Stock Structure of *Pristipomoides multidens* Resources across Northern Australia

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OBJECTIVES:

The objective of this study was to investigate the stock structure of *Pristipomoides multidens* in northern Australian waters, in order to assist in the development of appropriate management plans for deepwater snapper fisheries of the Northern Territory and Western Australia.

NON-TECHNICAL SUMMARY

The trap and line fishery for deepwater snapper in Western Australia and Northern Territory has grown substantially in the last nine years. *Pristipomoides multidens* (goldband snapper) is the most common species caught. This is a high priced fish favoured by the restaurants in Brisbane, Sydney and Perth. Western Australia and the Northern Territory are formulating management plans for the deepwater fisheries off their respective coastlines and are concerned about current levels of exploitation and the potential for overfishing. A key issue in formulating these plans is whether there is a single shared stock between States or distinct isolated stocks. This important question must be resolved before stock assessments can be attempted and appropriate management plans implemented.

If there is a single stock, then overfishing in one sector of the fishery could lead to depleted catches in other sectors. The broad aim of this project was to use population genetics to investigate the stock structure of *Pristipomoides multidens* in northern Australian waters in order to assist in the development of appropriate management plans for the deepwater fisheries of the Northern Territory and Western Australia.

Combined with the results of a previous analysis of similar populations (FRDC

1998/15, Newman et al., submitted), the results of this study support a separate gold-band snapper stock in the Kimberley region of north-western Australia. This degree of genetic distinctiveness may be explained by the sedentary nature of all life stages of the fish, including eggs and larvae. Adults have been shown to be sedentary on individual reefs by prior otolith composition analysis. This stock in the Kimberley region should have a management regime separate to other parts of the resource in the east and south.

There was no significant difference in goldband snapper populations located to the east and south of the Kimberley region. Several biological scenarios are proposed to account for this finding based on historical fluctuations in sea-levels or past exploitation of the species. Without an estimate of the statistical power of the genetic test applied in this study, it is unclear as to whether managers should combine or separate populations to the east and south of the Kimberleys region. The estimation of power in genetic tests used for fisheries management should be developed in future.

The results of the study show that goldband snapper in Indonesian and Australian waters are a separate stock. Within Indonesian waters it is likely that there are multiple stocks. The long-term implications of the fishery management regimes of the two countries are likely to be independent.

KEY WORDS: **Snappers, stock structure, goldband snapper, northern Australia, mitochondrial DNA**

BACKGROUND

Characteristics of the goldband snapper fishery

Goldband snapper (*Pristipomoides multidens*) inhabit reefs on hard bottom areas at depths of 60 to at least 180 metres, with the bulk of the population at 80 to 150 metres (Allen, 1985; Lloyd, 1994; Newman, unpublished data). It is a long-lived species with individual ages, calculated from otolith growth rings, up to 30 years not uncommon. The species is widely distributed throughout the tropical Indo-Pacific region from Samoa in the central Pacific to the Red Sea in the western Indian Ocean, and from southern Japan to northern Australia. Occasional goldband snapper found as far south as Albany on the south-western Australian coast are probably 'unsuccessful' migrants that cannot reproduce in local conditions (Newman, pers. comm.).

Over the last nine years there has been a rapid development of the deepwater trap and drop-line snapper fisheries in both Western Australia and the Northern Territory. *Pristipomoides multidens* are the most common species caught. Most fish are sold at the Brisbane, Sydney and Perth for the restaurant market. During the period 1990-1997, catches of *P. multidens* have increased from 84 to 385 t in the NT and from 9 to 329 t in the Northern Demersal Scalefish Fishery of Western Australia. As well as *Pristipomoides* spp., there are a number of other snapper species that are also caught. These include: *Lutjanus sebae* (red emperor); *L. malabaricus* (saddletail snapper); *L. erythropterus* (red snapper); *Etelis carbuncculus* (ruby snapper) and *Aprion virescens* (green jobfish). The value of the landed for 1997 was estimated to be over $5 M. In addition to these fisheries, *P. multidens* is also caught by trawlers working off Exmouth, off the Pilbara coast of Western Australia and in the Arafura Sea.

Prior to 1990 the fish communities on the northern and western Australian coast were exploited by at least four commercial fishing operations that caused measurable changes in overall species abundance and composition. Japanese stern trawlers operated in the region from 1959 to 1963, Taiwanese pair trawlers from 1972 to 1987, Australian and Korean "feasibility fishing" stern trawlers in 1979 and the fledgling Australian trap fishery since 1983. For the period 1980 to 1983 the annual catch of *P. multidens* exceeded the

sustainable annual yield (Sainsbury, 1987). During the operation of the pair-trawling operation from 1972 to 1983 the relative abundance of five genera *Lethrinus, Lutjanus, Epinehelus, Nemipterus* and *Saurida* changed significantly. Sainsbury (1987) implicated the direct and indirect effects of fishing for this alteration in community structure, through the effects of altered interspecific relationships and habitat modification indicated by a significant reduction in sponge density.

Project history

This project was originally designed in two stages, firstly to determine whether mitochondrial DNA or otolith microchemistry would be the best approach for determining stock structure, and then to measure the stock structure of the *Pristipomoides multidens* fishery in Western Australia and the Northern Territory.

A portion of the control region of the mitochondrial DNA was initially sequenced in a small number of samples (approximately 20) from each of five Australian locations. Preliminary analysis of these sequencing data suggested that the control region was an excellent genetic marker showing evidence of stock structure. The project participants decided to use the mitochondrial DNA technique for the remaining samples and to apply for a new FRDC grant to use the otolith microchemistry technique on the same samples. This grant application was successful (1998/154) and analysis of the otoliths has recently been completed (Newman et al., submitted). The use of both techniques, on the fish collected from the same locales, provides complementary independent information on stock structure and relationships.

A report describing the results of the genetic analysis of goldband snapper was presented to FRDC in draft format on 11th November 1998. The draft report suggested that this area might be genetically distinct from the remainder, but goldband snapper from this area were under-represented in the initial collection. The chief investigator was subsequently granted permission by FRDC to increase the sampling effort in one of the major fishing grounds, the Kimberley region. This final report includes all of the data from the draft report, as well as data on extra samples collected from the northern Kimberley region south to Broome, WA.

NEED

Fisheries imperative

Western Australia and the Northern Territory are presently formulating management plans for the deepwater fisheries off their respective coastlines and are concerned about current levels of exploitation and the potential for overfishing. A key issue in formulating these plans is whether Western Australia and Northern Territory share a single stock of *P. multidens* or whether distinct isolated stocks are present. If there is a single stock, then overfishing part of the stock could lead to depleted catches in other sectors dependent on the movement of fish between these areas. This important question needs to be resolved before accurate estimates of sustainable yield can be determined and appropriate management plans implemented.

The broad aim of this project was to use population genetics to investigate the stock structure of *Pristipomoides multidens* in northern Australian waters in order to assist in the development of appropriate management plans for the deepwater fisheries of the Northern Territory and Western Australia.

Biological imperative

Gene flow in marine and freshwater fish populations is the successful interchange of genes among populations. Success occurs when migrant genes are incorporated into the population through participation of the migrant in spawning. Biologists accept that populations of most species, especially marine, experience large amounts of gene flow (Ovenden et al, 1992). Isolating mechanisms restrict gene flow among populations and may be ultimately responsible for genetic subdivision. The complete cessation of gene flow caused by an impenetrable barrier under a vicariant scenario is probably rare in marine systems due to the large population size and ubiquitous distribution of most species. Rather, gene flow is thought to be restricted by less stringent mechanisms such as sharp environmental clines and dispersal opportunities, although rarely are the nature of these well known.

Gene flow in marine systems is a dynamic process, ranging from chaotically patchy (Doherty et al., 1995) on a micro-scale to inherently unstable on a macro-scale (Hedgecock, 1994). Most marine species have many phases to their life cycle, each of

which has distinct habitat requirements. The phase that has the greatest dispersal potential is normally responsible for the bulk of gene flow among marine populations. In marine species these are most likely to be eggs or planktonic larvae. Unless there is direct evidence to the contrary, the most conservative approach to the interpretation of gene flow is to assume that the population genetics of marine species is in a non-equilibrium state. This does not preclude the identification of genetically distinct populations, but does place limits on the estimation of absolute levels of gene flow.

Palumbi (1994) and others have predicted that for some marine species restrictions to gene flow among populations would be found even though their larval stages, for example, have enormous potential for dispersal. Flying-fish on the western coast of South America are a fine example of this phenomenon (Gomes et al., 1999). The species spawns off-shore, has pelagic larvae and is found in a region of intense long-shore currents, yet population samples taken hundreds of kilometres apart are genetically distinct. Others have taken a less extreme view and have hypothesised that among marine species dispersal capability might be correlated with the degree of genetic subdivision among populations. Doherty et al. (1995) found that the magnitude of gene flow was proportional to the logarithm of the length of larval life across seven fish species in the Great Barrier Reef, Australia. Shulman and Bermingham (1995) were unable to demonstrate a similar relationship for Carribean reef fish species.

Sedentary marine species are more likely to exist as genetically structured stocks than species that are migratory, have a high dispersal capacity or are not philopatric. Post-settlement goldband snapper have been shown to be largely sedentary by an otolith composition study (Newman et al., submitted). The ratio between oxygen and carbon isotopes in goldband snapper otoliths sampled from populations along the western and northern Australian coast, and in Indonesia, was significantly different. Discontinuities in reef habitats may be an effective isolating mechanism for this species if larval dispersal is not widespread. The environmental requirements of the fertilised egg or larval stage are poorly known. Even though the interpretation of patterns of genetic subdivision in marine species is complicated by multi-stage life histories and the lack of knowledge about dispersal and vicariant boundaries, genetic distinctions among geographically discrete populations is irrefutable evidence for the presence of multiple fisheries stocks.

The distribution of the goldband snapper encompasses the Indo-west Pacific region, an area of extraordinary marine biodiversity (McManus, 1985). The area is an eclectic mix of geologically recent islands and ancient continental plates that are surrounded by shallow tropical seas that have fluctuated from the present level to 150 metres below the current sea level in the last 125,000 years. Furthermore, the recently discovered Indonesian Through-Flow or Arlindo Current (Gordon and Fine, 1996) bisects the area. This current carries warm, near-equatorial water from the western Pacific Ocean to the Indian Ocean through the Indonesian Archipelago via the Timor Sea off northwestern Australia. In the Australian Indo-Pacific, genetically discrete populations of goldband snapper may have been formed as a consequence of barriers to dispersal linked to changing sea levels. Alternatively, prevailing currents may have promoted dispersal from north to south across the region leading to species-wide genetic homogeneity.

OBJECTIVES

The objectives of this study were broadly to explore the extent of gene flow on a graded scale by testing for the presence of genetic subdivision among goldband snapper populations from Australian and southeast Asian waters. The gradations encompassed spatial and temporal gene flow on a micro-scale among reefs, on a broader scale among populations in northern Australian waters and on a large scale between Australian and Indonesian fishing areas.

METHODS

Sample Collection

Goldband snapper (fig. 1) were collected from seven locales; Exmouth, Pilbara, Broome, Lynher Bank, Kimberley, Timor and Arafura; in Australian waters that corresponded to major areas of fishing effort (Appendix I, fig. 2 and 3). Fish for genetic analysis were sampled at random on board research or commercial vessels as a result of either drop-line (Exmouth, Pilbara, Broome, Lynher, North Kimberley, Timor and Arafura) or trap fishing methods (Barracouta, Vulcan, Heywood). Fish from three foreign locales were taken from landed catch in the Kupang fish market or opportunistically via colleagues in Western Irian Jaya and Madang, Papua New Guinea. Precise collection details for these fish are not available.

In 1996 at three locales; Exmouth, Pilbara and Lynher Bank; fish were sampled at the same place either on the same day, or on subsequent days. At the Broome locale, fish were collected in different years (1996, 1998 and 1999) in three different places within a 74.7km radius. At the Kimberley locale, fish were collected at four different locales (Heywood, 1998; Vulcan, 1999; Barracouta, 1996; and North Kimberley, 1996 and 1998) within a 121.3km radius. At the Arafura locale, fish were sampled on the same day in 1996 at four locales within a 32.3km radius. At the Timor locale, fish were sampled on the same day in 1996 at two locales within a 29.6km radius (Appendix 1). The fork length (FL) of most fish was recorded.

Laboratory Analysis

DNA Extraction

Total DNA was extracted from muscle stored in 95% EtOH. Using sterile scalpel and forceps a pinhead amount of tissue was taken and soaked for 3hrs in 1ml STE to rehydrate tissue. The tissue was removed using sterile forceps and placed into 500µl of 10% Chelex 100 solution, and 5µl Protease K (20mg/ml) was added. This solution was incubated for 3 hours or overnight at 55°C, with gentle mixing from time to time. It was then boiled for 8 mins, cooled to room temperature, and 55µl TE solution was added. The solution was again gently mixed and centrifuged for 5 mins at 13,000 rpm. Supernatant was removed into clean-labelled tubes and stored at -20°C. Appendix II describes the composition of the solutions used.

PCR Amplification

Eight µl of extracted DNA template was used in a 100µl PCR reaction with control region primers TDKD and PRO-L19 (Appendix III). This reaction mixture contains the following: 20 mM Tris-HCl pH 8.4, 50 mM KCl, 0.2 mM of each dATP, dCTP, dGTP and dTTP, 0.5µM of each primer, 2.5 mM $MgCl_2$, 0.1 mg/µl BSA, 4% DMSO, 3 units Taq DNA Polymerase (Life Technologies) and autoclaved distilled water. The tubes were capped and briefly centrifuged before being placed into a thermal cycler (Perkin Elmer 2400) using the following parameters: 1.5mins at 94°C followed by 35 cycles of 5sec at 94 °C, 30sec at 50°C and 30sec at 72°C with a final extension of 72°C for 5mins.

Automated Sequencing

The TDKD and PRO-L19 primers were used to prime cycle sequencing reactions. Sequences were obtained with an ABI automated sequencer using the chain-termination method with big-dye terminators. Amplified DNA was purified by electrophoresis in a 0.8% Tris-acetate agarose gel, followed by excision and recovery using conventional methods. A subset of fish from Exmouth, Pilbara, Kimberleys, Timor and Arafura locales was sequenced.

RFLP[1] Protocol

Digest

Five restriction enzymes were used for the analysis (*Ava* II recognition site G'GA/TCC[2], *Alu* I AG'CT, *Dde* I C'TNAG, *Dpn* II 'GATC, *Hin*f I G'ANTC, New England Biolabs). These enzymes were chosen because their restriction sites corresponded to polymorphic sites in the PCR fragment as determined by a comparison of the sequence of 111 fish. As concentrations of the five restriction enzymes were similar (8-10 units/µl) the same quantity of enzyme was used in each digest. For each individual 5-7µl of PCR product was added to 4µl of sterile water, 0.07µl of one of the restriction enzymes and 1µl of the corresponding restriction enzyme buffer in a sterile eight well strip tube. Samples were gently mixed, centrifuged, then left to incubate in a 37° C water bath for a minimum of three hours.

Visualisation

Fragments were visualised in 1.8-3% agarose gel consisting of 1/3 high resolution agarose (Biolife technologies) and 2/3 low resolution agarose (Boehringer Mannheim). Due to the large numbers of samples to be scored a 1xTAE (39.96mM TRIS, 19mM Glacial Acetic Acid, 1mM EDTA) buffer was used because the fragments run 10% faster in TAE compared to the commonly used TBE buffer.

Gel ingredients were heated on high for 1-2min in a standard microwave and shaken several times throughout this heating process. Once melted the solution was de-gassed,

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[1] Restriction fragment length polymorphism. This method uses electrophoresis to identify fragments of DNA that have been cleaved by restriction enzymes. In this study, length variation is used to indirectly infer sequence polymorphism via restriction site gain or loss.

[2] Cleavage position is marked with '.

cooled then poured into the gel mould and left to set. We used a large gel mould, consisting of three rows of twenty-four wells (4mm). Prior to loading 2µl of loading dye was added to each sample followed by centrifugation. The gels were run at a set voltage (80V) for approximately 2-2.5 hours then stained in ethidium bromide, visualised under UV light and photographed.

Scoring

Each sample was scored against a 25bp DNA ladder (Gibco BRL) consisting of 18 double-stranded DNA fragments between 25 and 450bp in multiples of 25bp plus a fragment at 500bp. Each new fragment pattern or morph was designated a letter name. In the final stages of the study restriction enzyme presence and absence of each of the morphs was verified by sequencing appropriate individuals. Restriction sites were numbered according to their cleavage position, not to the position of the first base pair in the recognition sequence.

Treatment of RFLP data to remove co-variance

In this study the less expensive and more rapid RFLP method was used for data collection as the goldband snapper control region was highly polymorphic. However the amount of sequence polymorphism was so large that restriction sites often overlapped. This caused the presence and absence of restriction sites in the final data set to be non-independent. An example of this is shown in figure 4. Two fish have identical sequence at five out of six consecutive nucleotide positions. The sequences differ by a single site where one fish has a 'T' and the other fish has a 'C'. This single substitution is responsible for the gain and loss of two different restriction sites. The first fish has a restriction site for *Hin*fI, but not for *Ava*II. The second fish has the opposite pattern. The first fish would be scored as '1 0' for the presence of the *Hin*fI site and the absence of the *Ava*II site. The second fish would be scored '0 1'. Before re-coding, the number of base pair differences between the two state haplotypes for fish one and two would incorrectly be calculated as equal to two. Co-variant restriction sites were re-coded to accurately reflect the number of base pair differences between them.

Co-variance was removed from the data set by examining the extent of sequence variation amongst the goldband snapper that were completely sequenced in regions where restriction sites were known to overlap. These regions were called hypervariable regions.

Examination of these regions often revealed a character that could be scored independently across all the fish. For example, the two fish in figure 4 could be re-scored for the presence or absence of a 'T' at nucleotide position 5. Substitution at this position is the cause for the presence or absence of the *Hin*fI and *Ava*II sites in this area.

At hypervariable regions where sequence variation was extensive, new characters were erected and re-coded (Appendix IV and Appendix V, Tables A-D) to reflect as well as possible the average amount of nucleotide changes between pairs of sequences. To assist this process, alternate sequences were linked with maximum parsimony networks (figs. 5 and 6). The effect of other re-coding schemes based on other equally parsimonious networks on the outcomes of genetic analyses has not been explored.

Lack of independence among restriction sites was removed to satisfy the assumptions of independence made by analysis techniques, especially AMOVA (Excoffier et al, 1992). This method performs a hierarchical analysis of molecular variance from the matrix of squared distances between all pairs of haplotypes and makes the assumption that all restriction sites are independent. The consequences of leaving the co-variance in the data set have not been explored. It may increase the variance of the squared distances and result in inflated Φ_{ST} values that may be less likely to be significantly different from random Φ_{ST} values produced during subsequent permutations aimed at assessing statistical significance.

Data Analysis

Genetic Structure Analysis

Genetic subdivision was assessed for goldband snapper populations using an hierarchical analysis of molecular variance (AMOVA) implemented by the software package Arlequin v1.1 (Schneider et al, 1997). The structure of the analysis is similar to conventional F-statistics, but adjusted for haploid transmission of mitochondrial genotypes. The Φ-statistics can be interpreted as follows:

- Φ_{ST} is the correlation of random haplotypes within populations relative to that of random pairs of haplotypes drawn from the whole species.
- Φ_{CT} is the correlation of random haplotypes within a group of populations relative to that of random pairs of haplotypes drawn from the whole species.

- Φ_{SC} is the correlation of the molecular diversity of random haplotypes within populations relative to that of random pairs of haplotypes drawn from the region (Excoffier et al, 1992).

Statistical significance for the Φ-statistics is inferred from a null distribution constructed from a random allocation of haplotypes to simulated populations that have the same sample sizes as the original populations. Probability values were calculated with 16,000 permutations that are guaranteed to have less than a 1% difference with the exact probability in 99% of cases (Guo and Thomson, 1992).

Analyses were performed on molecular differentiation among RFLP and sequence-defined haplotypes under an AMOVA framework and on differences in haplotype frequencies among populations. The hypothesis of random distribution of different haplotypes among populations was performed by a modification of Fisher's exact test (Raymond and Rousset, 1995) implemented by the software package Arlequin v1.1 (Schneider et al, 1997). The probability of observing a contingency table less likely than the sample configuration under the assumption of panmixia is assessed by a random walk between the states of a Markov chain. The number of Markov chain steps was 100,000 with intervals of 3,000 dememorisation steps before comparing the alternative table to the observed table. The latter type of analysis is appropriate if subdivision within the species is likely to be due only to patterns of gene flow. A combined analysis approach was adopted as it was assumed that subdivision in goldband snapper would be due to both haplotype evolution within and gene flow among populations.

To explore specific hypotheses about the genetic structure of goldband snapper populations, the significance of alternate hierarchical groupings of populations was assessed using pair-wise F_{ST}'s from mutational differences among haplotypes. Pair-wise transformed F_{ST}'s can be used as short-term genetic distances among populations (Reynolds et al, 1983). Haplotypes were randomly permutated 500 times among simulated populations to obtain a p-value for the F_{ST}'s. The p-value is the proportion of permutations leading to a F_{ST} larger or equal to the observed F_{ST}. Again, this method was implemented by the software package Arlequin v1.1.

Phylogenetic Analysis

A matrix of pair-wise mutational difference between RFLP haplotypes was calculated using PAUP v4.0 and clustered using the neighbour-joining algorithm of Saitou and Nei (1987). Bootstrap replicates (500) were made to assess the robustness of clades. A maximum parsimony (MP) tree for the nucleotide sequence data of 111 fish was constructed from a matrix of 58 variant characters. Indels and base substitutions were assigned equal significance, by allowing indels to be the equivalent of a 'fifth' base. Transversional substitutions and indels were weighted ten times that of transitional substitutions. Strict and 50% majority rule methods were used to produce a consensus tree from the set of shortest trees.

Mismatch Distribution

The distribution of the number of mutations between all pairs of haplotypes within each population was calculated by by the software package Arlequin v1.1.

RESULTS

General

Two techniques for assessing population subdivision were used in this study: full nucleotide or direct sequencing; and RFLP, an indirect sequencing method. Direct sequencing detects all of the genetic variation at a chosen gene among individuals. The RFLP technique detects a subset of the genetic variation present, in the form of the presence or absence of restriction sites. A total of 667 goldband snapper were analysed with the RFLP technique and nucleotide sequence was obtained from 111 fish (tables 1 and 2). The two techniques contribute uniquely to the analyses:

- The RFLP method was less expensive and time-consuming that direct sequencing and more amenable to screening large numbers of samples.
- Direct sequencing was useful for the rapid and accurate identification of polymorphic restriction sites in the amplified DNA fragment.
- Sequence data was able to confirm that the amplicon had verifiable characteristics of Pericformes mitochondrial control region, and was not a nuclear pseudogene that may have given spurious results.

- Sequence data was used to re-code restriction sites in hypervariable regions of the DNA fragment to ensure independence among haplotypes.
- The contribution of potentially homoplasious transitions to RFLP haplotype variation was assessed from sequence data.
- Phylogeographic patterns among populations was assessed more accurately with sequence data where homoplasies could be removed or weighted.

Restriction enzymes may distinguish about one-third of the alternate sequences present among individuals in hypervariable regions that are rich in actual or potential restriction sites. The hypervariable region 183 to 187 consisted of five adjacent polymorphic nucleotide positions (Appendix V, table B). It was followed by two non-polymorphic nucleotide positions (CC). Assuming transitions rather than the less common transversions were responsible for substitutions in this region, there could have been 32 different five-nucleotide sequences in a population sample. Two additional sequences containing transversions that were present in the data set have been included for this comparison (table 7). Of the 34 sequences in this simulated data set, 22 were not detectable with the five restriction enzymes used in this study, as they did not contain a recognition site for the enzymes. The remaining twelve sequences contained restriction sites for *Ava* II, *Alu* I, *Dde* I, *Dpn* II or *Hinf* I. Eight of these sequences were found in this study amongst the 667 goldband snapper. However, not all of these eight were scored as unique sequences using the RFLP method. One group of three sequences and one group of two had the same pattern of restriction site presence or absence. Outside the hypervariable DNA regions, where restriction sites were less common, the sensitivity of the RFLP technique was less. The 17 restriction sites used in this study (Appendix IV) included only 18 of the 58 polymorphic nucleotide positions detected by direct sequencing. A reduction in sensitivity of the RFLP method compared to direct sequencing is tolerable when balanced against time and dollar savings especially for large population surveys.

Characteristics of the left domain of the goldband snapper control region

Nucleotide sequence (360 base pairs) from the 5'end, or left domain of the goldband snapper control region showed similarity with other homologous teleost mtDNA sequence (table 1). The control region sequence was preceded by 20 base pairs of the adjoining region coding for the tRNA proline and the 19 base pair priming site used to

generate this sequence that lay 10 base pairs beyond that. The highly polymorphic right domain of the control region ended in two regions that are conserved across Perciformes (central conserved region) or fish and mammals (CSB-D, Lee et al., 1995). Within the first 26 (goldband snapper) and 52 (*Champsochromis spilorhynchus*; Cichlidae: Perciformes) bases of right domain control region sequence, lay a 23 base pair stretch that was 100% homologous between the two fish species. These 23 bases were also found in the right domain of the Japanese flounder (*Paralichthys olivaceus*, Fujii and Nishida, 1997) control region from position 24 onwards, but four of the 23 bases were different.

The degree of polymorphism in the left domain of the goldband snapper control region was similar to that reported by Fujii and Nishida (1997) for the Japanese flounder (*Paralichthys olivaceus*). They reported 54 sequence haplotypes from 55 fish, while this study found 61 haplotypes from 111 fish. Across the 424 bases of Japanese flounder sequence there were 126 polymorphic sites, while this study found 57 polymorphic sites across the 360 base pair stretch of control region (table 1).

Phylogenetic Relationships

An average of 350 nucleotides of double-stranded sequence was obtained from the control region of the mtDNA of 111 fish. Polymorphic sites accounted for 58 base pairs (table 3) across 61 different sequence haplotypes (table 4). Each unique goldband snapper sequence haplotype has been lodged on GeneBank (accession numbers AF192805-AF192865 http://www.ncbi.nlm.nih.gov/). All substitutions were transitions[3], except for four sites (numbers 185, 217, 228 and 265; table 3) that were transversions[4]. The RFLP technique detected 19 polymorphic characters among 677 fish for 35 RFLP haplotypes (tables 5 and 6).

The robustness of phylogenetic trees constructed to investigate the evolutionary relationships among the sequence and RFLP data sets were adversely affected by the amount of homoplasy in the data. The minimum number of steps for MP trees from the sequence data was 209 from a data set that contained 116 steps (52 transitional characters with one step, and 6 transversional characters with 10 steps) implying that on average every

[3] Substitution of adenosine (A) for guanine (G) and of cytosine (C) for thymidine (T).

[4] All substitutions other than transitions.

character experienced two state changes or homplasies. Consensus trees summarising topology of 1024 MP trees do not reveal any relationship between phylogenetic and spatial patterns. Neither was there was any resolvable phylogenetic relationship among the 35 RFLP haplotypes (fig. 7). Grant et al (1998) linked excess homoplasies in control region sequence and RFLP to spurious evolutionary relationships previously determined for several species of sardine (*Sardinops*).

Genetic Structure Analysis

The results of this report indicate that there are significant restrictions to gene flow between Australia and south-east Asia. Of the overall amount of molecular variance in the RFLP data set on 667 goldband snapper sampled from nine locales; six Australian and three foreign, 6.09% was found among locales (table 9). When the six Australian locales were grouped and compared to a group consisting of the three foreign locales the amount of variance between the two groups was a large 14.02% (table 10).

This report provides preliminary evidence that gene flow may be restricted among populations in south-east Asia. The magnitude of genetic variance among the Kupang, Western Irian Jaya and Madang locales (Φ_{ST}) was 0.0119 with a 13.2% probability of being greater than random permutations of the data (table 9). The difference between Kupang and Irian Jaya was particularly pronounced with (Φ_{ST} = 0.0383, p-value = 0.045, table 13C). Confirmation of the presence of multiple stocks within south-east Asian goldband snapper fishery will depend upon higher numbers of samples from larger numbers of locales. This work is currently proceeding, funded by ACIAR.

The frequencies of haplotypes supported the presence of genetic subdivision between Australian and south-east Asian goldband snapper populations. The relative frequencies of the five most frequent haplotypes differ between the Australian and foreign samples (fig. 8). For example, goldband snapper collected from Madang on the north-western coast of PNG had two haplotypes (BAAAA and CACBB, table 11) that were not found elsewhere in this study. Haplotype BBCBA was particularly common in Irian Jaya, Madang and Kupang being present in 53%, 42% and 33% of the fish sampled. This haplotype was less common in samples taken from Australian locales. Its frequency varied from 7.5% to 18.9% across the six locales.

The genetic distinction between Australian and south-east Asian samples was also reflected in the relative magnitude of intra-population genetic variation. The average gene diversity or the probability of two randomly chosen mitochondrial genomes being different, of the goldband snapper sampled from the three foreign locales was higher than that of the Australian locales. The foreign average gene diversity was 0.10+/-0.06 to 0.14+/-0.08, whereas the Australian average gene diversity was consistently 0.08+/-0.05. The Broome sample had a slightly higher gene diversity of 0.09+/-0.06 (table 12). The Madang sample had the highest average gene diversity in this study. This sample also had the highest variability in otolith chemical composition (Newman et al., submitted) that was explained by variability in metabolic rate due to the occurrence of the fish at a large range of depths, and hence temperatures, on the northeastern coast of Papua New Guinea.

The results of this report indicate that gene flow, and by implication dispersal, of goldband snapper does not occur freely along the northern and western Australian coastline. Molecular genetic variance was significantly structured among six Australian locales (Φ_{ST} = 0.0118, p-value = 0.007, table 9). The proportion of genetic variance detected by the direct and indirect sequencing method among populations was similar (table 8). Further, this genetic analysis shows that gene flow is likely to be most restricted within and around the Kimberley coastline of northwest Australia. Three of 21 pairwise comparisons among seven Australian goldband populations yielded significantly large F_{ST} 's and all involved the Kimberley population (table 13A). Two of these three significant comparisons involved geographically distant populations; Arafura and Pilbara. The remaining significant comparison involves the Broome population that is approximately 600 kms to the south-west. Populations adjacent to the Kimberleys; Lynher Bank and Timor were not significantly different to the Kimberley. These patterns of similarities were also obtained with the haplotype frequency differentiation test (table 13A, figs 9 and 10), except that the Kimberley population was significantly different from Pilbara, but not Arafura. The Exmouth population that was not significantly different using the F_{ST} test, was significantly differentiated to the Kimberley population on haplotype frequency differences. Taken together, the results of the two tests indicate that the Kimberley population is genetically distinct from the Arafura, Pilbara, Broome and Exmouth populations but not to Lynher and Timor, which are adjacent to the Kimberley region. Overall there appears to be evidence for

a genetically distinct, geographically extensive population of goldband snapper encompassing the Kimberely region, and possibly including Lynher Bank to the south and Timor to the north.

The fish sampled from the Kimberley region can be divided into four sub-populations; Vulcan, Heywood, Barracouta and North Kimberley to further investigate the relationship of the Kimberley region goldband snapper to nearby populations to the north and south. The southerly Broome population was not differentiated from the adjacent Lynher Bank or northerly Timor sample using the F_{ST} and exact test (table 13B). The Lynher Bank sample was distinct from the three of the four sub-populations in the Kimberley; Heywood, Barracouta and North Kimberley when the results of F_{ST} and exact tests were combined. The Heywood sample appeared similar (F_{ST} and exact test) to two other Kimberley region sub-populations, Barracouta and North Kimberley, but was separate from Lynher, Vulcan and Timor samples. The Barracouta sample appeared similar to Lynher, Heywood and North Kimberley, but separate to Vulcan and Broome on F_{ST} values; a similar pattern was found for the exact test but with less significant p-values. The North Kimberley population showed similarity to Heywood and Barracouta but not to Broome, or Timor, and to a lesser extent to Lynher Bank. The Vulcan Shoals sample was significantly distinct from the Heywood, Barracouta and North Kimberley collected nearby. It was more similar to the Broome, Timor and Lynher Bank samples. Caution is needed in the application of the results of these multiple tests of significance. If the alpha level is 0.05, then one out of 20 tests will lead to a Type I error; the rejection of a true null hypothesis.

This detailed pairwise comparison of the population genetics of goldband snapper from locales in and around the Kimberley area reveals a complex pattern of restrictions to gene flow. Three of the four Kimberley region samples were genetically similar to each other and genetically distinct from the populations to the north (Timor) and south (Lynher Bank and Broome). However, the extrapolation of these results into the finding that the goldband snapper of the Kimberley region are a distinct genetic stock with defined northern and southern borders may be premature; one of the four sub-populations from the region (Vulcan) does not have the 'genetic signature' of adjacent Kimberley populations.

Lack of temporal stability is unlikely to be responsible for the anomalous Vulcan result, as genetic differences among populations appear to be stable through time. In 1998,

the Broome and North Kimberley populations were significantly different at the 0.01 level, but in 1996 the comparison was not significant. This could be due to an unfavourable ratio between 'signal' and 'noise' related to smaller sample sizes in 1996. No significant difference was found among fish collected from North Kimberley in 1996 and 1998 or from Broome in 1996 and 1998 (table 15).

Mismatch Distribution

The distribution of the observed number of differences between pairs of haplotypes was unimodal for Australian populations of goldband snapper (fig. 11). Rogers and Harpending (1992) interpret a unimodal distribution as typical of a population that has recently experienced a demographic expansion. It is usually multimodal in samples drawn from populations at demographic equilibrium. A statistical test for the degree of modality of the distributions was not possible, as eight of the nine mismatch distributions had variances that were smaller than their means. When the variance of the mismatch distribution is smaller than the mean, the indices of Rogers and Harpending (1992) cannot be calculated.

The mismatch distributions of three of four Kimberley populations from which numerous samples were taken (Barracouta, Heywood and North Kimberley) were different to the distributions calculated for other Australian populations (fig. 11). A two-sample Kolmogorov-Smirnov test (alpha level 0.01) was used to test the hypothesis that there was no significant difference among pairs of mismatch distributions. The remaining population from the Kimberley region, Vulcan Shoals, was similar to Arafura and Broome. Other pairs of populations that were not significantly different were Arafura and Exmouth, Arafura and Pilbara, Arafura and Timor, Exmouth and Pilbara, Exmouth and Timor and Pilbara and Timor.

Length Frequency Distributions

The pattern of mismatch distributions across the four Kimberley populations (Barracouta, Heywood, North Kimberley and Vulcan) could not be explained by differences in the length frequency distribution of the fish that were sampled for genetic analysis. Fish sampled across the Kimberley region were generally between 350 to 700mm in length (fig. 12). An analysis of variance on the means and variances of the length distributions at each of these locations yielded a highly significant p-value of 0.000716. This

significant difference is not a result of the unique characteristics of the Vulcan Shoals samples as would be expected from the pattern among mismatch distributions. A Tukey (HSD, alpha 0.05) test revealed that the signal was from the Heywood sample that contained a larger percentage of smaller fish.

The length frequency distributions of samples from the five non-Kimberley Australian populations were similar in length to the fish sampled from the Kimberleys. Length frequency histograms showed that all Australian samples were generally between 350 to 700mm except that the fish from Exmouth were skewed towards larger sizes (fig. 12). Kupang was the only foreign sample for which length frequency information was obtained. The Kupang sample contained more small and large fish compared to the Australian samples. Precise collection details such as the method and depth of capture and exact geographical location were not available for the Kupang sample.

DISCUSSION

Genetic distinctiveness of Australian and Indonesian goldband snapper

The pronounced degree of genetic separation between Indonesian and Australian populations of goldband snapper implies that the Arlindo current is ineffective in facilitating dispersal in this species. Although full characterisation of the current has not been completed, it is thought to carry five to ten times the volume of Sydney Harbour through the Indonesian Archipelago per second (G. Meyers, pers. comm. CSIRO Marine Labs, Hobart). The downstream flow of the current passes in a southerly direction from Indonesia across the northwestern coast of Australia. However, none of the six Australian populations sampled in this study showed any genetic affinity to more northerly populations of goldband snapper, including the population sampled from Kupang that was less than 200 nautical miles away.

Flow patterns within the Indonesian Archipelago mediated by the Arlindo current are also presumably too weak to promote gene flow among Indonesian populations of goldband snapper. The western Irian Jayan and northern Papua New Guinea populations sampled both lie in the pathway of the Halmahera and Mindanao Eddies (Gordon and Fine, 1996) that are the northern Indonesian components of the Arlindo current. These eddies

appear not to promote gene flow as those goldband snapper populations are genetically distinct. Similarly, the Irian Jayan and western Timorese (Kupang) populations are genetically distinct despite their positions in the path of the Arlindo current from north to south through the archipelago. The multi-stock composition of the Indonesian goldband snapper fishery will be tested by a study currently underway funded by ACIAR and coordinated by CSIRO Marine Laboratories, Cleveland.

Homogeneity of five out of six Australian populations of goldband snapper?

This study was unable to reject the hypothesis that there was no difference among five of the six Australian populations sampled; from Exmouth, Pilbara, Broome, Timor and Arafura. The consolidation of the five populations into a single stock does not appear to make biological sense. The five populations have a disjunct distribution to the east or south of the Kimberley region. Furthermore, the lack of significant genetic subdivision among goldband snapper populations collected from locales separated by thousands of kilometres along the Australian coastline is in contrast to the presence of genetic subdivision observed among populations from Indonesia and Papua New Guinea. The genetic homogeneity of goldband snapper populations distributed from Exmouth (WA) to the Arafura Sea (Qld) is unlikely to be explained by extant gene flow. There are no known prevailing long-shore currents in the shallow northern Australian seas that could facilitate dispersal of pelagic life-stages. The distances involved are even greater than between Indonesia and Australia where gene flow is probably curtailed. Otolith data on northern Australian goldband snapper populations confirms that, as elsewhere, adult goldband snapper are sedentary.

Should the five populations be managed as a single unit because population subdivision was not detected? Firstly, the hypothesis of no difference among populations was not framed in terms of dispersal rates. Taylor and Dizon (1996) and Taylor et al (1997) suggests testing 'critical dispersal' rates instead of the conventional null hypothesis. Her definition of 'critical dispersal rate' is the minimum needed to maintain populations throughout the entire stock. Dispersal in general is important to fisheries management as it defines the ability of a stock to withstand overexploitation when harvesting exceeds recruitment. If fisheries managers and scientists suspect that a stock is recruitment overfished, then the results of genetic structure analysis can be applied to test a 'critical dispersal rate' hypothesis. Appropriate genetic models and fisheries knowledge of the

appropriate 'critical dispersal rate' for goldband snapper, or any managed species, are unknown at present.

The second impedient to the interpretation of the five Australian goldband populations as a single stock is the lack of knowledge about the statistical power of the genetic test. As Taylor et al (1997) succinctly stated:

> "If there were a 90% chance of detecting population subdivision, and no subdivision was found, a manager would probably be justified in lumping the populations. If there were only a 10% chance of detecting the effect, then the manager should conclude that little light was shed on the problem and further research was needed to resolve the problem"

Taylor et al (1997) develops a framework for the estimation of power based on the relationship between four statistical parameters; power, significance criterion, sample size and effect size. The parameters are related in such a way that if any three are known, the fourth is completely determined. The method appears to be soundly based, but much more development is need before it can be applied to non-mammal marine stocks.

The distribution of goldband snapper in northern and western Australian waters broadly corresponds to shallow seas and the continental shelf. The Timor and Arafura Seas on Australia's northern coastline are contiguous, shallow seas rarely deeper than 200 metres. In the east there is no bathymetric transition between the Arafura and Aru Seas on the southern Irian Jaya coast. To the west, the Timor Sea is sharply separated from Indonesian seas by the 2,000 metre deep Timor Trough that lies parallel to the island of Timor. South of the Timor Sea, the continental shelf, up to 200 metres deep, is about 10 to 60 nautical miles wide along the western Australian coast.

Genetic homogeneity may have been forced upon this sedentary species as a result of distributional changes caused by past changes in sea level or by more recent fluctuations in abundance linked to past exploitation. A peak of glacial activity 125,000 years before present (ybp) is thought to have reduced northern Australian sea levels by 150 metres (Shackleton, 1987). The distribution of goldband snapper under these conditions would have been dramatically altered. Bathymetric examination shows that habitat suitable for goldband snapper would have been discontinuous consisting of a patch to the north east of the Timor Trough and a strip from the south west of the Trough south to the Exmouth Gulf,

WA. This event was followed by a rise (115,000 years before present), a fall (18,000 ybp) and another rise (7,000 ybp) in sea levels (Keenan 1994). During these fluctuations, populations on the north and west coasts may have moved to habitat where conditions were still acceptable These repeated moves may have continuously broken down geographical barriers permitting genetic mixing. A similar mechanism has been proposed by Coope (1979) to account for the morphological and physiological stability in the beetle fauna of Europe during the cyclical advance and retreat of glacial ice.

The genetic consequences of range alteration have been reported for other tropical species in Australian waters. Genetic analyses of saddle-tail sea perch (*Lutjanus malabaricus*, Elliot 1996) from the north west Australian coast and the Gulf of Carpentaria are consistent with the re-colonisation after the last ice age from the western populations. Chenoweth and Hughes (in preparation) also suggested range expansion into the shallow Arafura Sea to explain genetic patterns observed in the threadfin salmon, *Polynemus sheridani*. However, a progressive decrease in genetic diversity associated with founder events normally linked to range expansion (Keenan, 1994) has not been observed in this genetic analysis of goldband snapper.

Are the goldband snapper from the Kimberley region a distinct 'stock'?

The draft report submitted to FRDC on 11th November contained preliminary evidence that the population of goldband snapper from the Kimberley region was genetically distinct from the bulk of the Australian resource. This has been validated by the evidence presented in this final report based on an extended genetic analysis of more fish subsequently sampled from the area. The geographical extent of the Kimberley stock appears to encompass at least 14.9°S (Lynher Bank) to 12.0°S and 122°E to 126°E. The combination of genetic distinctiveness for the resource from the region and otolith studies (Newman et al., submitted) is a persuasive argument in favour of the treatment of the Kimberley resource as a stock separate to the remainder of the resource in Australian waters. A fisheries stock is defined as a genetically cohesive population that is large enough such that immigration or emigration does not dominate abundance changes (Hilborn and Walters, 1992). As such it is an important unit in fisheries management.

Populations of several other marine species have shown genetic distinctiveness unique to the Kimberley region. Kimberley populations of *Penaeus monodon* (J. Benzie et

al 1992, 1993) and *P. esculentus* (S. Lavery, Harvard) are genetically distinct. Concordant genetic breaks across co-distributed unrelated taxa often correspond to boundaries between biogeographic regions. Avise and co-workers convincingly demonstrated a biogeographic boundary between the coast of the Gulf of Mexico and the coast of Florida for a variety of organisms ranging from oysters (Reeb and Avise, 1990) to beach-nesting sparrows (Avise and Nelson, 1989). This boundary had not previously been recognised. Several plant families (*Triumfetta, Troidia* spinifex and two aberrant forms of *Acacia*; *Lycopodifolias* and *Deltoidae*) have restricted distributions in the Kimberleys (Tim Willing, pers. comm.). The Kimberley and northern Australian tectonic plates collided about 1830 million years ago followed by erosion, sedimentation and further geological activity (Tyler, 1996). However, more comparative studies of a wide range of taxa are needed before the Kimberley region is given biogeographic distinction.

The Kimberley stock of goldband snapper may have been derived from a founder event from a remote and genetically distinct population. Close-by Indonesian populations would be the most likely donors, and the Arlindo current would be the most likely dispersal mechanism. However, this study has shown that the current is probably ineffective in mediating southward dispersal, and the Kimberley stock shows no phylogenetic affinity with any of the Indonesian populations sampled in this study at least. Furthermore, the heterozygosity of the Kimberley stock is not low as would be expected for a stock which has recently experienced a founder event (Ovenden and White, 1990). The star shape of goldband snapper RFLP haplotype phylogenetic tree is characteristic of virtually every marine species (Grant and Bowen, 1998) and is probably not the consequence of a recent bottleneck event. Rather it reflects the rapid pruning of branches that occurs when the variance of female reproductive success is high (Bermingham et al., 1998), especially in marine species (Hedgecock, 1994).

Waples (1998) provides a table describing the four outcomes that can occur when null hypothesis of no difference between populations is rejected by a statistical test. His outcome 'D' where the false null hypothesis is correctly rejected, is assumed to apply to the Kimberley 'stock' of goldband snapper proposed in this study and the Kimberley 'stock' is biologically meaningful for any of the reasons discussed above. However, there are three other possible outcomes. Firstly the hypothesis could be correctly rejected, but the

differences between the populations are biologically insignificant (outcome C). The probability of making this kind of error depends on statistical power, effect size, sample sizes, sample number, the number of genetic characteristics measured per fish and most importantly, the context. Secondly, the hypothesis could be incorrectly rejected due to violations of sampling assumptions (outcome B). Samples taken from fisheries almost always violate the random sampling assumption; certainly the goldband snapper taken is this study were not a random sample as they were taken from amongst the commercial catch and juvenile fish were not included. Lastly, the null hypothesis could be incorrectly rejected due to chance (outcome A, type I error). Multiple tests were performed in this study, increasing the likelihood of type I errors.

The Vulcan Shoals population embedded in the eastern edge of the proposed Kimberley 'stock' of goldband snapper challenges the idea of genetic cohesiveness of the proposed stock. There is minimal uncertainty about the location of collection of the Vulcan sample. Vessel monitoring (VMS) of the commercial vessel from which these samples were obtained showed that no stops were made between the port of Broome and Vulcan Shoal on the outward or return trips. In the laboratory, the Vulcan Shoals samples were processed in a batch with the North Kimberley, Heywood and Broome samples collected in 1998 and 1999 and after the processing of all other samples. Strict laboratory hygiene, including the use of negative controls on each batch of DNA amplifications, suggests that the distinctiveness of the Vulcan Shoals samples was probably not due to contamination. Temporal stability demonstrated in this study among samples collected two to three years apart at the same location, suggest that Vulcan Shoals was not recently invaded by a genetically distinct cohort. The lack of otolith microchemical heterogeneity within the Kimberley region (Newman et al, submitted) does not conflict with the possible presence of genetic heterogeneity, as genetic analysis has the potential to be effective on a much finer scale that otolith analyses.

The position of the Vulcan Shoals population on the eastern edge of the Kimberley region may be a rare example of fisheries stock parapatry. This is a narrow, precisely defined geographical boundary between closely related populations. Parapatric stocks of cetacean species, such as inshore and offshore populations of bottlenose dolphins, are known and appear to be the result of resource polymorphism (Hoelzel, 1998). Alternatively,

intensive harvesting of the Vulcan Shoals population may have sharply reduced the effective population size, increasing genetic drift and resulting in haplotype frequency shifts. Finally, genetic measurements of all populations in the vicinity of the Kimberley 'stock', including Vulcan Shoals, may be affected by the signal to noise ratio (Waples, 1998). Marine species, including goldband snapper, generally exhibit low values of F_{ST} where recision is adversely affected by insufficient sample size or genetic loci.

Adult and juvenile goldband snapper populations have been shown to be location specific or philopatric (Newman et al. submitted), but this genetic study presents strong, if indirect, evidence of the possibility that the eggs and larvae of goldband snapper are also sedentary. That is, externally fertilised eggs spawned into the water column may be negatively buoyant and sink directly back to the natal habitat and larvae may not be pelagic, but benthic. This suggestion is contrary to what is known about related species such as *P. filamentosus* and *P. sieboldii* which both spawn pelagic eggs (Leis, 1987). Knowledge of the ecology and behaviour of the early life history stages of eteline lutjanid species is particularly limited. Leis and Lee (1994) report that *Pristipomoides* larvae remain pelagic to considerable size, up to 46.7 mm in *P. multidens/typus* (to date, the larvae of *P. multidens* and *P. typus* cannot be distinguished from one another). Furthermore, eteline larvae including *Pristipomoides* spp. have been found to be distributed mostly seaward of the edge of the continental shelf and offshore of oceanic islands (Leis, 1987). If this early life history information holds true for *P. multidens*, that is, that the spawned eggs are pelagic and that larvae can remain pelagic until a large size, suggests that larvae of this species have a capacity to actively maintain their position in close proximity to the natal reef habitat. Alternatively, as lutjanid larvae in ichthyoplankton work are in general, relatively rare (see Leis, 1987), it may indicate that the larvae of *P. multidens* are semi-pelagic, with the majority of larvae settling rapidly in close proximity to their natal reef.

FURTHER DEVELOPMENT

In the Kimberley region restrictions to gene flow were found on a micro-scale among adjacent reef populations. The least conservative explanation of this result is that we detected a zone of transition between two genetically distinct and geographically widespread fish populations. Another, more extreme interpretation is that the majority of reefs along the

northern Australian coastline support genetically distinct goldband snapper populations but sampling error precluded their detection. If this micro-stocks hypothesis is correct, over-harvesting among reefs could lead to localised extinctions, declining biomass and the rapid erosion of genetic diversity. Declines in genetic diversity have been linked to decreases in growth and fecundity as well as changes in sex ratio and the ability to adapt to environmental change (Chapman et al, 1999). The hypothesis of micro-stocks could be investigated in a future genetic analysis of the resource where either the sampling of fish or genes was redesigned. In particular, microsatellite genetic loci should provide increased resolution. Microsatellite data are derived from nuclear genes and allow the male contribution to the genotype to be assessed. The micro-stock hypothesis predicts that goldband snapper eggs and larvae are not pelagic and are strongly associated with parental habitat. Investigations of the larval biology of the species could test this.

When this research proposal was lodged with FRDC, there was no commercial fishery targeting this species on the east coast of Queensland. In the intervening four years, a fishery has developed based in Cairns and Townsville. Analysis of offshore and inshore marine species has shown significant genetic differentiation to the west and east of Cape York. Species showing this pattern include the saddle-tail sea perch *Lutjanus malabaricus* (Elliot 1996), spanish mackerel *Scomberomorus commerson* (Shaklee, 1990), barramundi *Lates calcarifer* (Keenan 1994, Chenoweth et al, 1998), threadfin salmon (Chenoweth and Hughes, in prep.) and mud-crabs *Sylla serrata* (D. Gopurenko et al, 1999). The common explanation is low extant gene flow through Torres Strait combined with vicariance; a land bridge connected Papua New Guinea and Australia during the last glacial when sea levels were tens of metres lower than present. Our finding in this research project that gene flow in goldband snapper is localised in combination with the vicariance explanation used for other marine species strongly suggests that a distinct goldband snapper stock will be found on the east coast of Queensland. An ACIAR funded study (1999 – 2001) will use genetic techniques to test this expectation. In the interim we recommend that fisheries managers take a conservative or precautionary approach, and regard the east coast resource as a separate stock.

The fundamental problem of the assessment of the statistical power of genetic tests should be given the highest priority for further development. A resolution of the problem

would broaden the application of outcomes of this report in relation to the management of goldband snapper, and provide a rationale for the more extensive and more accurate application of genetic structure analysis to fisheries management. To my knowledge, Barbara Taylor's research group at the Southwest Fisheries Centre, La Jolla California USA are alone in addressing the problem. Interaction with her group possibly through sponsored reciprocal visits may facilitate the application of the method to Australian fisheries.

BENEFITS

The sectors of the Australian fishing industry that will benefit from this research project are the participants in the goldband snapper trap and line fishery in Northern Territory and Western Australia and the associated downstream industries such as the fish processing and marine supply industries.

The benefits to the northern Australian fishing industry of this research project lies in the improved management of the goldband snapper resource that will be possible as a direct consequence of this research. With the benefit of this information fisheries managers can confidently implement a plan for the sustainable exploitation of the species. Without this information, the exploitation plan may be unintentionally flawed and lead to the longer-term demise of the resource and its associated industries. The information from this research project is timely in that it facilitates the ecologically safe and economically viable use of a relatively newly discovered resource.

There is a secondary benefit of this research. The direct beneficiaries are stock assessment biologists and indirectly the fishing industry. The benefit is the demonstration of the way in which fisheries genetic and otolith chemistry studies can be integrated to yield a detailed picture of the species biology.

CONCLUSIONS

The results of this genetic analysis of goldband snapper, combined with the results of the otolith analysis of similar populations (FRDC 1998/15, Newman et al., submitted) provide sufficient evidence to propose that the goldband snapper resource in the Kimberley

region is a distinct fisheries stock. This should be considered in stock assessment and fisheries management studies on the resource in future.

Australian and Indonesian populations of goldband snapper are separate mega-stocks. The long-term implications of the fishery management regimes of the two countries are likely to be independent.

This genetic analysis of goldband snapper establishes a base line for future studies that may test for the presence of genetic erosion as a consequence of management policies.

This population genetic analysis of goldband snapper strengthens the proposal all life stages of the species are sedentary and have a remarkable lack of dispersal potential. This is contrary to expectation, as the dispersal potential of most marine species in the pelagic zone is huge. The hypothesis of goldband snapper as a philopatric species followed from the otolith chemical composition study of Newman et al. (submitted). Their interpretation of pronounced chemical differences among fish collected from different reef systems was limited to the duration of the adult phase as the whole otolith was used in the analysis. A comparison between this study and the otolith composition study clarifies the unique roles of each discipline in understanding fisheries resources.

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Table 1 Nucleotide sequence (380 bp) of the mitochondrial DNA of the 5' end of the goldband snapper control region. The first 20 base pairs correspond to the 3' end of the $tRNA^{Pro}$. The location of the putative termination associated sequence (TAS, Faber and Stepien, 1997), the first 19 base pairs of the central conserved region (CCR, Lee et al., 1995) and the conserved sequence block (CSB-D, Lee et al, 1995) are shown. Also shown is the location of a region of 23 consecutive bases that was 100% homologous with 23 bases from the 5' end of the cichlid (*Champsochromis spilorhynchus,* Lee et al., 1995) control region (Cichlid homology). Asterisks mark the 58 polymorphic base pairs. There were two insertion/deletion events (:) at postions 105 and 143.

```
      ↓----TAS-----↓  ↓-Control Region--->
                        ↓-Cichlid Homology-
TTAGTTAAAC TACTTTTTGC GTAATGCATA TATGTATTAA
1                   * *
----↓
CACCATACAT TTATATTAAC CAATATCAAT ATTAGTCAAG
41       * ***   **                * *   *

GACATAACTG TTTTATCAAC ATTA:CTCGG ACCACAACAT
81     *   *              *       * **

TCACTCACCA CCATAAACCT ACAGAAATAC ATAAAGCTAA
121 * **   *      **    ****       **   *

CCCTCATTAA TCAAACAATC TAGGATCCAC AGCTGGCGAA
  ***              ** ******* *   *       *
161

ACTTAAGACC GAACACATCC GTCCACAATC CTAATATATA
201             * *         *

                                        ↓--
CCAAGGACTC AACATCCCGC CATAACTCAG AATCTTAATG
241     *                  **   *

------CCR--------↓
TAGTAAGAAC CGACCATCAG TTGATTGCTT AATGCCTACG
  *
281

TTTAATGAAG GTGAGGGACA AGACTCGTGG GGGTTTCACT
321     ** *      *     *  *

           ↓-----CSB-D------↓
CAGTGAACTA TTCCTGGCAT CTGGTTCCTA CTTCAGGAGG
* *   **    *                          *
361
```

Table 2: Numbers of goldband snapper genetically analysed from seven Australian localities and three foreign locales with the RFLP or nucleotide sequencing (SEQ) technique. Degrees of latitude and longitude are approximate.

Location	Lat	Long	RFLP	SEQ
Australian				
Exmouth	23.6	113.1	47	18
Pilbara	19.7	115.7	87	26
Broome	17.6	120.8	104	-
Lynher	14.9	122.1	20	-
Kimberleys (Vulcan , Heywood, Barracouta and North Kimberley sub-locales)	13.0	124.4	200	19
Timor Sea	10.2	129.8	74	27
Arafura Sea	12.4	140.7	53	21
Foreign				
Kupang	10.4	123.4	57	--
Irian Jaya	0.4	129.8	26	--
Madang	5.0	146.1	19	--
Total			**687**	**111**

Table 3 Polymorphic or variant nucleotides (58) for 111 goldband snapper. Individual fish are from Exmouth (EX), Kimberley (KMB), Pilbara (PL), Timor (Pm12XX), Arafura (Pm11XX) and Kupang (KO5). In some fish, the nucleotide state (A, G, C or T) was ambiguous (?). The variant nucleotides are numbered according to the nucleotide sequence from Table 1. insertion/deletion events (indels) were found at nucleotide postions, 105 and 143. The missing nucleotide is shown (–).

```
          2 2 7 7 7 8 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3
          0 1 3 5 9 8 1 0 1 1 1 2 2 2 3 3 4 4 4 4 5 5 5 6 6 6 7 8 8 8 8 8 8 8 8 9 0 1 1 2 4 6 6 7 8 2 3 3 3 4 4 6 6 6 6 7 9
                    5 2 4 5 5 7 8 1 8 3 4 5 6 3 4 8 3 4 5 9 0 1 2 3 4 5 6 7 9 2 0 7 9 8 9 5 6 0 3 9 0 1 8 3 6 1 3 7 8 2 8
EX02      C G T G A C T - C A C T A C C C A G A A A A T C T C T T C A G G G T C A G A A C A T A C G G A G G A A C C G A T T ?
EX12      ? . . . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
EX19      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . C . . . G . . . . . . . . . T . . C . ?
EX22      . . . . . . . . - . . . C . . . . . . . . . . . . . . C C T . . . A . T . . . . . . . . . . . . . . . . . . ? ? ? ? ?
EX26      . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . . A . . . . . . . . . ?
EX27      . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . C . . . . . . . . . . . . . . . A . . . . . . . C . ?
EX28      . . . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . . . . . A . . . . . . ? ? ? ?
EX30      . . . . . . . . - . . . C . T . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . ? ? ? ? ? ? ?
EX31      . . . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . . . . . A . . . . . . . . . ?
EX32      ? ? . . . . . . - . . . C . . . . . . . . . G . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T . . C . ?
EX33      . . . . G . . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
EX34      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C C T . . . A . T . . . . . . . . . . . . . . . . . . C . A
EX36      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . G . . . . . . . . . T ? ? ? ? ?
EX39      . . . . . . . . - . . . C G . . . . . . . . . . . . . . C T . . . A C T . . . . . . . . . . . . A . . . T . . C . ?
EX4       . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . . A . . . . . . ? ? ? ?
EX53      . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . G . . . T T . T . . . . A . G . . ? ? ? ? ? ?
EX7       ? ? . . . . . - . . . . . . . . . . A . . . . . . . . . . . . . A . . G . . . . . . . . . . A . ? ? ? ? ? ? ? ? ? ?
EX8       ? ? . . . . . . . . . C . . T . . . . . . . . . . C C T . . . A . T . . . . . . . . . . . . . . . . . . . . C . ?
K05       . . . . G . . - . . . . . . . . . - A . . . . . . C T . C T . . . A . . . . . . T . C . . . . . A . . . . . . . C . ?
KMB1300   . . . . . . . . - . . . C . . . . . . . . G . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . . . C . ?
KMB1301   . C . . . . . . - . . . ? . . . . . . . . . . . . . . . . ? . . . ? . . . . . . . ? . . . . . . . . . . . ? ? ? ? ? ? ?
KMB1302   . . . . . . . . - . . . C . . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T ? ? ? ? ?
KMB1303   . C . . . . . . - . . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . ? ? ? ? ?
KMB1304   . . . . . . . . - . . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . ? ? ? ? ?
KMB1305   ? ? . . G . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . A . . . . . ? ? ? ? ?
KMB1306   . . . A G . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . A . . . . . . . . C . A
KMB1307   . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A C T . . . . . . . . . . . . . A . . . T ? ? ? ? ?
KMB1308   . . . . . . . . - . . . C . . . . . . . . G . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . . . C . ?
KMB1309   . . . . . . . . - . . . . . . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T ? ? ? ? ?
KMB1310   . ? . . G . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . A . . . . . ? ? ? ? ?
KMB1312   . C . . G . . - . . . . G . . . . . . . . . . . . . . . . ? . . . . . G . . . . . . . . . . . . A . . . . . ? ? ? ? ?
KMB1313   . C . . . . . - . . . C . . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T ? ? ? ? ?
KMB1314   . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T . . C . ?
KMB1315   ? ? . . . . . . - . . . C . . . . . . . . . . . . . . C C T . . . A . T ? . . . . . . . . . . . . . . . . . . ? ? ? ? ?
KMB1316   . . . . . T . - . . . . . . . . . . G . . . . . . . . . A A . . G . . . T T . C . . . . A . G . . . . . . C ?
KMB1317   . . C . . . . . . . C . . . . - A . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . A . . ? ? ? ? ? ? ?
KMB1318   . . . . G . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . . . . . C . ?
KMB1319   ? ? . . . . . . C . C . . . T . A . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T . . C . ?
PL01      . . . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . G . . . . . . . . A . . . . . . . . . . . . A
PL04      . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . . G . . . . . . . . . . . . . . . . . . . . . G
PL08      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . T . . C . G
PL1       . . . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . G . . . . . . . . A . . . . . . . ? ? ? ? ? ?
PL10      ? ? . . G . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . G . . . . . . . . . A . . . . ? ? ? ? ? ?
PL100     . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . A A . T . . . . . . . . . . . . . . . . G . T . . C . ?
PL12      ? ? . A . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . ? ? ? ? ? ?
PL13      ? ? . . . . . . - . . . . . . . . . . . . . . . . . . . C T . . . A . T . . . . T . . . . . . . . . . . . T ? ? ? ? ?
PL14      ? ? . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . G . . . . . . . . . . . A . . ? ? ? ? ? ? ? ?
Pl15      ? ? . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . A . T . . . . . . . . . . . . . ? ? ? ? ? ? ? ?
PL16      ? ? . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
PL2       . . . . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . . . . A . . . . . . . . . ?
PL24      ? ? . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . G A . . . . . . . . . . . . G . . . . . . . ?
PL26      ? ? . . . T . - . . . . . . . . . . G . . . . . . . . . . . A A . . G . . . T T . T . . . . A . G . . ? ? ? ? ? ?
PL29      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . . ? ? ? ? ? ?
PL31      . . . . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . T . . . . . . . . . ? ? ? ? ? ?
Pl32      . . . . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
Pl33      . . . . . . C - . . T . . . . . . . . . . . . . . . C C T . . . A . . . . . . . T . . . . . . . A . . . T . . . . ?
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        2 2 7 7 7 8 9 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3
        0 1 3 5 9 8 1 0 1 1 1 2 2 2 3 3 4 4 4 4 5 5 5 6 6 6 7 8 8 8 8 8 8 8 8 8 9 0 1 1 2 4 6 6 7 8 2 3 3 3 4 4 6 6 6 6 7 9
                    5 2 4 5 5 7 8 1 8 3 4 5 6 3 4 8 3 4 5 9 0 1 2 3 4 5 6 7 9 2 0 7 9 8 9 5 6 0 3 9 0 1 8 3 6 1 3 7 8 2 8
EX02    C G T G A C T - C A C T A C C C A G A A A A T C T C T T C A G G G T C A G A A C A T A C G G A G G A A C C G A T T ?
PL35    . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . ? . . . . . ? ? ? ? ? ? ? ?
Pl4     . . . . . - . . . . . . . . . . . . . . . . . . . . . A . . . . G . . . . . . . . . . . . . . ? ? ? ? ? ?
PL49    T . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . G . . . . . . . . . ?
Pl5     . . . . . - . . . . G . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . A . . . . . . . . . . . ?
PL58    . . . . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . A . . . . . . . C . ?
PL59    . . . . . - . . . . . . . . . . . . . G . . . . . . C . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . ?
PL87    . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . . . . A . . . . . . . . . ?
PL88    . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . ?
Pm1100  ? ? ? ? ? . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . ? ? ? ? ? ? ? ? ? ? ? ?
Pm1101  ? ? . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . . A . . G . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1102  ? ? . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . C . G . . . . . . . . . . . . . . . . . ? ? ? ?
Pm1103  ? ? . . . . . - . . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1105  ? ? . . G . . - . . . . . T . . . - A . . . . . . C T . C T . . . A . . . . . . T . C . . . . . A . . . . . . . C . ?
Pm1106  ? ? . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1108  ? ? . . . T . - . . . . . . . . . . G . . . . . . . . . . . A A . . G . . ? T T . T . . . . A . G . . . . ? ? ? ?
Pm1109  . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . . . ? . . . . A . . G . . . ? ? ? ?
Pm1110  . . . . . . C A . . . . . . . . . . . . . . . . . . . . . C T . . . A . . . . . . . . . . . . . . . . . . T . . C . ?
Pm1111  . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . G A . . . . G . . . . . . . . . . . . . . . . ? ? ? ? ? ?
Pm1112  ? ? . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . A . . G ? . . . . . . . . . . . . . . . . ? ? ? ? ?
Pm1113  . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1114  ? ? ? . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
Pm1116  ? ? . . . . . - . . . . G . . . . . . . . . . T . . . . . . . . . . . . . . . . . . . . . . . . . . . . . T . ? ?
Pm1118  ? ? C . . . . . - . . . C . . . . . ? . . . . . . . . . C T . . . A . T . . . ? . . . . . . . . . A . ? ? ? ? ? ? ? ?
Pm1120  ? ? . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A C T . . . . . . . . . . . . . . A . . . T . . C . ?
Pm1122  . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . . . . . G . . . . . . . . . . . . . . . . . . . ?
Pm1125  . . C . . . . . - . . . C . . . . - A . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . A . . . T . . C . ?
Pm1128  . . . . . - . . . C . . . . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . T . . . . . . . T . . C . ?
Pm1135  . . . . . T . - . . . . . . . . . . . . . . . . . . . . . . . A A . . G . . . T T . T . . . . A . G . . . . . . . ?
Pm1141  ? ? . . . . . - T . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
Pm1142  ? ? . . . T . - . . . . . . . . . . . . . . . . . . . . . . . . . A A . . G . . . T T . T . . . . A . G ? ? ? ? ? ? ? ?
Pm1143  ? ? . . . . . - . . . C . . . . . . . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . T . . C . ?
Pm1172  . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . . . A . . G . . . . . . . . . A . . . . . . . . . ?
Pm1176  . . . . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . A . . . . . . . C . ?
Pm1183  ? ? . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . . . . . . . G A . . . . . . . . . . . . . . C . . . A
Pm1198  . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . C . . . . . . . . . . . . . A . . . . . . . C . ?
Pm1209  ? ? . . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . ? . . . . . . . . A . . . . ? ? ? ? ? ?
Pm1211  ? ? . . . . . - . . . . G . . . . A G . . . . . . . . . . . A . . G . . . T . T . . . . A . . ? ? ? ? ? ? ? ?
Pm1212  ? ? . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . ? ? ? ? ? ? ? ?
Pm1213  ? ? . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . . . . ?
Pm1214  ? ? . . . . . - . . . . . . . . . . . . . . . . . . . . . . . C T . . . A . T G . . . . . . . . . . . . . . . . ? ? ? ? ? ?
Pm1215  . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . . . . . . . . C . . . . . . . . . . . . . A . . . . ? ? ? ? ? ?
Pm1216  . . . . . - . . . C . . . . . . . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . . . . . ? ? ? ? ? ?
Pm1217  ? ? . . G . . - . . . . . . . T - . . . . . C . C T . C T . . . A . . . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1218  ? ? . . G . . - . . . . . . . . - . . . . . . . . . . C T . . . A . . . . . . . C . . . . . A . . . . . . ? ? ? ?
Pm1221  ? ? . . . . . - . . . . . . . . . . . . . . . . . . . . . . G A . . . . G . . ? . . . . . . . . . . . . . . ? ? ? ?
Pm1222  ? ? . . . . . - . . . . G . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . T . . ? ? ? ?
Pm1223  . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . C T . . A . . . . . . . . . . . . . . . . . . . ?
Pm1224  . . . . G . C - . . . . . . . . . - A . . . . . C T . C T . . . A . . . . . T . C . . . . . A . . . . . . . C . G
Pm1225  ? ? . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . A . . G . . . . . . . . . . . A . . . . . . ? ? ? ?
Pm1234  ? ? . . . . . - . . . . . . . . T . . . . . . . . . . . . . . . . . C . G . . . . . . . . . . . . . ? ? ? ? ? ? ? ?
Pm1235  ? ? . . G . . - . . . . . . . . T - ? . . . . C . C T . C T . . . A . . . . . . . . . . . . . . A . . . ? ? ? ? ? ? ?
Pm1236  ? ? . . . . . - . . . . . G . . . . ? . . . . . . . . . . . . . . . . . . . . . . . . . . . . ? ? ? ? ? ? ? ? ? ? ? ?
Pm1237  ? ? . . . . . - . . . . . . . . . A . . . . . . . . . . . . . . A . . G . . . . . . . . . . . A . . . . ? ? ? ? ? ?
Pm1244  . . C . . . . . - . . . C . . . . - A . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . A . . . T ? ? ? ? ?
Pm1245  . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . T . . . . . ?
Pm1275  . . . . . - . . . . . . . . . . . . . . . . . . . . . . . . . . . . A . . . . . . . . . . . . . . A . . . T . . . . . ?
Pm1279  . . C . . . . . - . . . C . . . . - A . . . . . . . . . C T . . . A . T . . . . . . . . . . . . . A . . . T . . C . ?
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Table 4 The relative frequencies of 61 haplotypes derived from sequence data among 111 goldband snapper collected from five Australian locales.

Haplotype	Exmouth	Pilbara	Kimberley	Timor Sea	Arafura Sea
Code Number	N=18	26	19	27	21
1	0.056	-	0.053	-	-
2	0.111	0.039	0.105	0.100	0.091
3	0.056	-	-	-	-
4	0.111	-	0.053	-	-
5	0.111	0.077	-	0.033	0.136
6	0.056	-	-	-	-
7	0.111	0.077	-	-	-
8	0.056	-	-	-	-
9	0.056	-	-	-	-
10	0.056	-	-	-	-
11	0.056	-	-	-	-
12	0.056	-	-	-	-
13	0.056	-	-	0.033	0.091
14	0.056	-	-	-	-
15	-	-	-	-	-
16	-	-	0.105	-	-
17	-	0.154	0.158	0.033	0.091
18	-	-	0.105	0.067	-
19	-	-	0.053	0.033	-
20	-	-	0.053	0.033	-
21	-	-	0.053	-	-
22	-	-	0.053	-	-
23	-	-	0.053	-	-
24	-	-	0.053	0.067	0.091
25	-	-	0.053	0.033	-
26	-	-	0.053	-	-
27	-	0.077	-	-	-
28	-	0.077	-	-	-
29	-	0.039	-	-	-
30	-	0.039	-	-	-
31	-	0.039	-	-	-
32	-	0.039	-	-	-
33	-	0.039	-	-	-
34	-	0.039	-	-	-
35	-	0.039	-	0.033	-
36	-	0.039	-	-	-
37	-	0.039	-	-	-
38	-	0.039	-	-	0.046
39	-	0.039	-	0.033	-
40	-	0.039	-	-	-
41	-	0.039	-	-	-
42	-	-	-	0.033	-
43	-	-	-	0.067	-
44	-	-	-	0.033	-
45	-	-	-	0.033	-
46	-	-	-	0.033	0.046
47	-	-	-	0.033	-
48	-	-	-	0.033	-
49	-	-	-	0.033	-
50	-	-	-	0.033	-
51	-	-	-	0.067	-
52	-	-	-	0.033	-
53	-	-	-	0.033	-
54	-	-	-	0.033	0.046
55	-	-	-	-	0.046
56	-	-	-	-	0.046
57	-	-	-	-	0.046
58	-	-	-	-	0.091
59	-	-	-	-	0.046
60	-	-	-	-	0.046
61	-	-	-	-	0.046

Table 5 Nucleotide position numbers of original and re-coded characters (n=19) used to score each fish in the RFLP data set. Nucleotide positions are numbered according to the base pair immediately to the 5' of the cleavage position. See the appendix V for the method of re-coding characters for each hypervariable position.

Character Type	Character Position	Character Scored
Restriction Site	106	Presence or absence of AluI site
Nucleotide position	112	Presence or absence of 'C'
Nucleotide position	110/1/3	Not G, A or C
Restriction Site	156	Presence or absence of AluI site
Restriction Site	179	Presence or absence of DdeI site
Re-coded sites A-F	183-187	Presence or absence of re-coded sites
Nucleotide position	249	Presence or absence of 'T'
Re-coded sites G-J	264-274	Presence or absence of re-coded sites
Restriction Site	342	Presence or absence of HinfI site
Restriction Site	359	Presence or absence of DdeI site.

Table 6: Character states (0 absent, 1 present) for original and re-coded characters that were used to define each haplotype from the RFLP data set. See appendix 1 for the method of re-coding characters for each hypervariable position.

Haplotype designation	Character Name (italics) and Position																		
	Alu 106	*Site 112=C*	*Site 110/1/3*	*Alu 156*	*Dde l79*	*Site A*	*Site B*	*Site C*	*Site D*	*Site E*	*Alu l92*	*Site246-G*	*Site249-T*	*Site G*	*Site H*	*Site I*	*Site J*	*Hinf 342*	*Dde 359*
A B C B A	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
B A A A A	0	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0
C A C B B	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1
A A C A A	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1
A A C B E	0	1	0	0	0	1	0	0	0	0	1	1	1	1	0	0	1	1	1
B A C B A	0	1	0	1	0	0	0	1	0	0	1	1	1	1	0	0	1	1	1
A A C B A	0	1	0	0	0	0	0	1	0	0	1	1	1	1	0	0	1	1	1
D B C B A	0	1	0	0	0	0	0	0	1	1	0	1	1	1	0	0	1	1	1
B B C B A	0	1	0	1	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
B B A B D	0	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
B A C B E	0	1	0	1	0	1	0	0	0	0	1	1	1	1	0	0	1	1	1
B A C A D	0	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	0	1
C B C B A	0	1	0	1	0	0	0	0	1	1	0	1	1	1	0	0	1	1	1
E A C B E	0	1	0	1	0	1	0	0	0	0	1	1	1	1	0	0	0	1	1
B A C A A	0	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1
B A C B D	0	1	0	1	0	0	0	1	0	0	1	1	1	1	0	0	1	0	1
B B A B A	0	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	0	1	0
B B C A D	0	1	0	1	0	0	0	0	1	1	1	1	1	1	0	0	1	0	1
B A D B A	0	1	0	1	1	0	0	1	0	0	1	1	1	1	0	0	1	1	1
B E C A A	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1
C A C B A	0	1	0	1	0	0	0	1	0	0	0	1	1	1	0	0	1	1	1
B C C B A	0	0	1	1	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
B D C A B	0	1	0	1	0	0	0	0	0	0	1	1	0	1	0	0	1	1	1
B A A B F	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1
F A C A A	0	1	0	1	1	0	0	0	0	0	1	1	1	1	0	0	1	1	1
B A D A A	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
D A C A A	0	1	0	1	0	0	1	0	0	0	1	1	1	1	0	0	1	1	1
B B C B B	0	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	1	1	1
B B A B J	0	1	0	1	0	0	0	0	1	1	1	1	1	0	1	0	0	1	0
C A C B E	0	1	0	1	0	1	0	0	0	0	0	1	1	1	0	0	1	1	1
B B D B A	0	1	0	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1
C A C A A	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
B A A B E	0	1	0	1	0	1	0	0	0	0	1	1	1	1	1	1	0	1	0
B C C C A	0	0	0	1	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
B A C B C	0	1	0	1	0	0	1	0	0	0	1	1	1	1	0	0	1	0	1

Table 7 List of possible alternate sequences present at hyper-variable region 183-187. Alternate sequences are undetectable using the RFLP method, unless they contain an *Ava* II (G'GA/TCC), *Alu* I (AG'CT), *Dde* I (C'TNAG), *Dpn* II ('GATC), *Hin*f I (G'ANTC) recognition site.

Nucleotide Position Number							Was Sequence detected?*	Restriction Site with recognition sequence and cleavage position
Polymorphic, with possible states assuming transitions only.					Non-polymorphic			
183 (A/G)	184 (A/G)	185 (A/G)	186 (C/T)	187 (C/T)	188 (C)	189 (C)		
A	A	A	C	C	C	C	x	
A	A	A	C	T	C	C	x	
A	A	A	T	C	C	C	x	
A	A	A	T	T	C	C	x	
A	A	G	C	C	C	C	x	
A	A	G	C	T	C	C	?	Alu I AG'CT
A	A	G	G**	T	C	C	8	Ava II G'GA/TCC
A	A	G	T	C	C	C	x	
A	A	G	T	T	C	C	x	
A	G	A	C	C	C	C	x	
A	G	A	C	T	C	C	x	
A	G	A	T	C	C	C	?	Dpn II 'GATC
A	G	A	T	T	C	C	x	
A	G	G	C	C	C	C	x	
A	G	G	C	T	C	C	x	
A	G	G	T	C	C	C	?	Ava II G'GA/TCC
A	G	G	T	T	C	C	x	
G	A	A	C	C	C	C	x	
G	A	A	C	T	C	C	x	
G	A	A	T	C	C	C	3	Hinf I G'ANTC
G	A	A	T	T	C	C	x	
G	A	G	C	C	C	C	x	
G	A	G	C	T	C	C	?	Alu I AG'CT
G	A	G	T	C	C	C	x	
G	A	G	T	T	C	C	x	
G	G	A	C	C	C	C	x	
G	G	A	C	T	C	C	5	Hinf I G'ANTC
G	G	A	T	C	C	C	1	Dpn II 'GATC
G	G	C**	T	C	C	C	4	No sites
G	G	A	T	T	C	C	2	Hinf I G'ANTC
G	G	G	C	C	C	C	7	Ava II G'GA/TCC
G	G	G	C	T	C	C	x	
G	G	G	T	C	C	C	6	Ava II G'GA/TCC
G	G	G	T	T	C	C	x	

* If the sequence was detected amongst the Goldband Snapper surveyed in this study, then the sequence number from Table B, Appendix 1 is presented. Sequences contain (?) or do not contain (x) a restriction site detectable by the restriction enzymes used in this study.
** Sequence present amongst the Goldband Snapper surveyed, but does not conform to the transition-only rule by which this theoretical data was created.

Table 8 Comparison of RFLP and sequence data for an analysis of molecular variance (AMOVA) within the Australian goldband data set with no grouping of populations. The populations analysed were Exmouth, Pilbara, Kimberley, Timor and Arafura.

Assay Technique	% variance within populations	% variance among populations	Φ_{ST}
RFLP	98.91	1.09	$0.0109^{0.018}$
Sequencing	98.83	1.17	0.0117^{NS}

Table 9 Analysis of molecular variance (AMOVA) within the goldband RFLP data set with no hierarchical grouping of populations. The foreign locales analysed were Kupang (KU), Irian Jaya (I) and Madang (M). The Australian locales analysed were Exmouth (E), Pilbara (P), Broome (B), Kimberley (K), Timor (T) and Arafura (A).

	Populations	% variance within populations	% variance among populations	Φ_{ST}
Among all locales; Australian and foreign.				
	9 populations, 6 Australian and 3 foreign (E, P, B, K, T, A, KU, I, M)	93.91	6.09	$0.0609^{0.00}$
Among Foreign locales				
	3 foreign populations (KU, I, M)	98.10	1.90	$0.0119^{0.132}$
Among Australian locales				
	6 Australian populations (E, P, B, K, T, A)	98.82	1.18	$0.0118^{0.007}$

Table 10 Analysis of molecular variance (AMOVA) within the goldband snapper RFLP data set using hierarchical analysis of genetic structure on fish collected from Australian and foreign waters. Populations were Exmouth (E), Pilbara (P), Broome (B), Kimberley (K), Timor Sea (T), Arafura Sea (A), Kupang (Ku), Irian Jaya (I) and Madang (M). The fish were assayed by the RFLP method and the genetic difference among them was measured by pairwise substitutions. Probability values for Φ among populations within groups (Φ_{SC}), within populations (Φ_{ST}) and for the amount of genetic subdivision among groups (Φ_{CT}) are given in superscript.

Population grouping	% Variance					
	Within populations	Among populations within groups	Among groups	Φ_{SC}	Φ_{ST}	Φ_{CT}
Australian (EPBKTA) and foreign (Ku IM)	84.83	1.15	14.02	$0.0134^{0.000}$	$0.1517^{0.000}$	$0.1401^{0.000}$
Australian (EPBTA) and Kimberley (K)	97.91	-0.11	2.20	$-0.0012^{0.557}$	$0.0209^{0.007}$	$0.0220^{0.000}$

Table 11 Relative frequencies of mtDNA control region RFLP haplotypes among 13 locales. Haplotypes are a composite of morph designations for the restriction enzymes *Alu* I (AG'CT), *Ava* II (G'GA/TCC), *Dde* I (C'TNAG), *Dpn* II ('GATC), *Hin*f I (G'ANTC) restriction enzymes. Samples from Lynher Bank were only used in this study for the genetic comparison of locales within the Kimberley region.

	West Australia			Kimberley						Nth. Australia		Foreign		
Haplotype	Exmouth	Pilbara	Broome	Lynher Bank	Total	*Heywood Shoal*	*Barracouta Shoal*	*Vulcan Shoal*	*North Kimberley*	Timor	Arafura	Kupang	Irian Jaya	Madang
	N=46	86	104	20	200	*37*	*26*	*49*	*88*	74	53	57	26	19
A A C A A	0.087	0.151	0.135	0.200	0.180	*0.216*	*0.115*	*0.204*	*0.170*	0.230	0.226	0.018	-	-
A A C B A	-	-	0.010	-	0.010	*0.054*	-	-	-	-	-	-	-	-
A A C B E	0.022	0.012	0.010	0.100	0.010	-	*0.039*	-	*0.011*	-	0.019	-	-	-
A B C B A	0.022	-	0.019	-	-	-	-	-	-	-	-	0.018	-	-
B A A A A	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053
B A A B E	-	-	-	-	-	-	-	-	-	0.014	-	-	-	-
B A A B F	-	-	-	-	0.005	-	-	-	*0.011*	-	-	-	-	-
B A C A A	0.326	0.244	0.202	-	0.165	*0.108*	*0.269*	*0.204*	*0.136*	0.230	0.264	0.193	0.077	0.053
B A C A D	-	-	0.039	-	0.020	*0.027*	-	*0.061*	-	0.027	0.038	-	-	-
B A C B A	0.044	-	0.019	0.050	0.120	*0.162*	*0.115*	*0.020*	*0.159*	0.041	0.057	0.018	0.231	-
B A C B C	-	-	-	-	-	-	-	-	-	0.014	-	-	-	-
B A C B D	-	0.012	-	-	0.005	*0.027*	-	-	-	-	-	-	0.039	-
B A C B E	0.283	0.314	0.337	0.450	0.355	*0.351*	*0.385*	*0.245*	*0.409*	0.284	0.189	0.211	0.039	0.316
B A D A A	-	-	-	-	0.005	-	-	-	*0.011*	-	-	-	-	-
B A D B A	-	-	-	-	0.005	*0.027*	-	-	-	-	-	-	-	-
B B A B A	-	-	-	-	-	-	-	-	-	-	-	0.018	0.039	0.053
B B A B D	-	-	0.010	-	-	-	-	-	-	-	-	-	-	-
B B A B J	-	0.012	-	-	-	-	-	-	-	-	-	-	-	-
B B C A D	-	-	0.019	-	0.005	-	-	*0.020*	-	-	0.019	0.018	0.039	0.053
B B C B A	0.174	0.186	0.183	0.200	0.075	*0.027*	*0.039*	*0.204*	*0.034*	0.122	0.189	0.333	0.538	0.421
B B C B B	-	-	-	-	-	-	-	-	-	-	-	0.018	-	-
B B D B A	-	0.012	-	-	-	-	-	-	-	-	-	-	-	-
B C C B A	-	-	-	-	-	-	-	-	-	-	-	0.018	-	-
B C C C A	-	-	-	-	-	-	-	-	-	0.014	-	-	-	-
B D C A B	-	-	-	-	-	-	-	-	-	0.014	-	0.018	-	-
B E C A A	-	-	-	-	-	-	-	-	-	-	-	0.018	-	-
C A C A A	-	0.047	-	-	0.015	-	*0.039*	-	*0.023*	-	-	0.018	-	-
C A C B A	-	-	-	-	-	-	-	-	-	-	-	0.053	-	-
C A C B B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053
C A C B E	-	0.012	-	-	0.005	-	-	-	*0.011*	-	-	-	-	-
C B C B A	-	-	0.010	-	0.010	-	-	*0.041*	-	0.014	-	0.035	-	-
D A C A A	-	-	-	-	0.005	-	-	-	*0.011*	-	-	-	-	-
D B C B A	-	-	0.010	-	-	-	-	-	-	-	-	-	-	-
E A C B E	0.044	-	-	-	-	-	-	-	-	-	-	-	-	-
F A C A A	-	-	-	-	0.005	-	-	-	*0.011*	-	-	-	-	-

Table 12: Genetic diversity indices for five Australian (RFLP and sequencing data) and two non-Australian (Kupang, Indonesia and Mandang, northern Papua New Guinea; RFLP data only) populations of goldband snapper (NA, not analysed). Nucleotide or average gene diversity is the probability that two randomly chosen homologous nucleotides (or haplotypes) are different.

	Exmouth	Pilbara	Broome	Kimberleys	Timor	Arafura	Kupang	Irian Jaya	Madang
RFLP Data									
Sample size	47	87	104	200	74	53	57	26	19
Number of haplotypes	9	11	13	18	11	8	15	7	7
Number of polymorphic sites	7	13	11	10	14	6	15	9	12
Mean number of pairwise differences ± standard deviation	1.54±0.94	1.69±0.99	1.81±1.05	1.53±0.92	1.67±0.99	1.60±0.96	2.16±1.22	1.92±1.13	2.83±1.56
Average gene diversity over loci ± standard deviation	0.08±0.05	0.08±0.05	0.09±0.06	0.08±0.05	0.08±0.05	0.08±0.05	0.11±0.07	0.10±0.06	0.14±0.08
Sequencing Data									
Sample size	18	26	NA	19	27	21	NA	NA	NA
Number of haplotypes	14	19	NA	14	24	15	NA	NA	NA
Mean number of pairwise differences ± standard deviation	6.14± 3.06	6.59± 3.21	NA	5.30± 2.68	7.96± 3.81	6.32± 3.13			
Number of indels	0	1	NA	0	2	1	NA	NA	NA
Number of transitions	22	30	NA	21	30	23	NA	NA	NA
Number of transversions	4	2	NA	2	4	3	NA	NA	NA
Number of usable nucleotide positions (> 95% of the data present)	303	304	NA	279	262	293	NA	NA	NA
Nucleotide diversity ± standard deviation	0.021 ±0.012	0.022 ±0.012	NA	0.019 ±0.011	0.030 ±0.016	0.020 ±0.012	NA	NA	NA

Table 13 Patterns of genetic subdivision among A. Seven Australian populations, B. Seven populations in and surrounding the Kimberley region and C. Three foreign populations. Pairwise genetic distance (F_{ST} from RFLP data, below diagonal) and p of non-differentiation from the exact test of RFLP haplotype frequencies (above diagonal) is presented between pairs of locales. Significant values, assessed at 0.05 level, are given in bold. In table B, only the five most frequent haplotypes were included in the exact tests.

A.

	Arafura	Timor	Kimberley	Lynher	Broome	Pilbara	Exmouth
Arafura	-	0.82	0.19	**0.02**	0.60	0.09	0.31
Timor	-0.0057 $^{0.612}$	-	0.19	0.06	0.50	0.07	0.15
Kimberley	**0.0290** $^{\mathbf{0.004}}$	0.0063 $^{0.121}$	-	0.30	**0.01**	**0.01**	**0.05**
Lynher	0.0394 $^{0.059}$	0.0140 $^{0.195}$	0.0210 $^{0.142}$	-	0.13	**0.02**	**0.03**
Broome	0.0020 $^{0.272}$	0.0036 $^{0.214}$	**0.0326** $^{\mathbf{0.000}}$	0.0068 $^{0.280}$	-	0.10	0.48
Pilbara	0.0040 $^{0.264}$	-0.0017 $^{0.400}$	**0.0225** $^{\mathbf{0.006}}$	0.0106 $^{0.231}$	-0.0055 $^{0.734}$	-	0.20
Exmouth	0.0043 $^{0.301}$	-0.0048 $^{0.546}$	0.0138 $^{0.109}$	0.0095 $^{0.237}$	-0.0069 $^{0.660}$	-0.0121 $^{0.924}$	-

B.

	Broome	Lynher Bank	Heywood Shoal	Barracouta Shoal	Vulcan Shoal	North Kimberley	Timor
Broome	-	0.10	**0.01**	0.08	0.70	**0.01**	0.35
Lynher Bank	0.0068 $^{0.272}$	-	0.09	**0.04**	0.11	**0.03**	0.07
Heywood Shoal	**0.0719** $^{\mathbf{0.002}}$	**0.0530** $^{\mathbf{0.052}}$	-	0.50	**0.01**	0.96	**0.05**
Barracouta Shoal	**0.0386** $^{\mathbf{0.047}}$	0.0214 $^{0.199}$	0.0013 $^{0.372}$	-	0.08	0.59	0.30
Vulcan Shoal	-0.0083 $^{0.772}$	0.0317 $^{0.123}$	**0.0845** $^{\mathbf{0.001}}$	**0.0627** $^{\mathbf{0.012}}$	-	**0.01**	0.77
North Kimberley	**0.0621** $^{\mathbf{0.001}}$	0.0341 $^{0.077}$	0.0022 $^{0.345}$	-0.0224 $^{0.988}$	**0.0868** $^{\mathbf{0.001}}$	-	**0.01**
Timor	0.0036 $^{0.255}$	0.0141 $^{0.215}$	**0.0334** $^{\mathbf{0.027}}$	0.0093 $^{0.231}$	0.0033 $^{0.280}$	**0.0290** $^{\mathbf{0.015}}$	-

Cont.

C.

	Irian Jaya	Kupang	Madang
Irian Jaya	-	**0**	0.034
Kupang	**0.0383** $^{\mathbf{0.045}}$	-	0.612
Madang	0.0260 $^{0.175}$	-0.0088 $^{0.499}$	-

Table 14 Genetic diversity (mitochondrial DNA control region) indices for five Kimberley populations of goldband snapper (RFLP data only). Samples taken from Lynher Bank are not included elsewhere. Nucleotide or average gene diversity is the probability that two randomly chosen homologous haplotypes are different.

	North Kimberley	Barracouta Shoals	Vulcan Shoals	Heywood Shoals	Lynher Bank
Sample size	88	26	49	37	20
Number of haplotypes	12	7	8	9	5
Number of polymorphic sites	20	6	7	7	5
Mean number of pairwise differences ± standard deviation	1.37±0.85	1.22±0.80	1.78±1.05	1.55±0.95	1.74±1.05
Average gene diversity over loci ± standard deviation	0.07±0.04	0.06±0.04	0.09±0.06	0.08±0.05	0.09±0.06

Table 15 Genetic distance (F_{ST} calculated from the pairwise difference between fish assayed by the RFLP method) between fish from pairs of locales to test temporal stability at and across geographic locales.

	North Kimberely '96	North Kimberely '98	Broome '96	Broome '98
Sample Size	*16*	*72*	*36*	*53*
North Kimberely '96	-	0.0040 $^{0.326}$	0.0220 $^{0.187}$	NA
North Kimberely '98		-	NA	0.0460 $^{0.004}$
Broome '96			-	- 0.0060 $^{0.555}$

Figure 1 The goldband snapper, *Pristipomoides multidens*.

Figure 2 Collection locales and sample sizes for Australian and foreign goldband snapper.

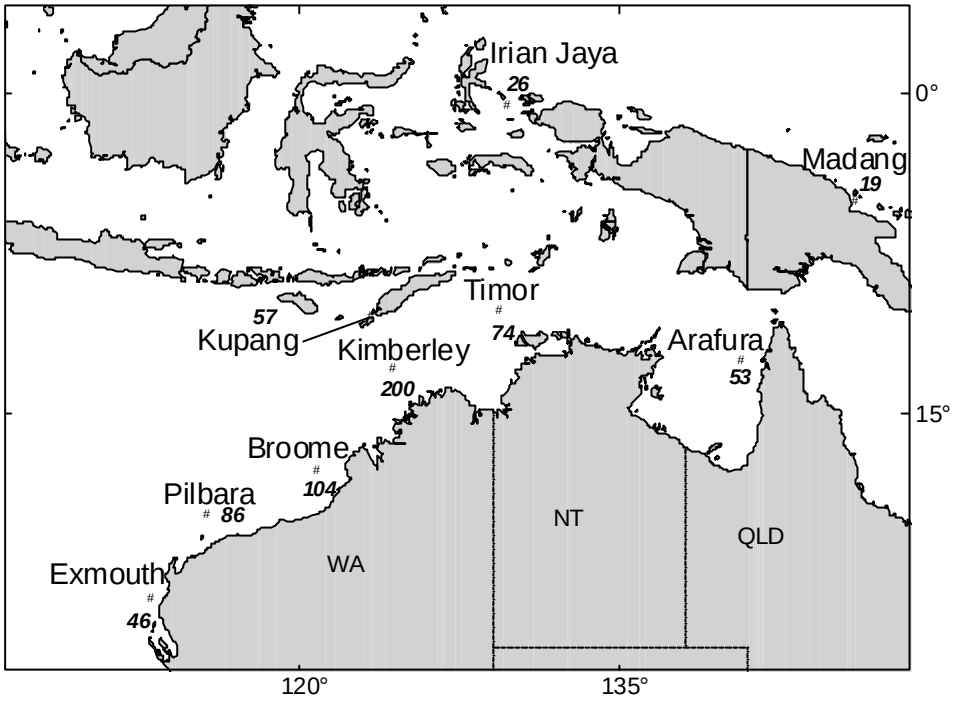


Figure 3 Collection locales and sample sizes for goldband snapper from the Kimberley region of north-west Australia.

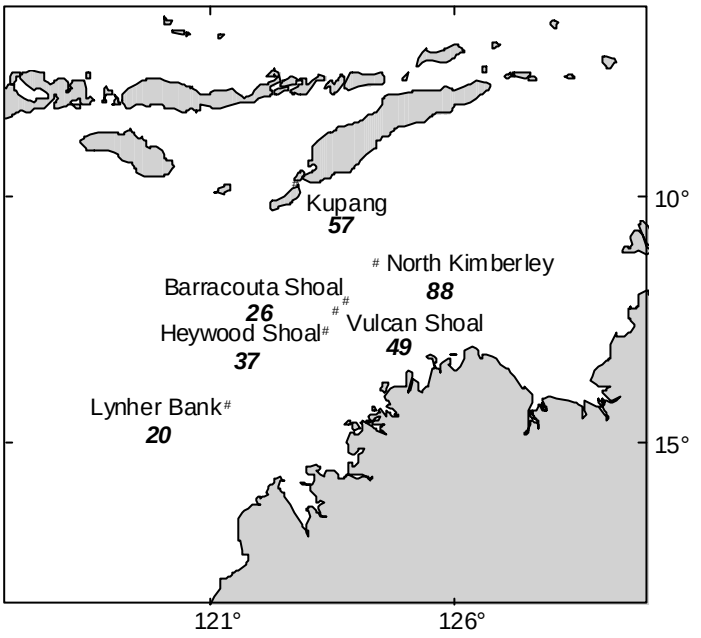


Figure 4 Nucleotide sequence variation at six consecutive, hypothetical nucleotide positions in two fish. The polymorphic site is shown in italics. The restriction site found in each sequence is shaded and named.

Fish Number	Nucleotide position						Restriction Enzyme
	1	2	3	4	***5***	6	
1	G	G	A	C	***T***	C	*Hin*fI
2	G	G	A	C	***C***	C	*Ava*II

Figure 5 Network describing the relatedness between eight sequences at hypervariable region 183-188.

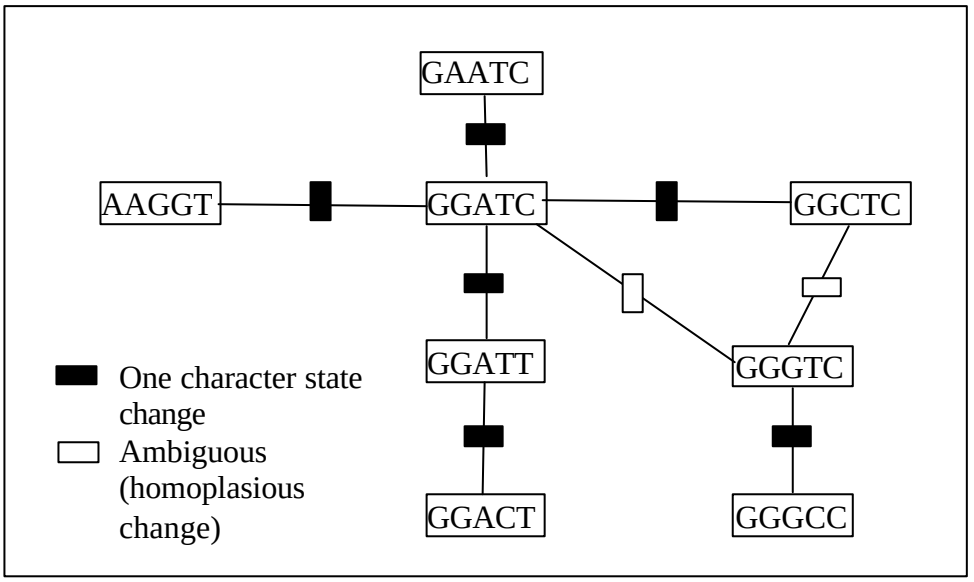


Figure 6 Network describing the relatedness between eight sequences at hypervariable region 264-274.

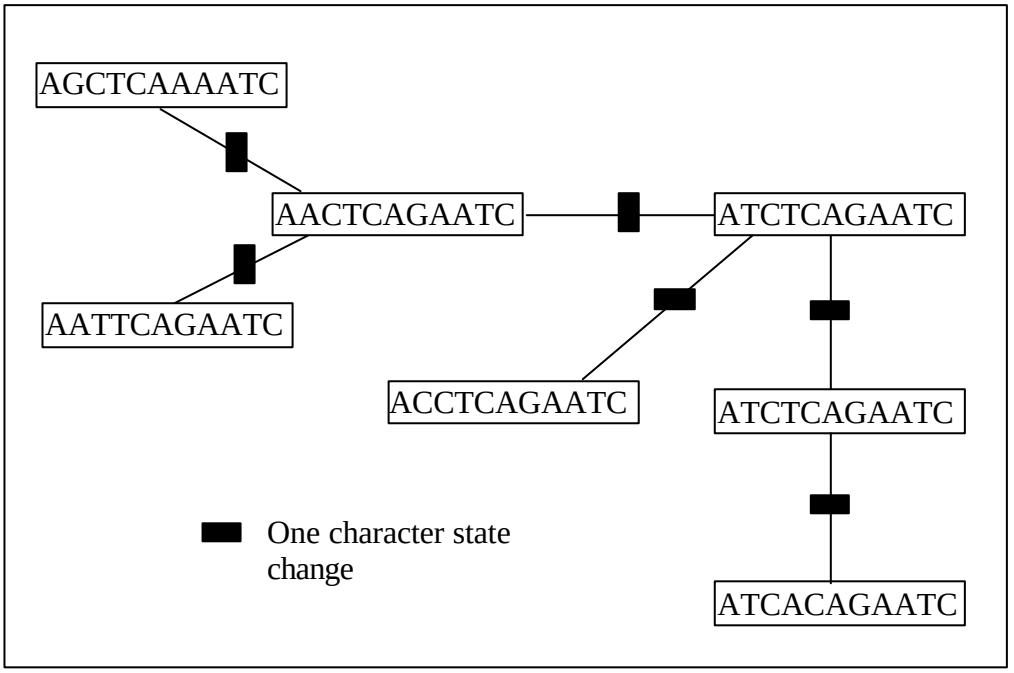


Figure 7A An unrooted neighbour joining network showing the phylogenetic relationship among the 35 RFLP goldband snapper haplotypes. Genetic distance between each haplotype was measured as pair-wise mutations. Branch points, when present, are accompanied by bootstrap values from 500 replicates.

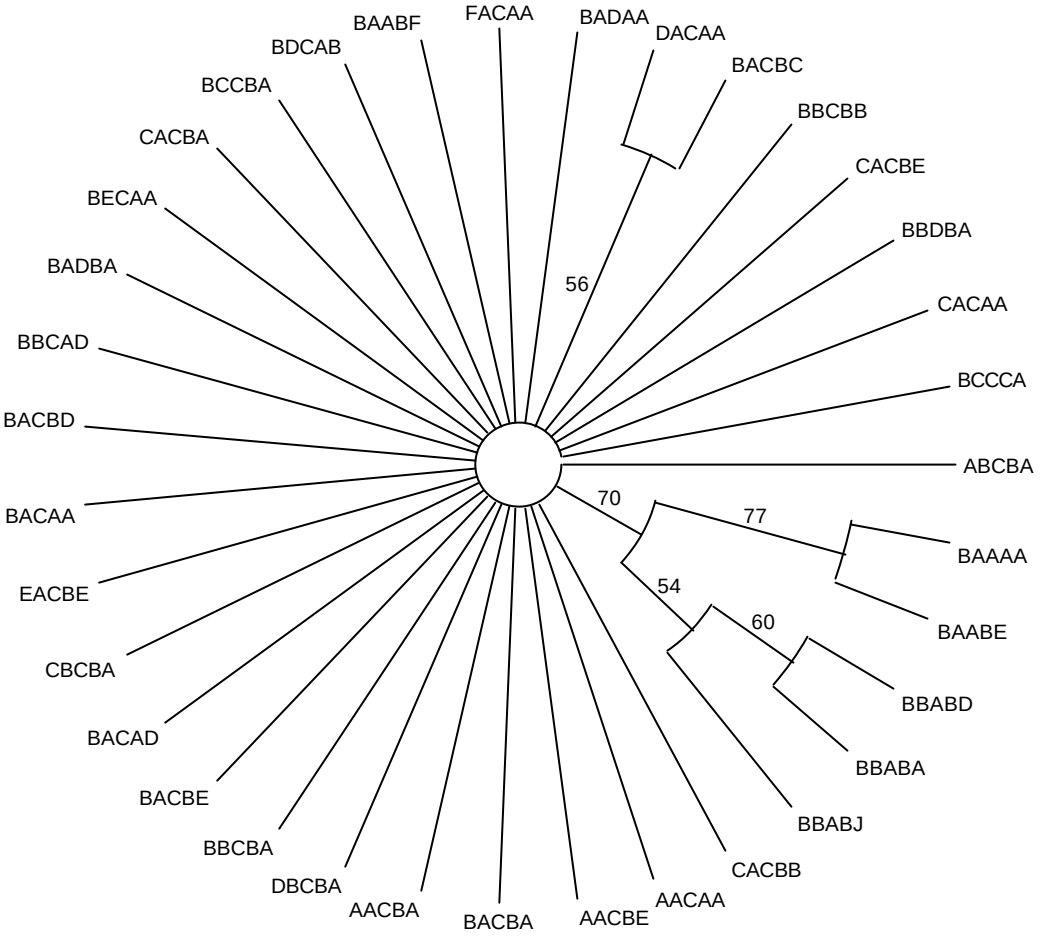


Figure 7B A strict consensus maximum parsimony network showing the phylogenetic relationship among the 111 goldband snapper from 400 base pairs of control region nucleotide sequence. The network is unrooted. Individual fish are from Exmouth (EX), Kimberley (KMB), Pilbara (PL), Timor (Pm12XX), Arafura (Pm11XX) and Kupang (KO5).

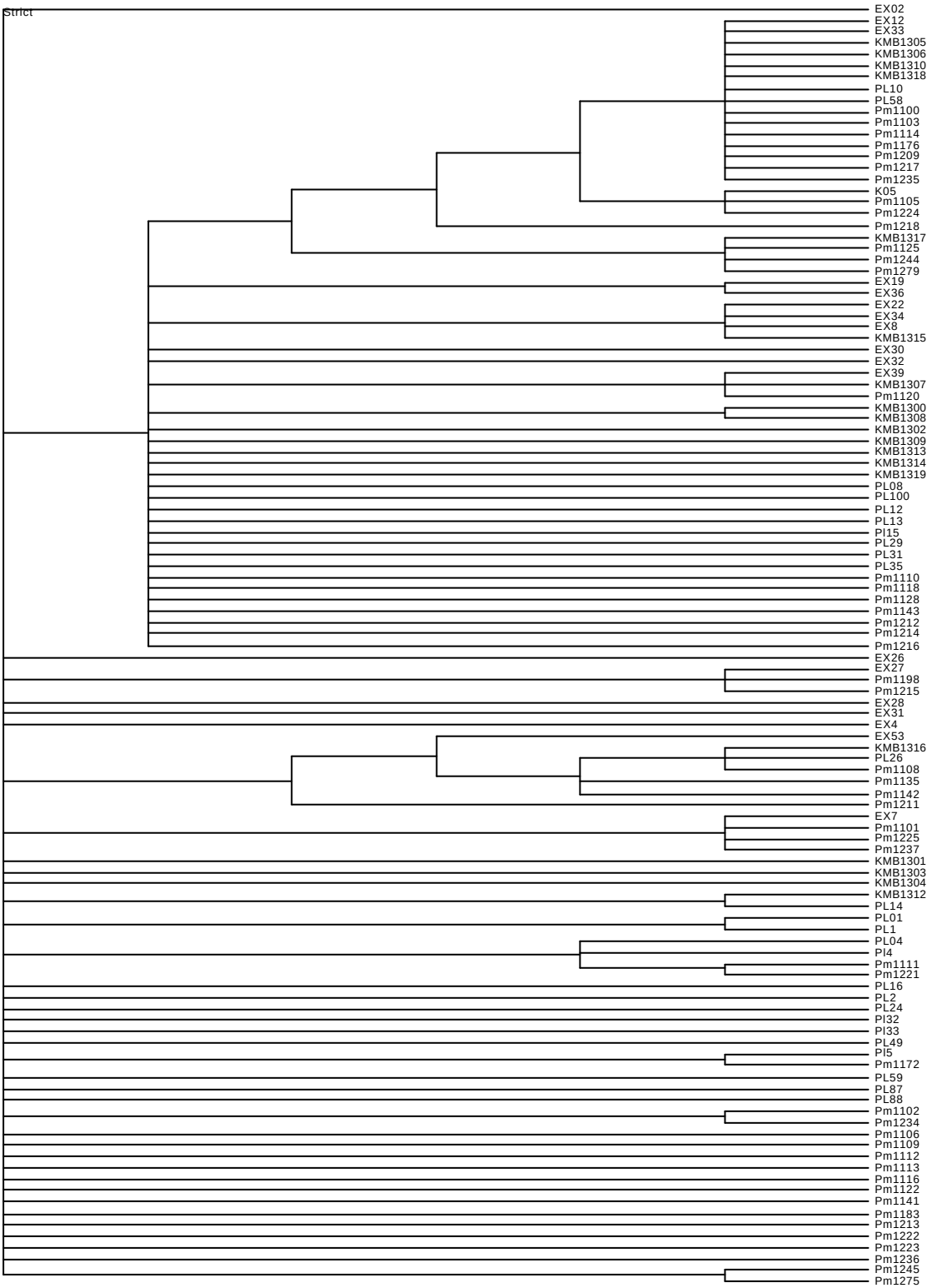


Figure 7C A 50% majority rule consensus maximum parsimony network showing the phylogenetic relationship among the 111 goldband snapper from 400 base pairs of control region nucleotide sequence. The network is unrooted. Individual fish are from Exmouth (EX), Kimberley (KMB), Pilbara (PL), Timor (Pm12XX), Arafura (Pm11XX) and Kupang (KO5).

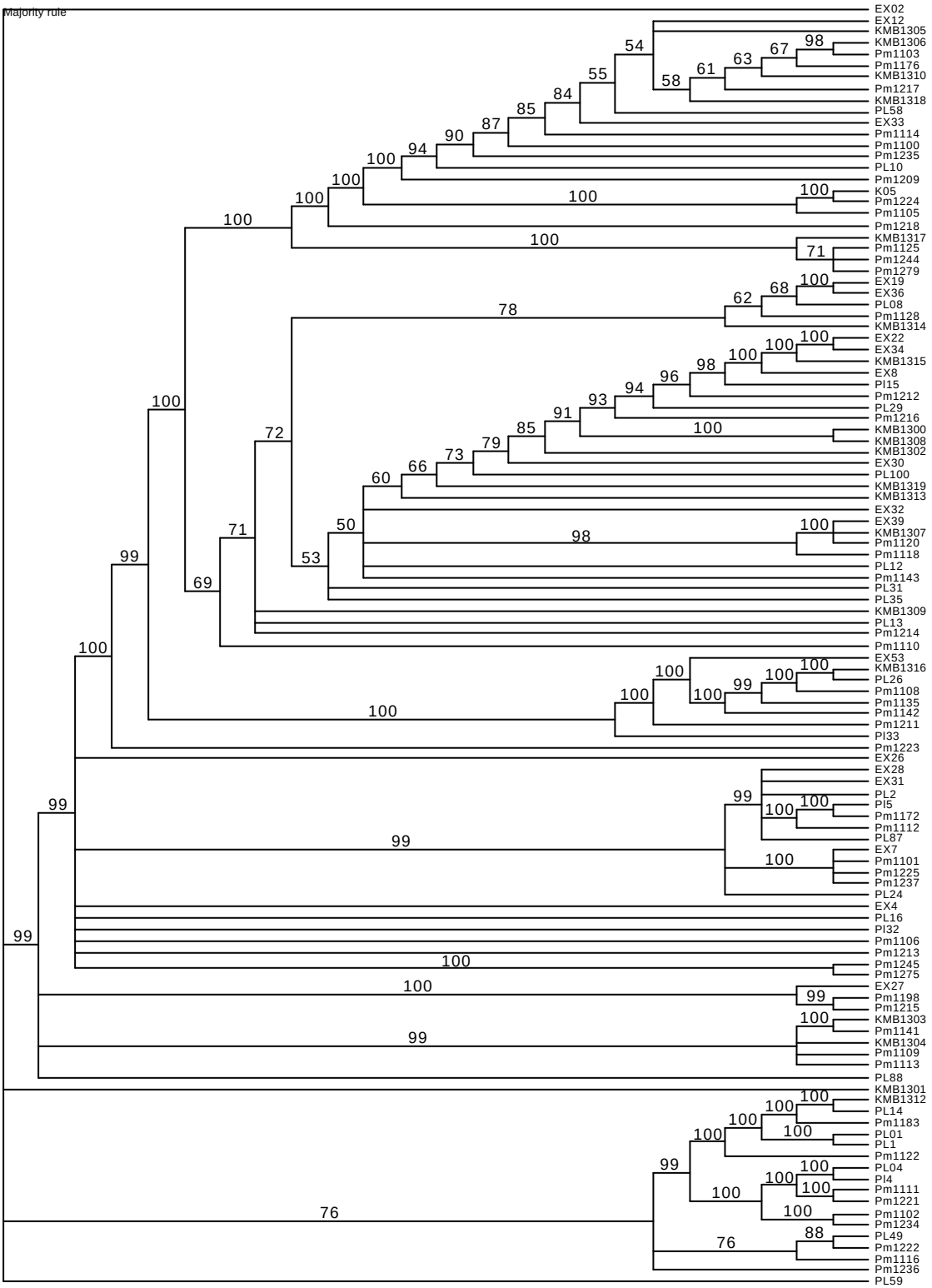


Figure 8. Relative frequencies of the five most common RFLP haplotypes among the three foreign and six Australian collection locales for the goldband snapper sampled in this study. The five haplotypes were AACAA, BACAA, BACBA and BACBE, BBCBA (Table 11).

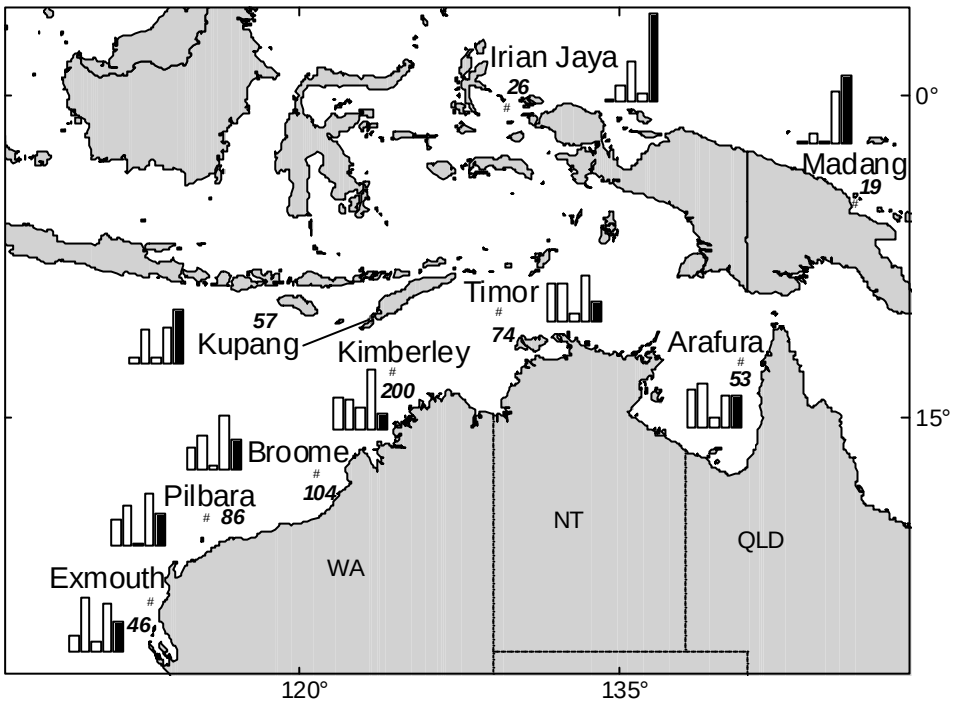


Figure 9. Relative frequencies of the five most common RFLP haplotypes among the six Kimberley collection locales for the goldband snapper sampled in this study. The five haplotypes were AACAA, BACAA, BACBA, BACBE and BBCBA (Table 11).

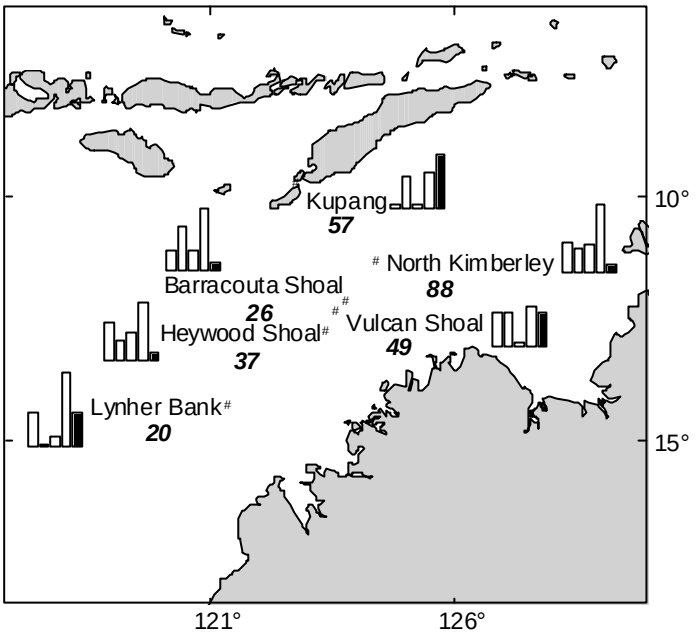


Figure 10. Relative frequencies of the five most common RFLP haplotypes among the eleven Australian collection locales for the goldband snapper sampled in this study. Histograms representing populations from the Kimberley region have either white or stippled bars. Histograms with black columns are from the non-Kimberley Australian locales.

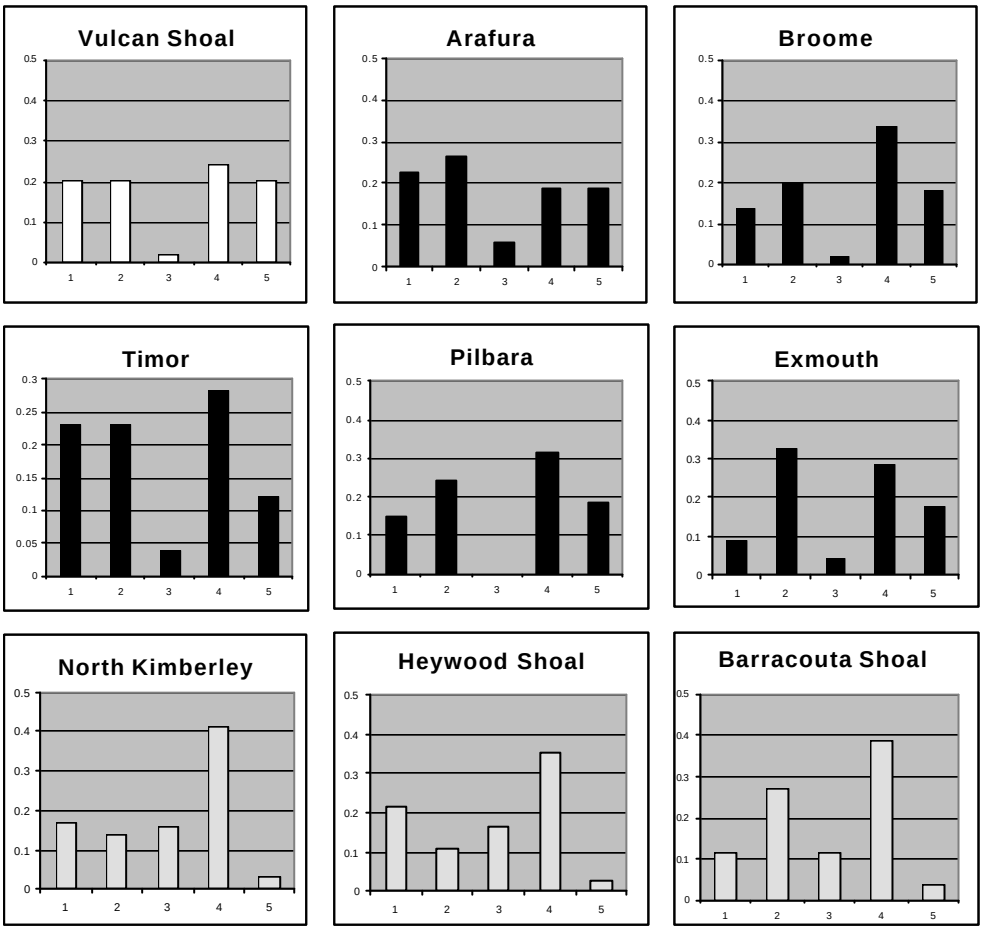


Figure 11. Mismatch distributions for nine Australian populations of goldband snapper. Histograms representing populations from the have white (Kimberley region) or black (non-Kimberley Australian) bars. The charts plot the relative frequencies of pairs of fish whose mtDNA control region RFLP haplotypes vary by 0 to 9 mutations. Statistical tests of the similarity among mismatch distributions, and their means and variances are given in the text.

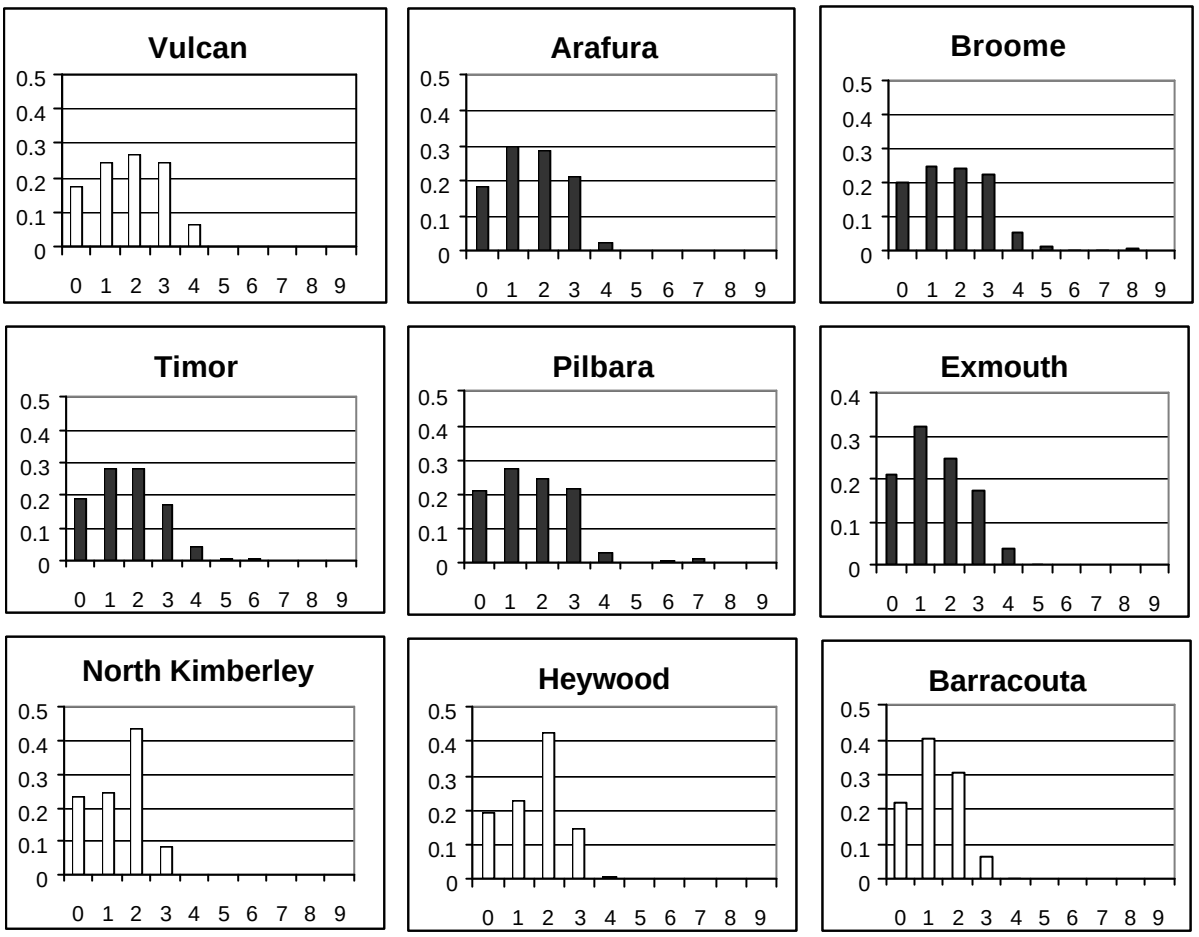
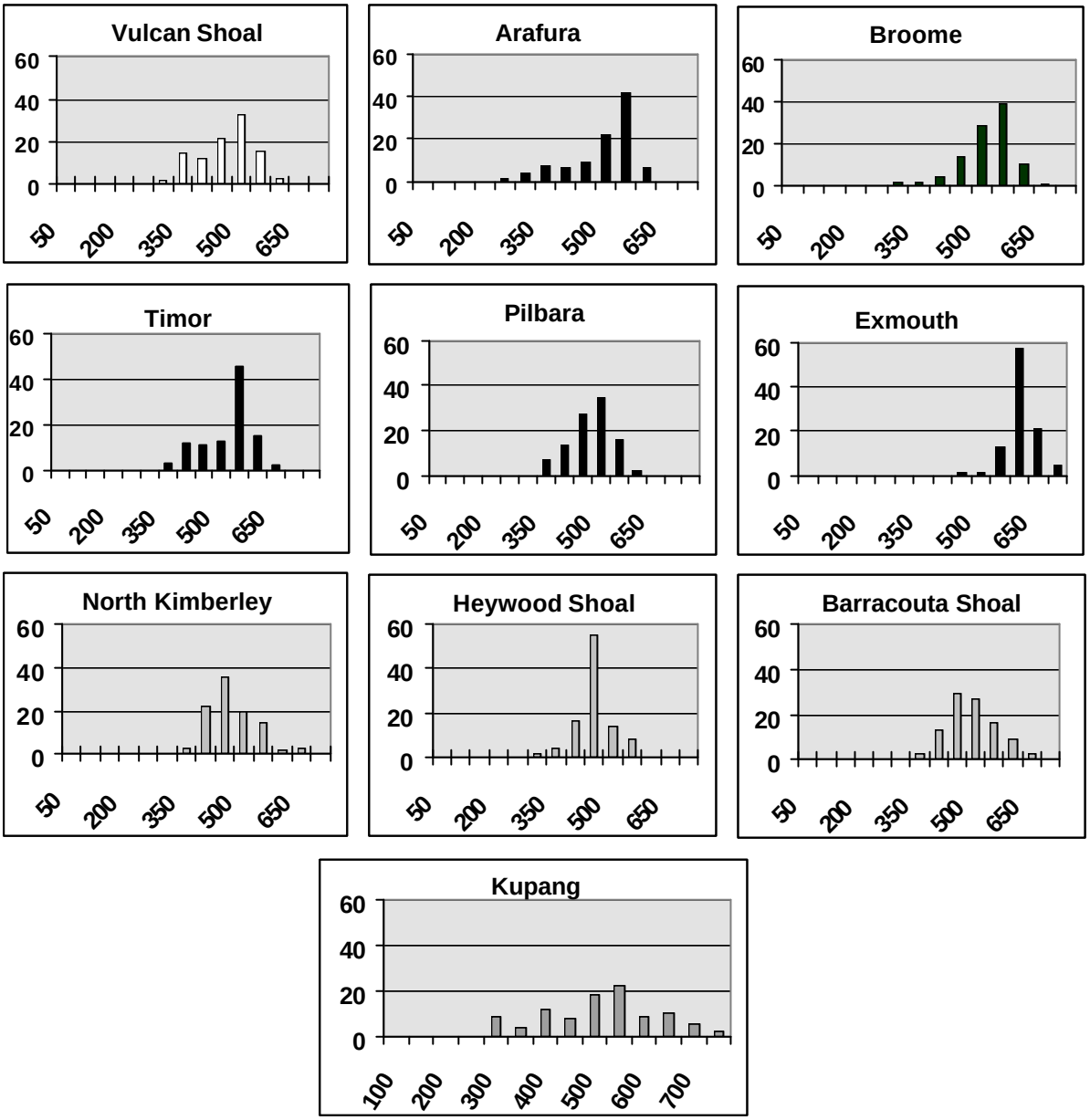


Figure 12 Length (mm) frequency distribution of fish sampled from 8 locales. Histograms representing populations from the Kimberley region have either white or stippled bars. Histograms with black columns are from the non-Kimberley Australian locales.



APPENDIX 1. INTELLECTUAL PROPERTY

NIL

APPENDIX 2. STAFF ENGAGED ON THE PROJECT

Employer	Name	Designation	Duration on Project
Southern Fisheries Centre, Queensland Department of Primary Industries			
	Ms. Raewyn Street	Part-time fisheries technician	Jul 96 - Oct 99
	Ms. Leigh Slater	Temporary part-time fisheries technician	June 98 – May 99
	Dr. Jenny Ovenden	Fisheries Biologist (Genetics)	Oct 97 – Oct 99
	Dr. Clive Keenan	Fisheries Biologist (Genetics)	Jul 96 – Dec 97
Research and Development Branch, Department of Primary Industry and Fisheries, Fisheries Division			
	Ms. Julie Lloyd	Fisheries Biologist	Jul 96 – Oct 99
	Mr. Charles Bryce	Fisheries technician	Jul 96 – Oct 99
Western Australian Marine Research Laboratories			
	Dr. Steve Newman	Fisheries Biologist	Jul 96 – Oct 99
	Mr. Richard Steckis	Fisheries technician	Jul 96 – Oct 99

APPENDIX I Full details on all fish sampled, including latitudes and longitudes, weight, length, depth captured. Genetic morph designation for each restriction enzyme for each fish is shown. Restriction site presence and absence data are available on request from J.R. Ovenden.

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
Fish that were successfully genetically analysed																
A1201	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	521	2600		M	A	B	C	A	A
A1202	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	519	2976		M	A	B	C	A	A
A1203	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	310	616		J	A	A	C	A	A
A1204	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	477	1909		F	B	B	C	B	A
A1205	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	510	2410		M	A	B	C	B	E
A1206	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	474	2064		M	B	B	C	B	A
A1207	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	556	3301		M	A	A	C	A	A
A1208	08/07/96	Arafura	Arafura Sea	Weipa	65	12.30	140.08	531	2627		F	A	B	C	B	E
A1210	08/07/96	Arafura	Arafura Sea	Weipa	65	12.30	140.08	536	2833		M	A	B	C	A	A
A1219	08/07/96	Arafura	Arafura Sea	Weipa	65	12.30	140.08	345	715		J	B	B	C	B	A
A1223	08/07/96	Arafura	Arafura Sea	Weipa	65	12.30	140.08	283	434		M	A	B	C	A	A
A1224	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	534	2454		F	A	B	C	A	A
A1225	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	550	2670		M	A	B	C	A	A
A1226	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	528	2695		F	A	A	C	A	A
A1227	08/07/96	Arafura	Arafura Sea	Weipa	65	12.43	140.68	487	2223		M	B	B	C	B	A
A1234	08/07/96	Arafura	Arafura Sea	Weipa	65	12.45	140.73	534	2555		M	A	B	C	B	A
A1238	08/07/96	Arafura	Arafura Sea	Weipa	65	12.45	140.73	423	1489		M	A	B	C	B	E
A1239	08/07/96	Arafura	Arafura Sea	Weipa	65	12.45	140.73	544	2900		M	A	B	C	B	E
A1240	08/07/96	Arafura	Arafura Sea	Weipa	65	12.45	140.73	495	2262		F	A	B	C	A	A
A1241	08/07/96	Arafura	Arafura Sea	Weipa	65	12.45	140.73	468	1824		F	A	B	C	A	A
A1244	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	348	759		F	A	B	C	B	E
A1245	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	383	438		F	A	B	C	A	D
A1247	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	391	1112		M	A	A	C	A	A
A1248	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	311	585		F	A	B	C	A	A
A1250	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	551	2974		M	A	B	C	A	A
A1251	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	549	3158		F	A	A	C	A	A
A1253	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	526	2699		F	B	B	C	B	A
A1256	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	540	2881		M	B	B	C	B	A
A1259	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	543	3025		M	A	B	C	B	E
A1260	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	537	2079		F	A	A	C	A	A
A1261	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	541	2781		M	B	B	C	B	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
A1262	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	406	1272		F	A	B	C	A	A
A1263	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	527	2618		M	A	B	C	B	E
A1264	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	536	2737		M	B	B	C	B	A
A1265	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	532	2868		M	B	B	C	B	A
A1266	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	448	1491		M	A	A	C	A	A
A1267	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	397	1168		F	A	A	C	A	A
A1268	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	572	3125		M	A	A	C	A	A
A1269	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	507	2255		F	B	B	C	B	A
A1270	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	520	2564		M	A	A	C	B	E
A1271	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	551	3037		M	A	B	C	B	E
A1272	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	438	1498		M	A	B	C	B	A
A1273	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	525	2542		M	A	B	C	A	A
A1274	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	514	2592		F	A	B	C	A	A
A1275	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	506	2329		M	A	B	C	A	D
A1276	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	478	1768		F	A	B	C	B	A
A1277	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	482	1971		M	A	B	C	B	E
A1278	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	468	1688		M	A	A	C	A	A
A1280	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	323	636		F	A	A	C	A	A
A1282	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	512	2392		F	A	B	C	B	E
A1283	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	537	2660		M	A	B	C	A	A
A1284	08/07/96	Arafura	Arafura Sea	Weipa	65	12 00	140.83	468	1882		F	A	A	C	A	A
GI041	11/09/98	Irian Jaya	Indonesia	Gag I.	180	0.43	129.81	320		602.86	F	B	B	C	B	A
GI043	11/09/98	Irian Jaya	Indonesia	Gag I.	180	0.43	129.81	498		2241.28	F	B	B	C	B	A
GI044	11/09/98	Irian Jaya	Indonesia	Gag I.	180	0.43	129.81	462		1793.68	M	B	B	C	B	A
GI048	13/09/1998	Irian Jaya	Indonesia	Gag I.	122	0.43	129.81	561	3100		M	A	B	C	B	A
GI049	13/09/1998	Irian Jaya	Indonesia	Gag I.	122	0.43	129.81	560	3150		F	B	B	C	B	A
GI050	13/09/1998	Irian Jaya	Indonesia	Gag I.	122	0.43	129.81	324	600		M	A	B	C	B	E
GI051	13/09/1998	Irian Jaya	Indonesia	Gag I.	122	0.43	129.81	385	1050		M	B	B	C	B	A
GI053	13/09/1998	Irian Jaya	Indonesia	Gag I.	122	0.43	129.81	326	650		M	B	B	C	B	E
GI067	14/09/1998	Irian Jaya	Indonesia	Gag I.	135	0.46	129.81	554	3150		M	B	B	C	B	A
GI068	14/09/1998	Irian Jaya	Indonesia	Gag I.	135	0.46	129.81	495	2250		F	B	B	C	B	A
GI089	14/09/1998	Irian Jaya	Indonesia	Gag I.	135	0.46	129.81	506	2350		F	A	B	C	B	A
GI090	14/09/1998	Irian Jaya	Indonesia	Gag I.	135	0.46	129.81	575	3200		M	A	B	C	B	A
GI100	15/09/1998	Irian Jaya	Indonesia	Gag I.	100	0.45	129.81	340	700		F	B	B	C	B	A
GI106	15/09/1998	Irian Jaya	Indonesia	Gag I.	100	0.45	129.81	376	900		F	B	B	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
GI137	17/09/1998	Irian Jaya	Indonesia	Gag I.	145	0.47	129.93	518	2550		M	B	B	A	B	A
GI138	17/09/1998	Irian Jaya	Indonesia	Gag I.	145	0.47	129.93	400	1200		M	A	B	C	B	A
GI140	17/09/1998	Irian Jaya	Indonesia	Gag I.	145	0.47	129.93	466	1800		M	B	B	C	B	A
GI143	17/09/1998	Irian Jaya	Indonesia	Gag I.	145	0.47	129.93	428	1400		M	B	B	C	A	D
GI144	17/09/1998	Irian Jaya	Indonesia	Gag I.	145	0.47	129.93	450	1600		M	A	B	C	B	A
GE002	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	450	3350		M	B	B	C	B	E
GE003	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	422	1300		F	A	B	C	A	A
GE004	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	509	2600		F	B	B	C	B	A
GE005	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	540	2850		F	A	B	C	A	A
GE006	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	390	1100		M	B	B	C	B	A
GE008	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	396	1200		M	B	B	C	B	A
GE009	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	266	350		M	B	B	C	B	E
GE010	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	405	1250		M	B	B	C	B	A
GE011	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	552	3050		F	B	B	C	B	A
GE012	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	410	1250		F	A	B	C	B	D
GE013	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	627	4450		F	A	B	C	B	A
GE014	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	395	1150		F	B	B	C	A	A
GE015	18/09/1998	Irian Jaya	Indonesia	Gebe I.	130	0.08	129.38	583	3400		M	B	B	C	A	A
K01	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	440	1300		M	A	B	C	B	E
K02	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	420	1400		F	A	B	C	A	A
K03	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	430	1800		M	A	B	C	B	A
K05	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	380	1200		M	D	B	C	A	B
K07	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	410	1500		F	B	B	C	B	D
K09	07/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	340	900		M	A	B	C	A	A
K11	10/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	420	1400		F	B	B	C	B	A
K15	11/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	490	2000		F	A	B	C	B	E
K16	11/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	430	1500		F	A	B	C	B	E
K19	11/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	580	3000		F	A	B	C	B	E
K20	11/04/97	Kupang	Indonesia	Kupang 97		10.17	123.50	430	1100		F	A	B	C	A	A
IN01	03/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	620	4600		F	A	B	C	A	A
IN02	03/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	670	5400		F	B	B	C	B	A
IN03	03/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	430	1900		F	A	B	C	B	E
IN04	03/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	420	1300		M	B	B	A	B	A
IN05	03/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	310	700		F	A	A	C	A	A
IN06	06/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	440	1600		M	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
IN07	06/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	460	1900		F	C	B	C	B	A
IN08	06/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	310	600		J	A	B	C	A	A
IN10	06/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	420	1500		M	A	B	C	B	E
IN11	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	310	600		J	A	B	C	A	A
IN12	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	470	1900		M	B	B	C	B	A
IN13	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	320	600		F	E	B	C	A	A
IN14	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	510	2400		M	B	B	C	B	A
IN15	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	440	1500		F	B	B	C	B	A
IN16	08/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	570	3300		M	A	B	C	B	E
IN17	09/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	400	700		J	A	C	C	B	A
IN18	09/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	290	500		J	A	C	C	B	A
IN19	09/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	220	300		J	A	C	C	B	A
IN20	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	365	800		F	B	B	C	B	A
IN21	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	330	700		M	A	B	C	A	A
IN22	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	250	400		J	B	B	C	B	A
IN23	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	255	400		J	B	B	C	B	A
IN25	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	240	300		J	B	B	C	B	A
IN26	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	213	200		J	B	B	C	B	A
IN27	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	210	200		J	B	B	C	B	A
IN28	11/04/98	Kupang	Indonesia	Kupang 98		10.17	123.50	236	300		J	B	B	C	B	A
KP 1	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	470	1900		M	B	B	C	B	E
KP 10	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	580	3400		M	A	B	C	A	A
KP 11	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	540	2600		F	B	B	C	B	A
KP 13	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	570	3000		M	B	B	C	B	A
KP 15	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	450	2700		M	B	B	C	B	B
KP 16	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	500	2300		F	B	B	C	B	A
KP 17	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	470	1900		M	B	C	C	B	A
KP 18	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	300	700		F	B	B	C	B	A
KP 19	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	330	700		M	A	B	C	A	A
KP 2	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	460	1700		F	A	B	C	B	E
KP 20	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	310	700		M	B	B	C	B	A
KP 21	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	610	340		F	B	B	C	B	A
KP 22	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	620	340		F	A	B	C	A	A
KP 29	13/2/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	580	3200		M	A	C	C	A	A
KP 3	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	470	1900		M	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
KP 4	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	460	1600		F	A	B	C	B	E
KP 5	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	400	1200		M	B	B	C	B	A
KP 6	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	470	1700		M	B	A	C	B	A
KP 7	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	470	1700		F	A	B	C	B	E
KP 9	01/02/1999	Kupang	Indonesia	Kupang 99		10.17	123.50	660	4600		M	B	C	C	B	A
A51	11/06/96	Barracouta	Kimberley	Vulcan Shoals	126	12.75	124.42	399		1160.68		E	B	C	E	E
A52	11/06/96	Barracouta	Kimberley	Vulcan Shoals	126	12.75	124.42	546		2945.42		A	B	C	B	A
A53	11/06/96	Barracouta	Kimberley	Vulcan Shoals	126	12.75	124.42	576		3452.37		A	A	C	A	A
A54	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	526		2636.51		A	B	C	B	A
A55	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	478		1984.47		A	B	C	B	A
A56	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	488		2110.29		A	A	C	A	E
A57	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	452		1680.85		A	A	C	A	A
A58	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	479		1996.82		A	B	C	B	E
A59	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	450		1658.86		A	B	C	A	A
A60	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	492		2162.06		A	B	C	A	A
A61	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	442		1572.83		A	B	C	B	E
A62	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	544		2913.51		A	C	C	A	A
A64	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	393		1109.62		A	B	C	B	E
A65	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	456		1725.40		A	B	C	B	E
A66	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	402		1186.78		A	B	C	A	A
A67	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	402		1186.78		A	A	C	A	A
A68	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	493		2175.13		A	B	C	B	E
A69	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	573		3399.26		A	B	C	A	A
A70	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	602		3935.91		A	B	C	B	E
A71	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	470		1887.48		A	B	C	A	A
A72	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	515		2476.16		A	B	C	A	A
A73	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	463		1805.23		B	B	C	B	A
A74	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	320		602.86		A	B	C	B	E
A75	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	418		1332.59		A	B	C	B	E
A77	12/06/96	Barracouta	Kimberley	Vulcan Shoals	123	12.75	124.42	508		2377.56		A	B	C	B	E
A78	13/06/1996	Barracouta	Kimberley	Vulcan Shoals	125	12.75	124.42	523		2592.11		A	B	C	B	E
A79	15/06/1996	Barracouta	Kimberley	Vulcan Shoals	125	12.75	124.42	546		2945.42		A	A	C	B	E
B069	24/06/1996	Broome	Kimberley	West Of Broome	110	15.92	120.46	510		2405.46		B	B	C	B	D
B070	24/06/1996	Broome	Kimberley	West Of Broome	110	15.92	120.46	543		2897.63		B	A	C	B	A
B071	24/06/1996	Broome	Kimberley	West Of Broome	110	15.92	120.46	567		3294.66		A	B	C	A	A

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B072	24/06/1996	Broome	Kimberley	West Of Broome	110	15.92	120.46	460		1770.72		B	B	C	B	A
B073	24/06/1996	Broome	Kimberley	West Of Broome	110	15.92	120.46	457		1736.66		A	B	C	B	E
B076	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	351		793.30		A	B	C	B	E
B077	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	289		445.48		A	A	C	A	A
B078	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	312		559.20		B	B	C	B	A
B079	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	438		1530.94		A	B	C	B	E
B080	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	445		1604.74		A	B	C	B	E
B081	24/06/1996	Broome	Kimberley	West Of Broome	115	17.92	120.43	455		1714.19		A	B	C	A	A
B082	25/01/1996	Broome	Kimberley	West Of Broome		15.92	120.46	516	2528		F	B	B	C	B	A
B083	25/01/1996	Broome	Kimberley	West Of Broome		15.92	120.46	538	2910		M	A	B	C	A	A
B087	25/01/1996	Broome	Kimberley	West Of Broome	115	17.86	120.46	526		2636.51		B	B	C	B	A
B088	25/01/1996	Broome	Kimberley	West Of Broome	115	17.86	120.46	513		2447.72		A	A	C	A	A
BR01	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	X	X		X	A	A	C	A	A
BR03	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	426	1395		F	A	B	C	B	E
BR04	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	521	2855		M	B	B	C	B	A
BR05	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	444	1545		F	A	B	C	B	E
BR07	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	406	1185		M	B	B	C	B	A
BR09	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	449	1540		M	A	B	C	B	E
BR10	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	433	1435		M	B	B	C	B	A
BR11	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	504	2435		F	A	B	C	B	E
BR12	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	549	3080		F	A	B	C	B	E
BR13	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	453	1605		F	A	A	C	A	A
BR14	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	454	1625		F	A	A	C	A	A
BR15	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	497	2020		M	A	B	C	B	E
BR16	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	522	2355		M	A	A	C	A	A
BR17	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	539	2750		M	A	A	C	B	E
BR18	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	513	2305		M	A	B	C	B	A
BR19	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	451	1660		M	A	B	C	B	E
BR21	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	321	640			B	B	C	B	A
BR23	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	569	3285		M	A	B	C	B	E
BR24	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	507	2325		M	A	B	C	B	E
BR25	12/11/96	Lynher Bank	Kimberley	Browse Is.	100	14.91	122.05	519	2440		M	A	A	C	B	E
BR201	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	449	1437		M	A	B	C	B	E
BR202	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	470	1660		M	B	B	C	B	A
BR203	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	574	2983		F	A	A	C	B	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
BR204	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	579	3350		F	A	B	C	B	E
BR205	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	448	1548		F	B	B	C	A	A
BR206	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	563	3233		F	A	B	C	B	E
BR207	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	460	1627		M	B	D	C	B	A
BR208	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	416	1313		F	A	B	C	A	A
BR209	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	471	1766		M	A	B	C	A	A
BR210	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	494	2102		M	A	B	C	B	A
BR211	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	520	2366		F	A	B	C	B	E
BR212	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	541	2739		F	A	B	C	B	E
BR213	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	534	2556		F	A	B	C	A	A
BR214	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	534	2710		M	A	B	C	A	D
BR215	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	541	2954		M	A	B	C	B	A
BR216	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	464	1750		M	A	B	C	A	A
BR217	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	565	3111		F	A	B	C	B	E
BR218	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	510	2424		M	A	B	C	A	A
BR219	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	543	2745		F	B	B	C	B	A
BR220	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	483	2063		F	A	B	C	A	A
BR221	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	518	2602		M	A	B	C	B	E
BR222	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	432	1387		M	A	B	C	B	E
BR223	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	497	2006		M	A	B	C	B	E
BR224	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	410	1215		F	A	B	C	B	E
BR227	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	525	2453		F	A	B	C	B	E
BR228	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	545	2671		M	A	B	C	A	A
BR229	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	523	2434		M	B	B	C	B	A
BR230	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	537	2665		F	A	B	C	A	A
BR231	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	508	2333		M	A	A	C	A	A
BR232	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	509	2455		M	A	A	C	A	A
BR233	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	433	1451		F	B	B	C	B	A
BR234	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	477	1964		M	B	B	A	B	D
BR235	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	456	1659		M	B	B	C	B	D
BR236	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	465	1749		F	A	B	C	B	E
BR237	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	486	1866		F	A	B	C	A	A
BR238	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	407	1161		M	A	B	C	B	E
BR239	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	398	1106		F	A	B	C	B	E
BR240	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	415	1299		F	A	B	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
BR243	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	490	1863		F	A	A	C	A	A
BR244	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	451	1675		M	A	A	C	A	A
BR245	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	503	2505		M	B	B	C	B	A
BR246	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	442	1462		F	A	B	C	B	E
BR247	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	423	1329		F	B	B	C	B	A
BR248	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	441	1498		M	B	B	C	B	A
BR249	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	436	1448		M	A	B	C	B	E
BR252	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	446	1518		M	A	B	C	B	E
BR253	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	462	1792		M	A	B	C	A	D
BR254	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	474	1803		F	B	A	C	B	A
BR255	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	486	2071		F	A	B	C	B	E
BR256	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	460	1652		M	A	B	C	B	E
BR258	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	521	2586		M	A	B	C	A	A
BR260	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	398	1189		F	A	A	C	B	E
BR261	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	490	1979		F	A	A	C	A	A
BR262	08/10/98	Broome	Kimberley	West Of Broome	116	17.65	120.80	453	1645		M	A	A	C	A	A
BR263	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	456		1725.40	F	A	B	C	B	E
BR264	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	522		2577.43	M	A	B	C	A	A
BR265	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	517		2504.82	F	A	A	C	A	A
BR266	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	502		2295.15	F	A	B	C	B	E
BR267	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	540		2850.36	M	B	B	C	B	A
BR268	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	530		2696.48	M	A	A	C	A	A
BR269	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	516		2490.46	M	A	B	C	A	A
BR270	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	464		1816.83	F	A	B	C	B	E
BR271	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	550		3009.95	M	A	B	C	A	A
BR272	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	523		2592.11	M	B	B	C	B	A
BR273	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	503		2308.76	M	A	A	C	A	A
BR274	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	505		2336.12	M	A	B	C	A	D
BR275	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	592		3744.95	M	A	B	C	B	E
BR276	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	569		3329.29	M	B	B	C	B	A
BR277	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	540		2850.36	M	A	B	C	B	E
BR278	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	508		2377.56	F	A	B	C	B	E
BR279	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	465		1828.48	F	A	B	C	B	E
BR280	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	446		1615.47	F	A	B	C	B	E
BR283	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	522		2577.43	M	A	A	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
BR284	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	434		1489.81	M	B	B	C	B	A
BR285	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	481		2021.68	F	A	A	C	A	A
BR286	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	483		2046.74	M	A	B	C	A	A
BR287	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	425		1399.94	M	B	B	C	B	A
BR289	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	459		1759.32	F	A	B	C	A	A
BR290	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	584		3596.69	M	A	B	C	B	E
BR291	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	580		3524.04	F	A	A	C	A	A
BR292	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	386		1051.96	F	A	B	C	B	E
BR293	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	521		2562.80	F	A	B	C	A	A
BR294	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	469		1875.58	M	A	B	C	A	D
BR295	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	542		2881.82	F	A	B	C	A	A
BR296	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	520		2548.22	F	B	B	C	B	A
BR297	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	521		2562.80	F	B	B	C	B	A
BR298	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	472		1911.42	M	B	C	C	B	A
BR300	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	499		2254.67	M	A	B	C	B	E
BR301	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	550		3009.95	M	B	B	C	B	A
BR302	18/02/1999	Broome	Kimberley	West Of Broome		17.67	121.66	423		1380.47	M	A	B	C	B	E
HS1	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	530	2502		M	A	B	C	B	A
HS10	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	350	786		F	A	B	C	A	A
HS11	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	381	1034		F	A	B	C	B	A
HS12	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	410	1072		F	A	B	C	B	E
HS16	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	440	1568		M	A	A	C	A	A
HS17	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	389	1096		M	A	B	C	B	A
HS19	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	381	1000		F	A	A	C	A	A
HS2	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	408	1258		M	A	B	C	B	E
HS20	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	415	1254		M	A	B	C	B	A
HS21	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	354	830		F	A	A	C	A	A
HS22	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	332	714		M	A	A	C	A	A
HS23	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	412	1304		F	A	A	C	A	A
HS26	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	351	782		M	B	B	C	B	A
HS27	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	417	1410		M	A	B	C	A	D
HS28	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	383	1056		M	A	B	D	B	A
HS29	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	420	1290		M	A	B	C	B	A
HS30	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	422	1356		M	A	A	C	B	A
HS31	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	385	1048		F	A	A	C	B	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
HS32	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	420	1332		F	A	B	C	A	A
HS33	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	470	1770		M	A	B	C	B	E
HS35	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	505	2560		M	A	B	C	B	E
HS36	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	417	1324		M	A	A	C	A	A
HS37	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	525	2604		M	A	B	C	B	E
HS38	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	403	1210		F	A	B	C	A	A
HS39	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	411	1248		F	A	B	C	B	E
HS4	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	426	1308		F	A	B	C	B	E
HS40	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	471	1998		M	A	A	C	A	A
HS41	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	421	1298		M	A	B	C	B	E
HS46	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	421	1256		M	A	B	C	B	A
HS47	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	452	1612		M	A	B	C	B	E
HS48	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	502	2402		F	A	B	C	B	E
HS49	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	483	1882		M	A	B	C	B	E
HS5	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	430	1328		M	A	B	C	B	D
HS6	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	412	1136		M	A	B	C	A	A
HS7	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	414	1230		F	A	B	C	B	E
HS8	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	421	1326		F	A	A	C	A	A
HS9	27/10/1998	Heywood	Kimberley	Heywood Shoals	110	13.41	124.02	284	450		F	A	B	C	B	E
KMB1303	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	A	C	A	A
KMB1304	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	A	C	A	A
KMB1305	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	A	C	A	A
KMB1306	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	A	C	A	A
KMB1307	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1308	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1309	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1310	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1313	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1314	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1315	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1316	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1317	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1318	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1319	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E
KMB1320	09/11/1996	Nth Kimb	Kimberleys	North west	?	12.04	125.08	?	?		?	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
KMB1321	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	512	2518		M	B	A	C	A	A
KMB1322	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	427	1332		F	A	F	C	A	A
KMB1323	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	515	2403		M	A	B	C	B	A
KMB1324	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	470	1928		M	A	B	C	B	E
KMB1325	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	438	1627		M	A	B	C	B	E
KMB1326	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	480	2213		M	A	B	C	B	E
KMB1327	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	415	1416		M	B	B	C	B	E
KMB1328	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	450	1687		F	A	B	C	B	E
KMB1329	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	485	2075		M	A	B	C	B	A
KMB1330	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	400	1224		F	A	B	C	A	A
KMB1331	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	520	2690		M	A	B	C	A	A
KMB1332	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	520	2551		F	A	B	C	B	E
KMB1333	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	470	1932		M	A	B	C	B	E
KMB1334	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	395	1186		M	A	A	C	A	A
KMB1335	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	365	834		M	A	B	C	B	E
KMB1336	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	542	2810		M	A	B	C	A	A
KMB1337	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	469	1916		F	A	B	C	A	A
KMB1338	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	603	3940		F	B	E	C	A	A
KMB1339	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	445	1808		M	A	B	D	A	A
KMB1340	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	426	1430		F	A	B	C	B	A
KMB1341	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	420	1260		M	A	B	C	A	A
KMB1342	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	410	1228		M	A	B	C	B	E
KMB1343	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	525	2670		F	A	B	C	B	E
KMB1344	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	450	1568		F	A	A	C	A	A
KMB1345	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	450	1663		M	A	B	C	A	A
KMB1346	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	470	1784		M	A	B	C	B	E
KMB1347	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	503	2260		M	A	B	C	B	E
KMB1348	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	430	1468		M	A	B	C	B	E
KMB1349	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	530	2710		M	B	A	C	A	A
KMB1350	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	459	1821		M	B	B	C	A	A
KMB1351	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	420	1338		M	A	B	C	B	A
KMB1353	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	449	1599		F	B	B	C	A	A
KMB1354	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	392	1119		M	A	C	C	B	E
KMB1355	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	576	3333		M	A	B	C	B	A
KMB1356	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	500	2299		M	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
KMB1357	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	370	979		F	A	A	C	A	A
KMB1358	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	406	1220		M	A	B	C	B	E
KMB1359	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	410	1231		F	B	B	C	B	E
KMB1360	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	309	1068		F	A	B	C	A	A
KMB1361	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	480	1974		M	A	B	C	B	A
KMB1362	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	483	1942		F	A	B	C	B	E
KMB1363	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	451	1620		M	A	B	C	B	E
KMB1364	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	502	1921		F	A	C	C	A	A
KMB1365	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	502	2285		M	A	A	C	A	A
KMB1366	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	439	1363		F	A	B	C	B	A
KMB1367	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	564	2977		F	A	B	C	B	A
KMB1368	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	509	2180		M	A	B	C	B	A
KMB1369	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	364	945		M	A	B	C	B	A
KMB1370	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	432	12176		F	A	B	C	A	A
KMB1371	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	452	1655		M	B	A	C	A	A
KMB1372	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	387	1036		F	E	B	C	B	E
KMB1373	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	449	1589		F	B	B	C	B	A
KMB1374	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	397	1145		M	A	B	C	B	A
KMB1375	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	392	1104		F	A	B	C	B	E
KMB1376	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	541	2760		M	A	B	C	B	E
KMB1377	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	429	1396		F	E	B	C	A	A
KMB1378	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	475	1862		M	A	B	C	B	E
KMB1379	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	485	1915		M	B	B	C	A	A
KMB1380	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	520	2509		M	A	B	C	B	E
KMB1381	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	644	4832		F	A	B	C	B	A
KMB1382	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	642	4118		F	A	A	C	A	A
KMB1383	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	459	1722		F	A	B	C	B	E
KMB1384	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	450	1933		F	A	B	C	A	A
KMB1385	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	455	1765		F	A	B	C	B	E
KMB1386	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	460	1860		M	A	B	C	B	E
KMB1387	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	485	2096		F	A	A	C	B	E
KMB1388	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	396	1178		F	A	B	C	B	E
KMB1389	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	439	1530		F	A	B	C	B	E
KMB1390	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	424	1394		F	A	B	C	A	A
KMB1391	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	439	1596		M	A	A	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
KMB1392	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	501	2390		M	A	B	C	B	E
KMB1393	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	449	1627		F	A	A	C	A	A
KMB1394	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	541	2561		M	A	A	C	A	A
KMB1395	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	456	1790		F	A	B	C	B	E
KMB1396	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	500	2491		M	A	B	C	A	A
KMB1397	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	445	1658		M	A	A	C	A	A
KMB1398	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	433	1722		M	A	C	C	A	A
KMB1399	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	439	1410		M	A	A	C	A	A
KMB1400	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	431	1699		M	A	A	C	A	A
KMB1401	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	413	1234		M	A	B	C	B	E
KMB1402	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	477	1884		M	B	D	C	A	A
KMB1403	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	374	994		M	A	D	C	A	A
KMB1404	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	415	1259		M	A	B	C	B	A
KMB1404	19/10/1998	Nth Kimberley	Kimberleys	North west	95	12.05	125.08	439	1493		M	A	B	C	B	E
VS04	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	567	3173		M	A	B	C	A	A
VS05	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	356	800		I	A	B	C	A	A
VS06	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	531	2892		M	A	B	C	B	E
VS07	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	485	2016		M	A	A	C	A	A
VS08	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	332	662		F	A	A	C	A	A
VS09	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	315	578		F	B	B	C	B	A
VS10	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	420	1311		M	A	A	C	A	A
VS11	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	514	2279		M	A	B	C	A	A
VS12	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	405	1165		F	B	B	C	B	A
VS13	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	496	2000		M	B	B	C	B	J
VS14	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	472	1815		F	A	B	C	A	A
VS18	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	488	2027		M	B	B	C	B	A
VS21	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	474	1900		M	A	B	C	B	E
VS22	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	487	1998		M	A	B	C	A	A
VS24	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	376	958		M	A	B	C	B	E
VS26	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	538	2768		M	A	B	C	A	A
VS28	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	523	2324		F	A	A	C	A	A
VS29	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	532	2300		M	A	B	C	A	D
VS30	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	462	1743		F	B	B	C	B	A
VS31	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	470	1821		M	A	B	C	A	A
VS33	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	500	2333		F	A	B	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
VS34	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	465	1709		F	A	B	C	B	E
VS35	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	481	1942		M	A	B	C	A	D
VS37	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	495	1956		F	A	A	C	A	A
VS39	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	351	857		F	A	B	C	B	E
VS41	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	423	1250		M	B	B	C	B	D
VS42	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	463	1581		M	A	A	C	A	A
VS43	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	391	1098		F	B	B	C	B	A
VS44	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	426	1329		M	B	B	C	B	A
VS45	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	470	1756		M	A	B	C	B	E
VS46	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	516	2409		M	A	B	C	B	E
VS47	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	497	2209		M	A	A	C	A	A
VS48	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	520	2426		M	A	B	C	B	E
VS49	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	537	2601		M	A	B	C	A	D
VS50	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	408	1194		F	B	B	C	B	A
VS51	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	443	1458		F	A	B	C	B	E
VS52	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	542	3067		M	B	B	C	B	A
VS53	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	527	2520		M	A	B	C	A	A
VS77	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	470	1828		F	A	B	C	B	A
VS78	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	443	1462		F	A	B	C	B	E
VS79	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	307	562		I	A	A	C	A	A
VS80	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	315	584		I	A	B	C	B	E
VS81	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	318	599		M	A	A	C	A	A
VS82	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	330	654		F	A	A	C	A	A
VS83	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	342	754		F	A	B	C	B	E
VS84	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	342	780		F	B	C	C	B	A
VS88	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	467	1850		F	A	B	C	A	A
VS89	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	487	2092		F	B	B	C	B	A
VS90	01/03/99	Vulcan	Kimberley	Vulcan Shoals		13.00	124.67	535	2690		F	B	C	C	B	A
PNG001	01/10/97	Madang	P.N.G.	Bagabag Is	94	4.11	146.19	364	800		M	A	B	C	B	E
PNG002	06/10/97	Madang	P.N.G.	Planet Rock	135	5.09	145.82	377	900		M	B	B	C	B	A
PNG003	07/10/97	Madang	P.N.G.	Planet Rock	185	5.09	145.82	481	1950		F	A	B	C	A	A
PNG004	08/10/97	Madang	P.N.G.	Planet Rock	146	5.09	145.82	580	3550		F	B	B	C	B	A
BAS-002	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	664	5050			A	B	C	B	E
BAS-003	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	710	5100			A	B	A	A	A
BAS004	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	376	850			A	C	C	B	B

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
BAS-005	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	450	1400			A	B	C	B	E
BAS-006	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	489	1800			B	B	C	B	A
BAS-007	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	560	2800			B	B	C	B	A
BAS-009	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	356	700			A	C	C	B	B
BAS-010	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	280	400			B	B	C	B	A
BAS-011	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	627	4150			B	B	A	B	A
BAS-012	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	349	700			B	B	C	B	A
BAS-013	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	413	1200			B	B	C	B	D
BAS-025	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	399	1050			A	B	C	B	E
BAS-026	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	462	1650			A	B	C	B	E
BAS-028	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	681	5300			A	B	C	B	E
BAS-031	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	399	1100			B	B	C	B	A
BAS-032	23/05/1998	Madang	P.N.G.	Pommern Bay	200	5.03	146.13	620	4400			B	B	C	B	A
PL01	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	358	776		F	B	B	A	B	J
PL02	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	479	1882		M	A	B	C	A	A
PL03	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	466	1664		M	A	B	C	B	E
PL04	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	350	778		F	B	B	C	B	A
PL05	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	446	1458		M	A	B	C	A	A
PL06	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	455	1620		M	B	B	C	B	A
PL07	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	452	1702		F	A	B	C	B	E
PL10	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	482	1820		F	A	A	C	A	A
PL100	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	543	2564		M	A	B	C	B	D
PL11	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	499	2088		F	B	B	C	B	A
PL12	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	447	1570		M	A	B	C	B	E
PL13	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	515	2320		M	A	B	C	B	E
PL14	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	430	1388		F	B	B	C	B	A
PL15	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	386	1036		F	A	A	C	A	A
PL16	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	479	1922		M	A	A	C	A	A
PL17	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	572	3292		M	A	B	C	B	E
PL18	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	490	1982		M	A	A	C	A	A
PL19	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	413	1178		M	A	B	C	B	E
PL20	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	390	1040		F	A	B	C	A	A
PL21	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	436	1378		M	A	B	C	A	A
PL22	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	544	2830		M	A	A	C	A	A
PL23	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	524	2422		F	A	A	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
PL24	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	512	2382		M	A	C	C	A	A
PL25	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	539	2668		M	A	B	C	B	E
PL26	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	459	1684		M	A	C	C	B	E
PL27	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	537	2628		M	A	B	C	A	A
PL29	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	435	1478		F	A	B	C	B	E
PL30	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	458	1550		F	A	B	C	A	A
PL31	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	483	1924		F	A	B	C	B	E
PL32	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	476	1764		M	A	B	C	A	A
PL33	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	451	1660		F	B	B	C	B	A
PL34	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	453	1600		F	A	B	C	B	E
PL35	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	549	2732		M	A	B	C	A	A
PL36	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	495	2272		M	A	B	C	B	E
PL37	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	402	1096		F	A	C	C	A	A
PL41	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	441	1584		F	A	B	C	B	E
PL42	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	436	1340		F	B	B	C	B	A
PL49	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	440	1442		F	B	B	C	A	A
PL50	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	390	1052		F	A	A	C	A	A
PL51	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	529	2458		M	A	B	C	B	E
PL52	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	440	1442		M	A	A	C	A	A
PL53	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	500	2262		M	A	B	C	A	A
PL54	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	328	616		M	A	C	C	A	A
PL55	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	378	914		M	A	B	C	B	E
PL56	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	460	1668		M	B	B	C	B	A
PL57	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	323	610		M	A	B	C	A	A
PL58	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	386	1022		M	A	A	C	A	A
PL59	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	516	2200		M	B	B	D	B	A
PL60	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	350	766		M	A	A	C	A	A
PL61	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	473	1792		F	B	B	C	B	A
PL62	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	505	2312		M	A	B	C	A	A
PL63	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	402	1158		F	A	B	C	B	E
PL64	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	394	1070		F	B	B	C	B	A
PL65	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	365	876		F	A	B	C	A	A
PL66	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	455	1672		M	A	B	C	B	E
PL67	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	469	1762		F	B	B	C	B	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
PL68	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	514	2380		M	A	B	C	B	E
PL69	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	453	1646		M	A	B	C	A	A
PL70	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	420	1320		F	A	B	C	A	A
PL71	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	473	1896		M	A	A	C	A	A
PL72	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	573	3290		M	A	B	C	B	E
PL73	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	493	2290		M	A	A	C	A	A
PL74	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	481	1984		M	A	B	C	A	A
PL75	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	431	1354		F	A	B	C	B	E
PL76	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	486	1910		M	A	B	C	B	E
PL77	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	414	1182		M	A	B	C	A	A
PL78	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	332	650		M	A	A	C	A	A
PL79	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	377	934		F	A	B	C	B	E
PL80	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	401	1148		F	A	B	C	A	A
PL81	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	408	1156		F	A	B	C	B	E
PL82	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	411	1258		M	A	A	C	A	A
PL83	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	430	1266		F	A	B	C	A	A
PL84	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	450	1494		M	B	B	C	B	A
PL85	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	447	1484		F	B	B	C	B	A
PL86	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	398	1130		F	A	B	C	A	A
PL87	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	469	1564		F	B	B	C	B	A
PL88	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	364	794		F	A	B	C	B	E
PL89	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	454	1684		M	A	B	C	B	E
PL90	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	470	1788		F	A	B	C	A	A
PL91	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	508	2280		M	A	B	C	A	A
PL92	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	375	962		M	A	B	C	B	E
PL93	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	454	1658		M	A	C	C	A	A
PL94	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	524	2470		M	A	B	C	A	E
PL95	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	334	718		F	A	B	C	B	E
PL96	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	453	1622		M	A	B	C	B	E
PL97	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	479	1804		M	B	B	C	B	A
PL98	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	425	1236		F	A	B	C	B	E
PL99	17/07/1996	Pilbara	Pilbara	Rankin bank	104	19.77	115.68	461	1752		F	B	B	C	B	A
EX01	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	577		3470.19	M	B	A	C	B	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
EX02	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	642		4764.25	F	B	B	C	B	A
EX04	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	572		3381.67	M	A	B	C	A	A
EX05	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	600		3897.21	M	A	A	C	B	E
EX06	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	603		3955.35	M	A	A	C	A	A
EX07	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	559		3158.55	F	A	B	C	A	A
EX08	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	520		2548.22	M	A	B	C	B	E
EX09	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	622		4336.97	F	A	B	C	B	E
EX11	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	591		3726.20	M	A	B	C	A	A
EX12	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	617		4234.28	F	A	A	C	A	A
EX13	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	623		4357.70	F	A	B	C	B	E
EX14	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	580		3524.04	M	B	B	C	B	A
EX15	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	611		4113.19	F	B	B	C	B	A
EX16	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	550		3009.95	F	A	B	C	B	E
EX17	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	592		3744.95	M	A	B	C	B	E
EX18	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	622		4336.97	F	A	B	C	B	E
EX19	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	598		3858.77	M	A	E	C	B	E
EX20	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	562		3209.15	M	A	B	C	A	A
EX21	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	563		3226.13	M	A	B	C	B	E
EX22	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	591		3726.20	F	A	B	C	B	E
EX23	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	659		5148.65	F	A	B	C	A	A
EX24	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	518		2519.23	M	A	B	C	A	A
EX25	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	633		4568.68	F	A	B	C	B	E
EX26	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	554		3075.41	M	A	B	C	A	A
EX27	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	579		3506.03	M	A	B	C	B	A
EX28	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	577		3470.19	M	A	B	C	A	A
EX29	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	567		3294.66	M	B	B	C	B	A
EX35	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	554		3075.41	M	A	B	C	A	A
EX36	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	529		2681.41	F	A	E	C	B	E
EX39	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	599		3877.96	F	A	B	C	B	E
EX40	13/07/1996	Exmouth	South	Ningaloo		23.60	113.11	652		4987.97	F	B	B	C	B	A
EX42	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	554	3225		M	A	B	C	A	A
EX43	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	597	3410		F	B	B	C	B	A
EX47	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	586	3710		M	A	B	C	B	A
EX48	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	543	2625		M	A	B	C	B	E
EX51	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	554	2800		M	A	A	C	A	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
EX52	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	589	3300		M	A	B	C	A	A
EX53	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	551	2620		M	A	B	C	A	E
EX54	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	540	2770		F	A	B	C	A	A
EX55	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	553	3095		M	A	A	C	A	A
EX56	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	519	2470		F	A	B	C	B	E
EX57	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	573	3200		F	A	B	C	A	A
EX58	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	584	3195		F	B	B	C	B	A
EX59	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	565	3280		M	A	B	C	A	A
EX60	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	635	4670		F	B	B	C	B	A
EX61	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	590	3420		M	A	B	C	B	E
EX62	19/97/1996	Exmouth	South	Ningaloo		23.60	113.11	518	2180		F	A	B	C	A	A
T1103	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	398	1061		M	B	B	C	B	A
T1105	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	531	2855		M	A	A	C	A	A
T1121	02/06/96	Timor	Timor Sea	NW Australia	98	10.23	129.80	580	3477		F	A	A	C	A	A
T1124	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	529	2566		F	A	B	C	B	A
T1125	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	575	3256		M	A	B	C	B	E
T1126	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	521	2563		F	A	B	A	B	E
T1127	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	554	3116		M	A	A	C	A	A
T1128	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	550	3131		M	A	B	C	A	A
T1129	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	522	2768		F	A	B	C	B	E
T1130	02/06/96	Timor	Timor Sea	NW Australia	108	10.25	129.80	571	5020		F	A	B	C	B	E
T1131	02/06/96	Timor	Timor Sea	NW Australia	108	10.25	129.80	542	3022		M	A	B	C	B	E
T1132	02/06/96	Timor	Timor Sea	NW Australia	108	10.25	129.80	520	2624		F	A	B	C	A	A
T1133	02/06/96	Timor	Timor Sea	NW Australia	108	10.25	129.80	546	3129		M	A	B	C	B	E
T1134	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	540	2924		F	A	B	C	A	A
T1135	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	518	2638		M	B	B	C	B	A
T1136	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	507	2383		M	A	B	C	A	A
T1137	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	565	3280		M	A	A	C	A	A
T1138	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	530	2723		F	B	B	C	B	A
T1139	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	533	2777		F	C	B	C	C	A
T1140	02/06/96	Timor	Timor Sea	NW Australia	100	10.25	129.80	551	2850		F	A	B	C	B	C
T1141	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	483	2052		F	A	A	C	A	A
T1142	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	500	2264		M	A	B	C	B	E
T1144	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	565	2956		F	A	B	C	B	A
T1145	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	129.80	416	1455		M	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
T1146	02/06/96	Timor	Timor Sea	NW Australia	100	10.05	129.37	336	743		M	A	B	C	A	A
T1147	02/06/96	Timor	Timor Sea	NW Australia	100	10.05	129.37	458	1725		M	A	B	C	B	E
T1148	02/06/96	Timor	Timor Sea	NW Australia	100	10.05	129.37	582	3199		F	A	B	C	A	D
T1149	02/06/96	Timor	Timor Sea	NW Australia	100	10.05	129.37	364	1000		F	A	A	C	A	A
T1150	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	531	2878		F	A	B	C	B	E
T1151	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	394	1162		M	A	B	C	B	E
T1152	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	481	2062		M	A	B	C	A	A
T1153	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	523	2580		F	B	B	C	B	A
T1154	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	530	2743		F	B	B	C	B	A
T1155	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	612	4309		M	A	A	C	A	A
T1156	02/06/96	Timor	Timor Sea	NW Australia	100	10.23	12.80	535	3064		M	A	B	C	A	A
T1157	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	505	2535		F	A	B	C	B	E
T1158	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	544	3037		F	A	B	C	A	A
T1159	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	524	2743		F	B	B	C	B	A
T1162	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	376	1029		F	A	B	C	B	E
T1163	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	474	2079		F	A	B	C	B	E
T1164	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	565	3329		M	A	B	C	B	E
T1165	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	523	2615		M	A	B	C	B	E
T1166	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	427	1552		M	A	B	C	A	A
T1167	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	369	881		F	A	B	C	A	A
T1169	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	510	2158		M	A	A	C	A	A
T1170	02/06/96	Timor	Timor Sea	NW Australia	108	10.23	12.80	371	1015		F	A	B	C	A	A
T1171	02/06/96	Timor	Timor Sea	NW Australia	98	10.23	12.80	477	2015		M	A	B	C	B	E
T1172	02/06/96	Timor	Timor Sea	NW Australia	98	10.23	12.80	445	1548		F	A	B	C	A	A
T1173	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	603	3797		F	A	B	C	A	D
T1174	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	537	2809		M	A	A	C	A	A
T1175	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	499	2424		F	A	B	C	A	A
T1176	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	495	2215		F	A	B	C	B	E
T1177	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	357	893		M	A	B	C	A	A
T1178	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	446	1542		F	A	A	C	A	A
T1179	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	398	1058		F	B	B	C	B	A
T1180	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	503	2269		M	A	A	C	A	A
T1181	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	481	2038		M	B	C	C	B	A
T1182	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	350	814		M	B	B	C	B	A
T1183	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	402	1176		M	A	B	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
T1184	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	446	1688		M	A	B	C	B	E
T1185	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	393	1105		F	A	B	C	A	A
T1186	02/06/96	Timor	Timor Sea	NW Australia	98	10.05	129.37	339	773		F	A	A	C	A	A
T1187	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	414	1180		F	A	A	C	A	A
T1188	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	544	2969		M	A	A	C	A	A
T1190	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	545	2965		M	A	A	C	A	A
T1191	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	465	1778		F	A	B	C	A	A
T1192	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	522	2494		M	A	B	C	B	E
T1193	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	528	2866		F	A	A	C	A	A
T1194	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	566	2998		F	A	B	C	A	A
T1195	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	540	2842		M	A	B	C	B	E
T1196	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	540	2706		F	A	B	C	B	A
T1197	02/06/96	Timor	Timor Sea	NW Australia	98	10.25	129.80	539	2834		M	B	B	C	B	A
Fish that wholly or partly failed genetic analysis																
A1200	08/07/96		Arafura Sea	Weipa	65	12.43	140.68	345	826		m	A	X	C	B	E
A1220	08/07/96		Arafura Sea	Weipa	65	12.30	140.08	280	445		F	B	X	C	B	X
A1246	08/07/96		Arafura Sea	Weipa	65	12 00	140.83	454	1633		F	A	X	C	A	A
A1249	08/07/96		Arafura Sea	Weipa	65	12 00	140.83	560	3009		F	A	X	C	B	E
A1252	08/07/96		Arafura Sea	Weipa	65	12 00	140.83	471	1814		F	A	B	X	X	E
A1254	08/07/96		Arafura Sea	Weipa	65	12 00	140.83	522	2401		M	A	X	C	B	E
A1279			Arafura Sea	Weipa	65			523	2501		M	A	B	X	B	X
A6	12/06/96		Kimberley	Vulcan Shoals	100	12.75	124.43	455		1714.19		Failed				
A63	12/06/96		Kimberley	Vulcan Shoals	123	12.75	124.42	375		965.43		B	B	C	B	x
A7	09/06/96		Kimberley	Vulcan Shoals	100	12.75	124.43	447		1626.24		Failed				
A76	12/06/96		Kimberley	Vulcan Shoals	123	12.75	124.42	522		2577.43		A	B	x	A	A
A8	09/06/96		Kimberley	Vulcan Shoals	100	12.75	124.43	459		1759.32		Failed				
A9	09/06/96		Kimberley	Vulcan Shoals	100	12.75	124.43	392		1101.26		Failed				
BR02	12/11/96		Kimberley	Browse Is.	100	14.91	122.05	462	1755		M	x	A	C	B	E
BR06	12/11/96		Kimberley	Browse Is.	100	14.91	122.05	514	2850		F	A	x	C	B	E
BR08	12/11/96		Kimberley	Browse Is.	100	14.91	122.05	542	3645		F	A	x	C	A	A
BR20	12/11/96		Kimberley	Browse Is.	100	14.91	122.05	478	1990		F	A	x	C	x	A
BR22	12/11/96		Kimberley	Browse Is.	100	14.91	122.05	484	2180		F	Failed				
BR241	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	410	1198		M	A	x	C	B	E
BR242	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	486	2107		M	A	x	C	B	A
BR250	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	473	2077		F	A	x	C	x	A

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
BR251	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	434	1412		F	A	B	x	B	E
BR257	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	463	1791		M	B	x	C	B	A
BR259	08/10/98		Kimberley	West Of Broome	116	17.65	120.80	502	2251		M	x	B	C	A	B
BR281	18/02/1999		Kimberley	West Of Broome		17.67	121.66	425		1399.94	M	A	x	C	x	x
BR282	18/02/1999		Kimberley	West Of Broome		17.67	121.66	493		2175.13	M	x	x	C	B	x
BR288	18/02/1999		Kimberley	West Of Broome		17.67	121.66	484		2059.34	M	A	x	C	A	x
BR299	18/02/1999		Kimberley	West Of Broome		17.67	121.66	591		3726.20	F	A	x	A	B	E
BR303	18/02/1999		Kimberley	West Of Broome		17.67	121.66	396		1134.96	F	A	x	C	A	x
EX03	13/07/1996		South	Ningaloo		23.60	113.11	563		3226.13	M	Failed				
EX10	13/07/1996		South	Ningaloo		23.60	113.11	571		3364.15	M	B	E		B	A
EX30	13/07/1996		South	Ningaloo		23.60	113.11	596		3820.58	F	Failed				
EX31	13/07/1996		South	Ningaloo		23.60	113.11	656		5079.37	F	Failed				
EX32	13/07/1996		South	Ningaloo		23.60	113.11	564		3243.17	F	Failed				
EX33	13/07/1996		South	Ningaloo		23.60	113.11	555		3091.92	M	Failed				
EX34	13/07/1996		South	Ningaloo		23.60	113.11	608		4053.52	F	Failed				
EX37	13/07/1996		South	Ningaloo		23.60	113.11	602		3935.91	F	A	B	x	B	E
EX38	13/07/1996		South	Ningaloo		23.60	113.11	622		4336.97	F	A	B	x	A	A
EX41	19/97/1996		South	Ningaloo		23.60	113.11	495	2195		F	Failed				
EX44	19/97/1996		South	Ningaloo		23.60	113.11	440	1515		M	Failed				
EX45	19/97/1996		South	Ningaloo		23.60	113.11	635	4480		M	Failed				
EX46	19/97/1996		South	Ningaloo		23.60	113.11	579	3055		F	Failed				
EX49	19/97/1996		South	Ningaloo		23.60	113.11	578	3210		F	A	X	C	A	E
EX50	19/97/1996		South	Ningaloo		23.60	113.11	577	3260		M	A	X	X	A	E
GE007	18/09/1998		Indonesia	Gebe I.	130	0.08	129.38	501	2300		F	A	B	C	A	x
HS42	27/10/1998		Kimberley	Heywood Shoals	110	13.41	124.02	426	1374		F	A	B	C	x	A
HS45	27/10/1998		Kimberley	Heywood Shoals	110	13.41	124.02	463	1706		M	A	A	C	x	A
IN09	06/04/98		Indonesia	Kupang 98		10.17	123.50	620	4200		M	B	X	C	B	A
IN24	11/04/98		Indonesia	Kupang 98		10.17	123.50	230	300		J	B	B		B	A
K06	07/04/97		Indonesia	Kupang 97		10.17	123.50	580	1200		F	B	B	C	B	X
K08	07/04/97		Indonesia	Kupang 97		10.17	123.50	380	1100		M	A	B		B	X
K10	10/04/97		Indonesia	Kupang 97		10.17	123.50	320	600		M	B	B	C	B	X
K12	11/04/97		Indonesia	Kupang 97		10.17	123.50	500	2400		M	Failed				
K13	11/04/97		Indonesia	Kupang 97		10.17	123.50	540	3000		M	Failed				
K14	11/04/97		Indonesia	Kupang 97		10.17	123.50	510	2500		M	Failed				
K17	11/04/97		Indonesia	Kupang 97		10.17	123.50	530	2800		F	Failed				

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
K18	11/04/97		Indonesia	Kupang 97		10.17	123.50	420	1400		F	Failed				
KMB1352	19/10/1998		Kimberleys	North west	95	12.05	125.08	421	1447		F	A	B	C	B	x
KP 12	01/02/1999		Indonesia	Kupang 99		10.17	123.50	540	2700		F	A	x	C	B	A
KP 14	01/02/1999		Indonesia	Kupang 99		10.17	123.50	470	2000		M	x	B	C	A	A
KP 23	01/02/1999		Indonesia	Kupang 99		10.17	123.50	480	1800		F	B	x	C	B	A
KP 24	01/02/1999		Indonesia	Kupang 99		10.17	123.50	440	1600		F	B	x	C	B	A
KP 25	01/02/1999		Indonesia	Kupang 99		10.17	123.50	400	1200		F	A	x	C	B	E
KP 26	02/02/1999		Indonesia	Kupang 99		10.17	123.50	523	2600		F	A	x	C	B	E
KP 27	02/02/1999		Indonesia	Kupang 99		10.17	123.50	490	1900		M	B	x	C	B	A
KP 28	04/02/1999		Indonesia	Kupang 99		10.17	123.50	500	2300		F	B	x	C	B	A
KP 30	13/02/1999		Indonesia	Kupang 99		10.17	123.50	500	2300		F	A	x	C	B	E
KP 31	13/02/1999		Indonesia	Kupang 99		10.17	123.50	580	3200		M	A	x	C	B	E
KP 8	01/02/1999		Indonesia	Kupang 99		10.17	123.50	560	3300		M	x	x	A	B	A
PL08	17/07/1996		Pilbara	Rankin bank	104	19.77	115.68	453	1598		M	X	A	C	B	E
PL09	17/07/1996		Pilbara	Rankin bank	104	19.77	115.68	432	1366		M	X	B	C	B	E
PL38	17/07/1996		Pilbara	Rankin bank	104	19.77	115.68	399	1156		F	Failed				
PL39	17/07/1996		Pilbara	Rankin bank	104	19.77	115.68	469	1610		M	Failed				
PL40	17/07/1996		Pilbara	Rankin bank	104	19.77	115.68	348	768		M	B	B	C	B	
T1113	02/06/96		Timor Sea		98	10.23	129.80	540	2993		M	A	B	C	X	E
T1114	02/06/96		Timor Sea		98	10.23	129.80	574	3259		F	A	B	C	X	E
T1123	02/06/96		Timor Sea		98	10.23	129.80	548	3031		F	A	B	C	X	E
T1189	02/06/96		Timor Sea			10.25	129.80	507	2470		M	A	A	X	A	A
VS01	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	344	731		F	A	A	C	A	x
VS02	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	463	1820		F	A	B	C	B	x
VS03	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	438	1580		F	A	B	C	B	x
VS15	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	515	2354		M	B	B	C	x	A
VS16	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	455	1681		M	A	B	C	x	E
VS17	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	390	1092		F	A	B	C	x	E
VS19	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	441	1542		M	A	x	C	A	x
VS20	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	329	644		F	A	B	C	A	x
VS23	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	346	806		M	A	x	C	A	A
VS25	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	327	649		I	A	A	x	A	A
VS27	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	542	2768		M	A	x	C	A	A
VS32	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	394	1106		F	B	x	C	B	A
VS36	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	455	1798		F	A	x	C	B	E

Sample number	Date	Analysis Name	Collection Location	Collection Region	Depth (m)	Lat.	Long.	FL (mm)	TotalWt (gm)	CalcWt (gm)	Sex	AVA Morph	ALU Morph	DDE Morph	DPN Morph	HINF Morph
VS38	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	500	2185		M	B	B	A	B	x
VS40	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	424	1309		F	A	x	C	B	E
VS54	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	476	1921		M	B	B	C	B	x
VS55	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	456	1649		F	A	B	C	B	x
VS56	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	519	2280		M	A	x	C	B	x
VS57	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	466	1751		M	B	x	C	B	x
VS58	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	394	1067		F	B	x	C	B	x
VS59	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	416	1235		M	A	x	C	A	x
VS60	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	443	1142		M	x	x	C	A	x
VS61	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	361	849		M	A	A	C	A	x
VS62	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	327	628		F	A	B	C	A	x
VS63	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	381	985		F	A	A	C	A	x
VS64	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	372	905		F	A	A	C	A	x
VS65	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	482	1874		F	B	B	C	B	x
VS66	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	411	1337		M	A	B	C	A	x
VS67	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	364	863		F	B	B	C	B	x
VS68	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	407	1134		M	A	B	C	B	x
VS69	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	428	1466		M	A	B	C	A	x
VS70	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	463	1689		M	A	B	C	A	x
VS71	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	446	1585		F	A	x	C	A	A
VS72	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	407	1183		F	x	x	C	A	x
VS73	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	404	1166		M	B	x	C	B	A
VS74	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	407	1144		M	A	B	C	A	x
VS76	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	480	2137		M	x	B	x	x	x
VS85	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	345	712		M	A	A	C	A	x
VS86	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	584	3119		F	A	A	x	A	x
VS87	01/03/99		Kimberley	Vulcan Shoals		13.00	124.67	300	555		F	A	A	x	A	x

APPENDIX I I Chemical Solutions

STE

2M NaCl	5ml
1M Tris pH 8.0	1ml
0.25 M EDTA pH 8.0	0.4ml
Distilled water	to 100ml

Autoclave

10% Chelex 100 Solution

Chelex 100	10g
Distilled water	to 100ml

Autoclave

TE

1M Tris pH 8.0	100µl
0.25M EDTA pH 8.0	40µl
Distilled water	to 10ml

Autoclave

*0.25M EDTA pH 8.0**

EDTA	9.31g
NaOH pellets	1g
Distilled water	to 100ml

Autoclave

*Add EDTA and NaOH pellets to about 80ml of distilled water and stir until dissolved. Measure pH and adjust to 8.0 with liquid NaOH if necessary. Add distilled water to 100ml.

APPENDIX III Nucleotide Sequence of Mitochondrial Control Region Primers

TDKD	5′ CCTGAAGTAGGAACCAGATG 3′
PRO(L19)	5′ CCACTAGCTCCCAAAGCTA 3′

APPENDIX IV The presence and absence of restriction sites before re-coding, for part of the mitochondrial control region of gold-band snapper (0/1, restriction site absent/present). The text contains a discussion of the methods used to infer restriction site presence and absence from fragment presence and absence after restriction enzyme cleavage.

Restriction Enzyme	Morph Name	Restriction Site Coding				
Site position		109	184	245		
*Ava*II	A	1	0	0		
*Ava*II	B	1	1	0		
*Ava*II	C	0	1	0		
*Ava*II	D	1	0	1		
*Ava*II	E	0	0	0		
Site position		106	156	192	265	
*Alu*I	A	0	0	1	0	
*Alu*I	B	0	1	1	0	
*Alu*I	C	0	1	0	0	
*Alu*I	D	0	0	0	0	
*Alu*I	E	0	1	1	1	
*Alu*I	F[1]	1	1	1	0	
Site position		180	266	359		
*Dde*I	A	0	0	0		
*Dde*I	D	1	1	1		
*Dde*I	C	0	1	1		
Site position		109	183			
*Dpn*II	A	0	1			
*Dpn*II	B	0	0			
*Dpn*II	C	1	0			
*Dpn*II	E	1	1			
Site position		183	184	246	270	342
Hinf I	A	0	0	1	1	1
Hinf I	B	0	0	0	1	1
Hinf I	C	1	0	1	1	0
Hinf I	D	0	0	1	1	0
Hinf I	E	0	1	1	1	1
Hinf I	F	1	0	1	1	1
Hinf I	J	0	0	1	0	1

[1] *Alu*I morph F has not been confirmed by direct sequence analysis.

APPENDIX V. Re-coding of Restriction Sites in hypervariable regions to remove co-variance. Sites are numbered according to the base pair immediately to the 5' of the cleavage position, not according to the position of the first base pair of the recognition sequence.

Table A Presence (1) or absence (0) of original or recoded characters at two sequences from hypervariable region 109-113

Character	Sequence	
	GGACC	GGATC
Original		
*Ava*I 109	1	0
*Dpn*I 109	0	1
Re-coded		
Site 112-C	1	0
Site 110/1/3	0	0

Table B Presence (1) or absence (0) of original or recoded characters at eight sequences from hypervariable region 183-187

Character	Sequence							
	GGATC (1)	GGATT (2)	GGACT (3)	GAATC (4)	GGCTC (5)	GGGTC (6)	GGGCC (7)	AAGGT (8)
Original								
*Dpn*I 183	1	0	0	0	0	0	0	0
*Hin*fI 183*	0	0	0	1	0	0	0	0
*Ava*II 184	0	0	0	0	0	1	1	1
*Hin*fI 184	0	1	1	0	0	0	0	0
Re-coded								
Site A	0	1	1	0	0	0	0	0
Site B	0	0	0	1	0	0	0	0
Site C	0	0	0	0	1	0	0	0
Site D	0	0	0	0	0	1	1	1
Site E	0	0	0	0	0	1	1	1

* Identified in two fish from sequence data only.

Table C Presence (1) or absence (0) of original or recoded characters at eight sequences from hypervariable region 245-250

	Sequence		
Character	GGACTC	GGACCC	GAACCC
Original			
*Ava*I 245	0	1	0
*Hin*fI 246	1	0	0
Re-coded			
Site 249-T	1	0	0
Site 246-G	1	1	0

Table D Presence (1) or absence (0) of original or recoded characters at seven sequences from hypervariable region 264-274

	Sequence						
Character	AGCTCAGAATC	AACTCAAAATC	AATTCAGAATC	ATCACAGAATC	ATCTCAGAATC	ACCTCAGAATC	AACTCAGAATC
Original							
*Alu*I 265	1	0	0	0	0	0	0
*Dde*I 266	1	0	0	0	1	1	1
*Hin*fI 270	1	0	1	1	1	1	1
Re-coded							
Site G	1	0	1	1	1	1	1
Site H	0	1	1	1	0	0	0
Site I	0	0	1	1	0	0	0
Site J	0	0	0	0	1	1	1