the documentary video; particularly to schools and catchers. CORALINA will also take on the onus of ensuring the formation and successful operation of the Black Crab Conservation Unit, including the review of existing regulations. It is hoped that this work will be supported in the future through further grants from both within and outside Colombia.

7. PROJECT EXPENDITURE

Table 4 provides a breakdown of final project expenditure in line with the original budget, brackets indicating a difference +/- 10% of the budget.

Variation in expenditure +/-10% was mainly as a result of a late start in the project, caused by DEFRA administrative delays back in 2002, and a number of agreed changes to the budget throughout the course of the project. Positive balances also reflect wise use of funds.

It should be noted that a DEFRA letter of 11 June 2003 approved the carry over of monies unspent from Year 1. It was previously agreed that of the unused labour funds for CORALINA would be transferred to the CORALINA staff budget for Years 2 and 3 and that the remainder would aid in the funding of the documentary, if necessary. It should also be noted that DEFRA approval was granted on 24 January 2004 for the transfer from the excess T&S from year 2 to cover an extra 2 weeks of Dr Hartnoll's time.

Table 4 Expenditure over the 3 years against the original grant

Category	Grant	Expenditure	Difference

8. PROJECT OPERATION AND PARTNERSHIPS

8.1 Colombian Partners

The main project partner in San Andres was the Colombian government environmental management agency CORALINA (Corporation for the Sustainable Development of the Archipelago of San Andres, Old Providence and Santa Catalina). CORALINA is part of the National Environment System and one of seven Colombian regional autonomous sustainable development corporations with a mandate that combines responsibilities of conservation, planning, management and education. CORALINA's mission is to manage, protect and recover the Archipelago's environment by using appropriate technologies for renewable resource use and by promoting sustainable human development in consultation with the community, in order to improve quality of life through participation and agreement. Functions include environmental planning and zoning, community participation in sustainable resource management, promoting equitable benefit distribution, enacting environmental regulations and developing research projects with national and international partners. The agency has 33 permanent staff. CORALINA was responsible for carrying out the research jointly with the UK partners and participated in the development of the management plan. Upon completion of the project, CORALINA will administer the formation of the Black Crab Conservation Unit, enact subsequent regulations, and will initiate and continue the monitoring programmes recommended in the management review. Additionally, CORALINA led the educational components of the project. CORALINA managed contract project personnel which included biologists, education specialist, technicians and a community promoter. Other CORALINA personnel devoted time to the project's completion including the Director, an economist, a GIS specialist and the head of the OPSC branch. Also involved in the project were the offices of the general direction (in-country co-ordination and supervision), general secretary (in-country administration), juridical (regulations), education (community outreach), and support staff (secretaries, boatmen, drivers).

A private institution of tertiary education, the Christian University of San Andres, was initially meant to support the experimental terraculture activity; providing laboratory and field space, student researchers, classroom, and office facilities. After initial enthusiasm, including good attendance at training and the onset of terraculture trials, their continued involvement was not as strong as originally envisaged. Two students remained active throughout the project, working hand in hand with the CORALINA team, and the

university contributed space for the terraculture studies and donated classrooms, when required. The university also set aside space to set up a special laboratory for the project. However, the university was counting on a contribution from another source that unfortunately was not received to buy the equipment needed to make the lab operational. CORALINA was able to donate some basic equipment, but this proved to be insufficient for the lab to be used in the project. University administration underwent major revision during the last two years, which contributed to the lack of involvement, as did changes in teaching staff soon after the project began.

In addition, neighbourhood NGOs were involved in aspects such as information gathering and organising stakeholder meetings on a volunteer basis.

A crucial partnership was the catchers, who although not formally organised in an association, did aid in many aspects of the research, monitoring and project discussions.

8.2 Other Projects

Within the San Andres Archipelago, there was some co-operation between this project and other initiatives, such as the development of a Marine Protected Areas system and the management of the Biosphere Reserve. More co-operation was warranted on other projects that would have a direct management impact on black crab populations, such as the development of forestry management plans

(with implications for crab habitat). Unfortunately this was not achieved to a suitable degree.

8.3 International Partners

The main international partner for the first half of the project was Heriot-Watt University, Scotland, managed by Dr Mark Baine. Dr Baine took up the position of Director of the Motupore Island Research Centre in Papua New Guinea in October 2003. Project management was retained by him, after a request by Heriot-Watt University and in consultation with the Darwin Secretariat. Heriot-Watt University remained involved in terms of financial administration. Dr Baine directed the project.

Dr Richard Hartnoll, from the Port Erin Marine Laboratory, Isle of Man, was the project's land crab expert and provided training and advice on monitoring and research. Dr Hartnoll has also provided invaluable input and guidance to the development of the management review and terraculture assessment.

Dr Paul Clark from the Natural History Museum, London collaborated with Dr Hartnoll on the description of the megalop stage of *Gecarcinus ruricola*.

Dr John Bishop, with the Marine Biological Association of the UK, was involved in genetic analyses of the black land crab.

Studio Lezard Bleu, (Canada and Colombia), produced the educational documentary.

8.4 Future Co-operation in the San Andres Archipelago

The following is an extract from the recommendations section of the management review, specifically those recommendations on management planning and responsibilities. These recommendations are based on widespread agreement at management workshops, and should hopefully be in place this year. Subsequent recommendations rely on such a spirit of co-operation.

In the past, there has been considerable ignorance within communities of the content of pertinent legislation; there has been disagreement with the content of said legislation; and there has also been concern at the equitability of enforcement measures. During the course of this project, there has been increased co-operation between the catching community and CORALINA; there has been a willingness to participate in management discussions; and there has been support expressed for more formal involvement in future management. With the international recognition of the San Andres Archipelago as a UNESCO Biosphere Reserve, there is an inherent drive for participatory management of island resources. The following recommendations are made with all of the above in mind.

R1: ***A Black Crab Conservation Unit (BCCU) is established as soon as possible in 2005, preferably in March/April, prior to the crab migration season.***

R2: ***CORALINA accept responsibility for the formation of the BCCU, and take on the role of its administration, though each committee should have a chairperson independent of CORALINA and crab catchers/processors.***

R3: ***The BCCU should be given statutory recognition within the San Andres Archipelago, perhaps through adequate identification within newly approved legislation.***

The creation of a BCCU with representation of local catchers is considered an essential prerequisite for successful management of the crab catcheries. Formation of the BCCU should broadly follow the proposals and responsibilities laid out in Section 4.4.3, which in summary include:

- The formation of 2 committees, 1 for SAI and 1 for OPSC, each of which has representation from CORALINA, the catching community, Agriculture and Education Secretariats, organised Churches and relevant NGOs.
- The review, implementation and enforcement of management measures.

- The development and implementation of monitoring programmes and the involvement of catchers in data collection.
- The development and implementation of education and community-wide management awareness initiatives.
- The pursuit of funding support.

R4: A series of meetings and workshops should be organised early in 2005 by CORALINA for catchers on both SAI and OPSC, which examines the logistics and benefits of forming Catchers Cop-operatives. CORALINA should also involve an invitation to representatives from the local Fishermen's Co-operatives to share their insight on the subject. The workshops should conclude with firm decisions from the catching community on the possible formation of co-operatives. The BCCU should provide adequate support to catchers in their development, if the option is pursued.

The suggestion from an OPSC catcher that a co-operative could be formed met with informal approval from many workshop participants. It is an option that would provide catchers with a unified public voice and a stronger presence when in management negotiations. It would also enable exploration of improved product marketing and price control. This suggestion deserves further exploration on both SAI and OPSC.

9. MONITORING AND EVALUATION, LESSON LEARNING

9.1 Monitoring and Evaluation

Monitoring and evaluation was continual throughout the project, and operated at a number of levels. A project manager was established on the ground in the Archipelago, who answered to both the Director of CORALINA, and the Project Director. The project manager was responsible for the conduct of technical aspects of the project. The CORALINA Director and the Project Director liaised on administrative aspects of the project.

Liaison on project progress, both technical and administrative, for the main part took the shape of regular e-mail correspondence on the progress of unit tasks, e.g. production of the documentary, preparation of the crab lore book, market sampling of crabs, migration monitoring, fecundity studies etc. Approximately every quarter, the project manager was also asked to submit a progress report to the Project Director by e-mail.

For project workers contracted to CORALINA, there are internal administrative procedures that require record keeping of project activities undertaken by personnel.

The most important assessments of progress were undertaken during visits to the Archipelago by the Project Director and land crab specialist (approximately twice yearly). A 2-3 day project meeting was normally held at CORALINA offices, with detailed discussions on the progress of individual tasks. All personnel associated with the project were usually in attendance. The majority of these meetings are minuted.

Although, at times, the above procedures seemed overburdening; it proved an essential aspect of project management given the breadth of research and educational activities being undertaken. Table 5 summarises the main achievements, their measure and verification.

There was no external valuation of the project.

Table 5 Main project achievements and their verification

Achievement (value)	Measurable indicators	Verification
The prospects for management of the black land crab catchery have been improved.	Improved co-operation and collaboration between CORALINA and local communities.	Management review Workshop reports CORALINA employment records Catchery log-sheets Socio-economic reports Management workshop reports Minutes of catcher meetings
	Input of catchers to management planning.	Management review Management workshop reports Minutes of catcher meetings Commitment to the formation of a BCCU
	BCCU formation	Statutory recognition (2005) Minutes of meetings (2005 -)
	Management planning in progress	Management review BCCU formation Review of regulations
Information available on the black land crab within the Archipelago has been improved.	Database on crab biology and ecology, covering those parameters discussed in Section 4.1 of this report.	Database 2 Dissertations
	Database on socio-economic information related to the operation of the crab catchery, as discussed in Section 4.2	Database Socio-economic reports 2 Dissertations
	Reference collection established	Catalogue list
	Culture experiments	Brief reports on terraculture experiments Terraculture communiqué 1 Dissertation
Improved Archipelago wide education on the black crab and its catchery	Production of educational material	Documentary (DVD) Posters Newsletters Lore book Children's activity book
	School and community activities	Crab clubs School reports Workshop reports
	Inclusion of black land crab studies in the school curricula	Curriculum reports Correspondence
Improved local capacity for research and monitoring	Training programmes	Course material Attendance lists University curriculum reports

9.2 Lessons

The key positive lessons, from research undertaken, are as follows:

- Education and awareness raising is an essential and relatively straightforward component of management planning.
- The involvement of catchers in the research and monitoring programme was a valuable exercise as it instilled trust and also appreciation of the nature of the research being undertaken.
- Maintain continual contact with communities, in the form of workshops, fun activities, talks etc, to ensure interest remains high.
- Direct involvement of communities in management planning will yield stronger co-operation and can lead to a more informed acceptance of management decisions.

Negative lessons relate to administration, the following offered for consideration by future projects and the Darwin Secretariat:

- Darwin funds should be provided in advance, at least in year 1 of projects, as many developing country institutions are unable to operate on a basis whereby funds are paid in arrears.
- Agreement should be reached on project personnel duties with respect to concurrent projects also administered by the host country organisation.

10. DARWIN IDENTITY

The project used the Darwin name and logo at all workshops and meetings, on all correspondence related to the project, on all educational material produced by the project, and on all reports attributed to the project. One main example of this is the production of a documentary, which has full acknowledgement of the Darwin Initiative in the opening and closing credits.

All peer-reviewed papers will fully acknowledge the Darwin Initiative.

In the San Andres Archipelago, there is a high level of understanding of the Darwin Initiative as a UK funding initiative for conservation and natural resource management projects. This understanding is built not only on the impact of the black land crab project, but also on previous Darwin Initiative projects within the Archipelago. At present, all public sectors of society are aware of this project, through extensive media coverage and a strong effort to involve all sectors in the project. At the grass roots level, there is again considerable awareness of the project through educational work with local communities.

The project is recognised as a distinct project with its own clear identity.

11. LEVERAGE

No additional funds were attracted to the project during its course. There was, however, an increased level of support for the project from UK organisations, including the involvement of the Natural History Museum and the Marine Biological Association of the UK.

The project also witnessed a considerable input of time and effort from the main UK partners, well in excess of that funded by the Initiative.

The UK partners have provided advice to CORALINA on the pursuit of additional funds to help maintain a momentum for the project upon the exit of the Darwin Initiative.

12. SUSTAINABILITY AND LEGACY

The project team offer the following main points for consideration, in terms of sustainability and legacy:

- A management review has been produced and there is a commitment from both CORALINA and the local communities to discuss and implement the recommendations, through a specialist body, to be known as the Black Crab Conservation Unit, which will be given statutory recognition.
- The existing regulations in place, to ensure conservation of crab populations, will be changed in light of the project's recommendations.
- The changes to the local school curricula in the Archipelago will be a lasting legacy of the project.
- Dr Baine and Dr Hartnoll have offered their long-term support for black crab management initiatives in the Archipelago, be this in the form of voluntary advice or other funded initiatives.
- Strong links already exist between Heriot-Watt University and CORALINA and are likely to continue between CORALINA and Dr Baine (now with the University of Papua New Guinea).
- It is anticipated that Heriot-Watt University will continue to promote the Archipelago as a destination for dissertation research to its MSc students.
- It is anticipated that some project staff will remain with CORALINA in other positions, but contributing to black crab management issues.

13. POST-PROJECT FOLLOW UP ACTIVITIES *(max. 300 words)*

(1) Based on the recommendations of the management review, further research may be needed to assess the viability of terraculture of the black land crab in San Andres. One possibility is a study of larval and postlarval rearing and early release into natural habitat. There are precedents for such an approach in the Japanese stone crab, and the Far Eastern mud crab fisheries.
(2) A detailed examination of spawning activity, larval development in the sea and subsequent recruitment. There is great inter-ear variation and a 2 year observation window is too short.
(3) A comprehensive tagging and monitoring programme to appreciate in more detail the behaviour and movement of this cryptic animal, particularly during the migration season. Studies on the Christmas Island red crab indicate how this might be achieved.
(4) The investigation and development of road bypasses (arches or tunnels) to allow safe passage for spawning crabs from inland forest areas to the sea and for returning juveniles, ensuring a reduction in large numbers of road kill during the migration season.

These projects are suitable for post-project funding as they will supplement the work of the present project and further highlight the importance of this species through international recognition of the threats and possible solutions. Information provided by such projects would aid in the conservation and sustainable management of this species and would also provide an immediate responsibility for the Black Crab Conservation Unit.

The Colombian agency CORALINA has a mandate that combines responsibilities of conservation, planning, management and education. CORALINA's mission is to manage, protect and recover the Archipelago's environment by using appropriate technologies for renewable resource use and by promoting sustainable human development in consultation with the community, in order to improve quality of life through participation and agreement. With approximately 33 permanent staff and 70 contracted staff on average, adequate facilities and black crab project experience and enthusiasm (including training) CORALINA will play a major role in follow-up activities in co-operation with the Black Crab Conservation Unit.

14. VALUE FOR MONEY

This project has provided excellent value for money.

Prior to the onset of this project, there was considerable observational evidence that crab populations were under severe threat from a number of activities, including crab catching. Little was known about this species, and it was therefore difficult to introduce appropriate management measures; this exacerbated by the fact the crab is a major source of income and subsistence for local communities, with strong cultural importance for local islanders.

In 2005, we now have scientific and socio-economic baseline data, which provides an indication of the threats facing the crab population. This data has been used, along with the results of extensive consultation with local communities, to provide recommendations on future management of the catchery. There is an increased level of co-operation between CORALINA and local catchers, including mutual endorsement of the formation of a specialist unit. There is a wish to move forward, and to do so collaboratively and proactively.

The archipelago, and in particular the catching community and CORALINA, are in a better position to understand the problems facing the crab, better equipped to monitor the problems, and better placed to provide effective management.

AUTHOR(S)/DATE

Dr Mark Baine, Dr Richard Hartnoll and Ms Elizabeth Taylor 15 April 2005

Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use		Develop national strategies which integrate conservation and sustainable use.
7. Identification and Monitoring	50%	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities which have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	10%	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation		Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity	20%	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures		Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	10%	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	10%	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.

14. Impact Assessment and Minimizing Adverse Impacts		Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources		Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology		Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information		Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol		Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

Appendix 2: Outputs

Code	Total to date (reduce box)	Detail (←expand box)
Training Outputs		
1a	Number of people to submit PhD thesis	
1b	Number of PhD qualifications obtained	
2	Number of Masters qualifications obtained	1 under assessment
3	Number of other qualifications obtained	
4a	Number of undergraduate students receiving training	
4b	Number of training weeks provided to undergraduate students	
4c	Number of postgraduate students receiving training (not 1-3 above)	
4d	Number of training weeks for postgraduate students	
5	Number of people receiving other forms of **long-term** (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	
6a	Number of people receiving other forms of **short-term** education/training (i.e not categories 1-5 above)	17 Colombian students and CORALINA staff receive training on crab biology, data analysis and economics; and community based resource management
6b	Number of training weeks not leading to formal qualification	22 weeks of training (17 theoretical and 5 practical)
7	Number of types of training materials produced for use by host country(s)	2 sets of course notes for the above training blocks 1 children's activity book 1 book on crab lore
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	22 (Richard Hartnoll and Mark Baine) 48 (4 Heriot-Watt MSc students)
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	1 management review 1 communique on terraculture 1 terraculture feasibility study
10	Number of formal documents produced to assist work related to species identification, classification and recording.	3 research protocols appended to the management review
11a	Number of papers published or accepted for publication in peer reviewed journals	1 accepted 1 submitted 2 in preparation by authors
11b	Number of papers published or accepted for publication elsewhere	1 published in conference proceedings
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	1 database on crab population analyses
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	
13a	Number of species reference collections established and handed over to host country(s)	1 literature reference collection
13b	Number of species reference collections enhanced and handed over to host country(s)	

Dissemination Outputs		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	2
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	1
15a	Number of national press releases or publicity articles in host country(s)	2
15b	Number of local press releases or publicity articles in host country(s)	50+
15c	Number of national press releases or publicity articles in UK	
15d	Number of local press releases or publicity articles in UK	1
16a	Number of issues of newsletters produced in the host country(s)	2
16b	Estimated circulation of each newsletter in the host country(s)	120
16c	Estimated circulation of each newsletter in the UK	
17a	Number of dissemination networks established	
17b	Number of dissemination networks enhanced or extended	
18a	Number of national TV programmes/features in host country(s)	1 documentary vIdeo
18b	Number of national TV programme/features in the UK	
18c	Number of local TV programme/features in host country	10
18d	Number of local TV programme features in the UK	
19a	Number of national radio interviews/features in host country(s)	
19b	Number of national radio interviews/features in the UK	
19c	Number of local radio interviews/features in host country (s)	25+
19d	Number of local radio interviews/features in the UK	
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	
21	Number of permanent educational/training/research facilities or organisation established	1 Black Crab Conservation Unit to be established 1 School Curriculum Input
22	Number of permanent field plots established	
23	Value of additional resources raised for project	

Appendix 3: Publications

The following are details of all publications and material that can be publicly accessed. Those publications that are provided with this final report are marked with an asterisk. There is no cost associated with each publication, except perhaps for postage.

Type	Detail	Publishers	Available from
Conference paper*	Grandas, Y., M. Baine and R. Hartnoll. 2004. The conservation and sustainable management of the black land crab, *Gecarcinus ruricola*, in the San Andres Archipelago. Proceedings of the 2nd Congreso Internacional Ambiental del Caribe, CONCARIBE. Corporacion Universitaria de la Costa.	CONCARIBE	Dr Manuel Cuenca, Chair of the 2004 Permanent Committee, ecotechnos@rogers.com
Report*	Baine, M., Hartnoll, R. and Taylor, E. 2005. The Black Land Crab (*Gecarcinus ruricola*) Catchery in the San Andres Archipelago, Management Review, 50pp.	CORALINA	Ms Elizabeth Taylor Director, CORALINA coralsai@telecom.com.co
DVD*	Conservation and Sustainable Management of the Black Land Crab, Colombia (Educational Documentary)	Studio Lezard Bleu, Canada	Ms Elizabeth Taylor Director, CORALINA coralsai@telecom.com.co
Book*	Black Land Crab in our Islands' Tradition	CORALINA	Ms Elizabeth Taylor Director, CORALINA coralsai@telecom.com.co
Book (in press)	Las Islas Misteriosas del Cangrejo Negro (The Mysterious islands of the Black Crab)	CORALINA	Ms Elizabeth Taylor Director, CORALINA coralsai@telecom.com.co
MSc thesis	Britton, A. 2005. The feasibility of black land crab terraculture in the San Andres Archipelago, Colombia	Heriot-Watt University	Dr Sandy Kerr Heriot-Watt University S.Kerr@hw.ac.uk
MSc thesis	Atkin, H.A. 2004. The distribution and abundance of the black land crab (*Gecarcinus ruricola*) in accordance with catch effort, within the Archipelago of San Andrés, Colombia	Heriot-Watt University	Dr Mark Baine Director, MIRC bainemsp@upng.ac.pg
MSc thesis	Frederiksen, J. 2003. A participatory approach for the sustainable management of the black land crab.	Heriot-Watt Universty	Dr Mark Baine Director, MIRC bainemsp@upng.ac.pg
MSc thesis	Richmond, M.G. 2003. Population biology of the black land crab (*Gecarcinus ruricola*), within the Archipelago of San Andrés, Colombia.	Heriot-Watt University	Dr Mark Baine Director, MIRC bainemsp@upng.ac.pg
MSc thesis	Watson, C. 2002. A bio-economic evaluation of the black land crab, San Andres, Colombia.	Heriot-Watt University	Dr Mark Baine Director, MIRC bainemsp@upng.ac.pg

The following papers are either in press, submission or preparation:

(1) Hartnoll, R. and P. Clark. (in press). A mass recruitment event in the land crab *Gecarcinus ruricola* (Linnaeus, 1758) [Brachyura: Grapsoidea: Gecarcinidae], and a description of the megalop. *Zoological Journal of the Linnean Society.*

(2) Baine, M., Taylor, E., Grandas, Y., James, J. and Hartnoll, R. (in submission). Towards sustainable management of the black land crab (*Gecarcinus ruricola*) in the San Andres Archipelago, Colombia. *Ocean and Coastal Management.*

(3) Hartnoll, R.G., Baine, M., Britton, A., Grandas, Y., James, J. and H. Atkin. Population biology of the

black land crab, *Gecarcinus ruricola*, in the San Andres Archipelago, Western Caribbean. To be submitted to *Journal of Crustacean Biology*.

(4) Hartnoll, R.G., Baine, M., Britton, A., Grandas, Y., James, J., and M. Richmond. Reproductive biology of the black land crab, *Gecarcinus ruricola*, in the San Andres Archipelago, Western Caribbean. To be submitted to *Journal of Crustacean Biology*.

Appendix 4: Darwin Contacts

Project Title	Sustainable management of the black land crab (*Gecarcinus ruricola*)
Ref. No.	162/11/015
UK Leader Details	
Name	Dr Mark Baine
Role within Darwin Project	Project Director (first with Heriot-Watt University, then with the Motupore Island Research Centre)
Address	MIRC, UPG, PO Box 320, University 134, NCD, PNG
Phone	
Fax	
Email	
Other UK Contact (if relevant)	
Name	Dr Richard Hartnoll
Role within Darwin Project	Land Crab Specialist
Address	Port Erin Marine Laboratory, Isle of Man IM9 6JA, UK
Phone	
Fax	
Email	
Partner 1	
Name	Ms Elizabeth Taylor
Organisation	CORALINA
Website address	www.coralina.gov.co
Role within Darwin Project	Project Manager, Colombia (Director, CORALINA)
Address	Via San Luis, Bight Km 26, San Andres Island, Colombia
Fax	
Email	
Partner 2 (if relevant)	
Name	
Organisation	
Role within Darwin Project	
Address	
Fax	
Email	

Appendix 5: Logical Framework

Project summary	*Measurable indicators*	*Means of verification*	*Important assumptions*
Goal ***To assist countries rich in biodiversity but poor in resources with the conservation of biological diversity and implementation of the Biodiversity Convention***		Research reports and database CORALINA environmental management reports: regulatory control and monitoring Research reports, stakeholder meeting records, management plan Economic Action Plan, Model Terraculture Project (if viable)	a) Political and institutional will exists for sustainable management b) SINA supported at national/departmental levels c) Migration to San Andres controlled in accord with existing legislation d) Traditional methods and cultural values respected e) Future financial backing
Purpose 1. Conserve, recover and ensure future sustainable exploitation of the black land crab in the San Andres Archipelago by developing management initiatives, education tools, and studying the potential for terraculture of this species to help eliminate growing poverty, while serving as a model for regional action	1.1 Local, national, and regional information access 1.2 Species management plan distributed 1.3 Policies and regulations 1.4 Terraculture project (1) designed and submitted for funding, if viable 1.5 Resource managers and stakeholders applying training	1.1 Web site postings, records of contact with IOCARIBE, IRF, CCA, etc. 1.2 File copies, mail log 1.3 Regulation(s) enacted by CORALINA (legal registry) 1.4 Project document, submission letters, mail log 1.5 Reports of CORALINA, BCCU, and multiplier activities	f) Regional involvement g) Institutional stability and funding of CORALINA maintained h) Regulations enforced, police/authority support i) Local community interest in sustainable use and terraculture j) Trainees remain at local institutions in archipelago
Outputs 1. Information base improved and research undertaken 2. Management planning to conserve, recover, and promote sustainable species use completed 3. Implementation of management initiatives 4. Training and education of local resource managers and stakeholder groups undertaken	1.References, biological and socio-economic data, culture experiments, database set up 2. Management plan, economic study 3. Regulations, terraculture viability, monitoring 4.Resource management and terraculture training, MSc qualification, education awareness materials	1. Catalogue, research reports, maps, experimental site report, database 2. Minutes, study document 3. Draft documents, reports, database records 4. Certificates, reports, attendance records, degree certificate, dissertation, video, poster, collection of black crab lore, publicity items	k) Adequate baseline data l) CORALINA Board approves management plan m) Good relationship b/w CORALINA/stakeholders n) Training/MSc completed o) Education materials well distributed p) Interest in producing and airing video and publishing press releases
Activities 1. Lit search, surveys, socio-economics, stakeholder consultation; database, experimental terraculture site 2. Management and economic study/action plans 3.Regulations, terraculture project, BCCU, monitoring program, regional contacts 4. Training programmes; crab lore, documentary video and publicity material	1. Months 1-36 2. Months 18-30 3. Months 25-36 4. Months 1-36 Project Expenditure	1. Task assessment forms (TAFs), budget reports, annual project report 2. Task assessment forms (TAFs), budget reports, annual project report 3. Task assessment forms (TAFs), budget reports, annual project report 4. Task assessment forms (TAFs), budget reports, annual project report	q) Sufficient/timely human and financial resources available to CORALINA l) Timely provision of information and data by relevant bodies m) Good communication between UK and Colombian organisations n) Prompt disbursement of funds and efficient procurement