TOWARDS A NEW APPROACH FOR COASTAL GOVERNANCE WITH AN ASSESSMENT OF THE PLETTENBERG BAY NEARSHORE LINEFISHERIES

A thesis submitted in fulfillment of the requirements for the degree of

MASTER OF SCIENCE
of
RHODES UNIVERSITY

By

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June 2005

Data + Context = Information

Information + Analysis = Understanding

Understanding + Management = Possibility of sustainable action

(Doody 2003)

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ACKNOWLEDGEMENTS

I thank the ORCA Foundation, specifically Tony Lubner for providing the opportunity and funding to carry out the project. My supervisor Warwick Sauer is thanked thoroughly for his input, guidance and support throughout the project.

My thanks must also go to all those fishermen that willingly allowed me to interview them and inspect their catch. Without their co-operation a large part of this project would not have been possible. I am extremely grateful to the management and staff of both Plett Fish and Pesca Fresca for accommodating my needs and allowing me into their packing facilities. I am equally grateful to the staff at Tsistikamma National Park specifically Rob Milne for their help in the launching and loading of the dive boat.

A number of people assisted me in gathering the required data and are gratefully acknowledged. Albrecht Goetz for all his advice and the willingness to help whenever asked. Glenn White, from the Plettenberg Bay Beach Control, for all his assistance, many talks and providing the launch records, the various skippers who volunteered their time whilst I dived in particular James Boyd, Graeme Grant, Chris Hugo and Pete Watt-Pringle for diving when needed and lastly Kelly King for always giving up of her time to go diving and fishing with me.

Finally I thank my parents for their unending support.

ABSTRACT

Under the guidance of the new coastal management policies within South Africa this thesis advocates a more integrated, co-operative approach to local coastal management. The project aimed to acquire baseline information on the local nearshore fishery and resource state and to propose a set of indicators that could be incorporated into the new management strategy. To gather the required information the project was split into two parts: 1) An assessment of the local linefisheries and 2) A comparative study of the reef fish community structure between exploited and unexploited reefs.

The local linefisheries were assessed through the use of launch records, commercial catch records, access point and boat based surveys. A questionnaire was used to gather data on catch and effort, fisher demographics, fisher attitudes towards and knowledge of the current management regulations, assess the efficacy of the fisheries inspectorate and highlight spatial areas of fishing pressure. A total of 252 interviews and catch inspections were conducted.

Total effort for the ski-boat fishery estimated from the access point survey was 890 boat days.year^{-1} or 3560 fisher days. year^{-1} compared to 736 boat days.year^{-1} or 2944 fisher days. year^{-1} recorded in the launch records. Effort was seasonal with greater pressure occurring over the summer holiday period. Analysis of the catch showed that *Merluccius capensis, Argyrozona argyrozona, Argyrosomus inodorus, Chrysoblephus laticeps* and *Atractoscion aequidens* were the most frequently caught species. The overall CPUE was 3.00±5.54kg.fisher^{-1}.day^{-1} or 4.71 ±4.117 fish.fisher^{-1}.day^{-1}. Estimated targeted CPUE was 0.91±0.67kg.fisher^{-1}.day^{-1} or 0.97 ±0.77

fish.fisher^{-1}.day^{-1} for *C. laticeps*, 8.47±8.57kg.fisher^{-1}.day^{-1} or 1.24±1.16 fish.fisher^{-1}.day^{-1} for *A. aequidens* and 2.05±3.78kg.fisher^{-1}.day^{-1} or 1.10±1.80 fish.fisher^{-1}.day^{-1} for *A. inodorus*. Issues identified included poor fisher knowledge regarding linefish regulations, the low occurrence of fishery inspections and a limited degree of non-compliance. Although most fishers supported the current linefish management regulations, when tested on the size limits, bag limits and closed seasons of their target species a high proportion of fishers did not know the regulations (recreational 64%, charter 53%, commercial 42%). Furthermore only 27% of fishers had had their catch inspected whilst fishing in Plettenberg Bay and the majority of these had only been inspected once. Just over half the interviewees (60%) indicated that fishing had deteriorated within Plettenberg Bay with fewer and smaller fish being caught. The most common causes cited for this decline were commercial and recreational overfishing respectively.

Underwater point counts and experimental angling were used to rapidly assess the state of the reef fish resource in Plettenberg Bay through a comparative study of the community structure between two exploited sites in Plettenberg Bay and two protected sites within the Tsitsikamma National Park. Generalized linear modeling showed that relative density of certain species was significantly different between the protected reefs inside the TNP and those exploited reefs within Plettenberg Bay. Both *P. rupestris* and *C. laticeps* had greater densities within the protected area whilst Chi-squared tests showed that the size frequency distributions were significantly different with larger size-classes and the maximum size of fish greater within the reserve. These trends were noted with both the underwater visual surveys and the experimental angling. Multi-dimensional scaling and cluster analysis showed that there was an overall difference in the community structure between the study sites. It is hypothesised that through removal of key reef species and larger individuals that fishing has directly and indirectly affected the overall community structure.

Within a simple framework based on ecological, institutional and social sustainability domains along with the results of the study area, a set of indicators is proposed and the sustainability of the local fishery scored within a rapid assessment matrix. The socio-economic domain scored the highest (83%) whilst the institutional domain scored the lowest (8.3%) and the ecological domain scored 25%, giving a total sustainability score of 38.8%. The results of this matrix show that at present the local fishery is non-sustainable and in need of greater management. By synthesizing papers dealing with and based on the concepts involved in Integrated Coastal Management, a structured approach is proposed to developing and implementing more holistic local coastal governance. It is envisaged that the framework to implement such an approach should be through the development of a local Coastal Management Plan and a subsidiary Bay Management Plan. Although stakeholder participation and representation is an essential component in the development of these plans, it is recommended that the local municipality should be the lead agent and incorporate the plans into the local Integrated Development and Spatial Plans thereby gaining long term local government support.

CHAPTER 1 - INTRODUCTION

Due to the growing demand and the ongoing overexploitation and degradation of coastal areas, fisheries and coastal management have been increasingly coming under the spot light (Jentoft *et al* 1998, Hauk & Sowman 2001), with numerous calls (Anderson 1987, Stephenson & Lane 1995) and support (Caddy 1999, Caddy & Cochrane 2001, Sinclair et al 2002) for a paradigm shift in resource management. The question has become not one of "do we need a change in management philosophy" but rather one of "what new approach to resource management is most appropriate"? For the current project which contributes to the development of a localised Bay Management Plan (BMP) for Plettenberg Bay there needs to be an awareness of new or current management trends occurring on both a global and local scale. Presently there are no other inclusive BMP's in existence within South Africa and as a result no management structure or "blue print" exists for the present project to follow. This necessitated the development of a framework within which to work, a framework based on, and in compliance with, the various management concepts currently being incorporated into both fisheries and coastal management. The following parts to this introduction therefore provide some background information on the various applicable management theories and helps to place the current project in context.

1.1 An overview of Ecosystem Based Management:

The search for improved management frameworks has led to a global shift towards the introduction and implementation of more holistic Ecosystem Based Management (EBM) approaches (Table 1.1). This broad terminology generally implies an approach that within ecologically meaningful boundaries simultaneously addresses and balances the diverse societal needs and desires with those requirements of the environment to ensure the ultimate goal of sustainability (Griffis & Kimball 1996, Heissenbuttel 1996, Pajak 2000) (Figure 1.1). Although EBM is being accepted as the way forward, application is still in its infancy with the international community still seeking precedents for how these ecosystem approaches should be implemented (Caddy & Cochrane 2001). This is largely due to the lack of clearly defined objectives (de la Mare in press) and the limits of our knowledge regarding complex ecological interactions (Reichman & Pulliam 1996). Various adaptive management approaches that embody the principles of EBM for conservation and fishery management, (Figure 1.1 & 1.2), are being explored and include:

- Large Marine Ecosystem management (LME),
- Integrated Coastal Management (ICM),
- Co-management,
- Ecosystems Approach to Fisheries (EAF) and
- Marine Protected Areas (MPAs),

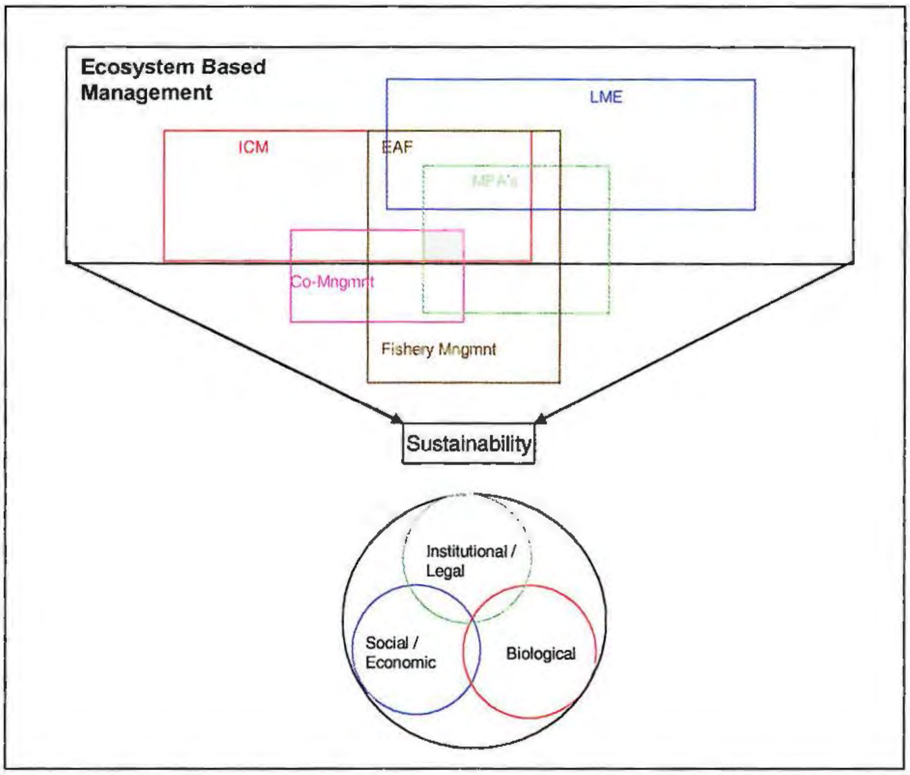


Figure 1.1: Diagram showing the various management options incorporating EBM principles aimed at achieving sustainability by addressing the three domains of Institutions, Biological and Socio/Economic (adapted from Caddy 1999 and Pajak 2000). The management options that have bearing on the current project, which deals with localized coastal fisheries are indicated by the shading. ICM = Integrated Coastal Management, LME = Large Marine Ecosystem management, EAF = Ecosystem Approach to Fisheries, MPAs = Marine Protected Areas

Table 1.1: Principles of Ecosystem based management and the Ecosystems Approach to Fisheries.

Principles of the Ecosystem Approach (Convention on Biological Diversity 1993)
1: Objectives of Management are a matter of societal choice.
2: Management should be decentralized to the lowest appropriate level.
3: Ecosystem managers should consider the effects of their activities on adjacent and other ecosystems.
4: Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management program should: a) Reduce those market distortions that adversely affect biological diversity b) Align incentives to promote biodiversity conservation and sustainable use c) Internalise costs and benefits in the given ecosystem to the extent feasible
5: Prioritise conservation of ecosystem structure and functioning to maintain ecosystem services.
6: Managed within limit of functioning.
7: Undertaken at the appropriate spatial and temporal scales.
8: Objectives set for long term, varying temporal scales and lag-effects recognised.
9: Recognise change is inevitable.
10: Seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11: Should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12: Should involve all relevant sectors of society and scientific disciplines.
Principles of the EAF (FAO 2003)
1: Natural resources should not be allowed to decrease below their level of maximum productivity.
2: Fisheries should be managed to minimize their impact on the ecosystem.
3: Ecological relationships between harvested, dependent and associated species should be maintained.
4: Management measures should be compatible across the entire distribution of the resource (across jurisdictions and management plans).
5: Because the knowledge on ecosystems is incomplete, the precautionary approach should be taken.
6: Governance should ensure both human and ecosystem well-being and equity.

1.1.1 Large Marine Ecosystems and Integrated Coastal Management

Although both LME management and ICM embody the principals of EBM, there are some fundamental differences. LME's are more science driven with a focus on understanding how large-scale discrete ecosystems function from an ecological perspective whereas ICM efforts are primarily issue-driven with a focus on governance processes and people management (Griffis & Kimball 1996). This is largely a result of the coastal zone area being more complex in terms of activities, institutions and numbers of role players that need to be involved in the management process.

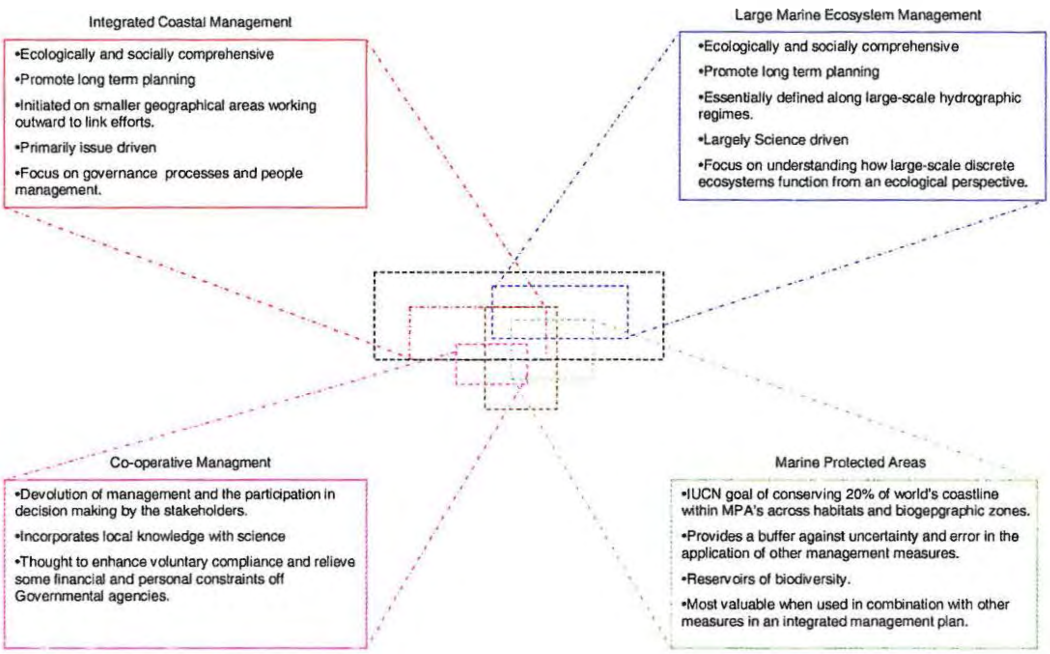


Figure 1.2: Key components of the various management approaches that can be used to achieve EBM.

The ICM process provides the mechanism for negotiating acceptable levels of use amongst the various stakeholders, facilitating changes from resource-use maximisation in one dimension to resource-use optimisation and balancing between several dimensions. In other words, the balancing of interests through wise, informed choices and tradeoffs. It is a system which brings together the multiple resource users and factors their effects on each other and also the combined effect on the environment in order to optimise social and economic benefits whilst maintaining the environment and its processes by reducing the impacts (Masalu 2000, Olson 2003). This requires greater knowledge, understanding and involvement of the social and political forces shaping the behaviour of the resource users. It is by now well known and accepted that management is not only about managing the resource base but rather the ability to manage and influence the resource users (Caddy & Cochrane 2001, Sinclair et al 2002). One method to achieve this, which is gaining recognition as potentially more effective than the traditional centralised top-down, authoritarian command and control style of management, is cooperative or co-management (Pomeroy 1999).

1.1.2 Co-management

Co-management refers to a more devolved, holistic, ecosystems approach to resource management that includes the participation of the various resource users or stakeholders in the overall decision making and management of those resources (Jentoft *et al* 1998, Hauk & Sowman 2001, Caddy & Cochrane 2001, Wittmer & Birner 2001). Motivation for this shift in resource management comes from three fundamental factors: firstly by incorporating knowledge gained from social and biological sciences with traditional and local knowledge gained over time, more effective and relevant solutions to management issues may be reached. Secondly, stakeholder involvement in the regulatory decision making process may enhance acceptance and compliance (Jentoft *et al*, 1998) and thirdly governmental agencies often face limited financial, personal and equipment facilities to adequately monitor and enforce standing regulations (FAO 1982).

It may be argued that due to changes in fisheries technology, increased human populations and the erosion of particular cultural practises and values required for the long term sustainability of co-management initiatives, it may not be possible to re-instate traditional systems of self-management. Sowman (1993) and Hutton & Pitcher (1998) identified the imbalance of capacity between potential partners and the lack of organization amongst user groups as a limitation in the implementation of co-management initiatives in South Africa.

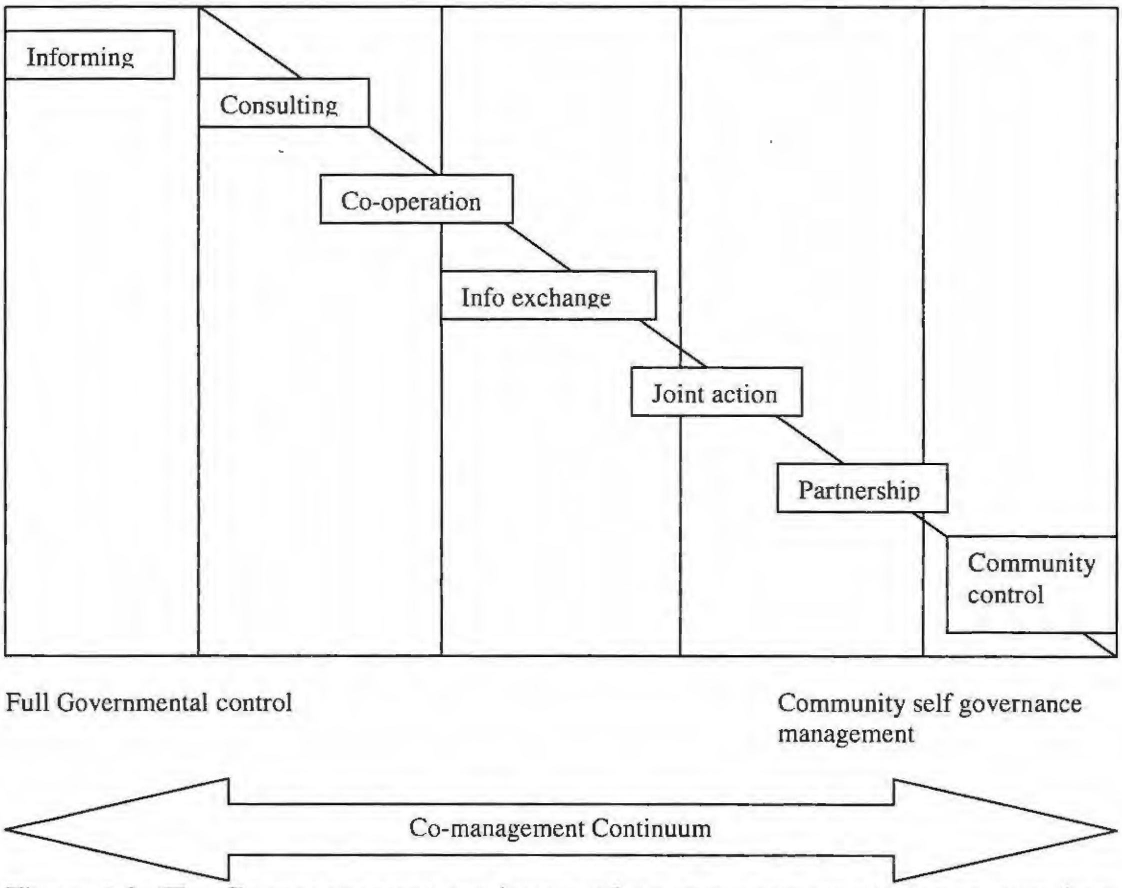


Figure 1.3: The Co-management continuum where management structures vary from users being merely consulted with regard to regulation formation to users becoming actively involved in the design, implementation and enforcement of regulations (adapted from Pomeroy and Berkes 1997).

However as shown in Figure 1.3, co-management does not necessarily mean total control of resource management by communities. Instead depending on the characteristics of the various stakeholders involved and the physical and technical attributes of the resource being managed, co-management initiatives may fall along a continuum between pure state control at one end and pure stakeholder based control at the other (Pomeroy 1999, Pomeroy & Berkes 1997, Wittmer & Birner 2001). By firstly building coastal partnerships between the stakeholders, various spheres of government, coastal communities and the general public and secondly by devolving management to include local stakeholders in decision making, ICM can be seen to fit in with the co-management continuum. The extent to how far along the continuum it falls will again depend on the cultural, economic and political environment of the program and the length of time a local ICM initiative has been running and the success it has been showing (McCleave *et al* 2003).

1.1.3 South Africa in Context

Co-management in South Africa is still in its infancy, as is evident in Table 1.2, with most co-management projects being initiated and implemented in the last ten years (Hauck and Sowman 2001). Although this makes it difficult to evaluate under what conditions co-management is likely to succeed, a set of conditions central to achieving the success of co-management arrangements in South Africa has been identified (Hauck and Sowman 2001, Hutton and Pitcher 1998). Given the history of inequality in South Africa, where a large number of South Africans were denied access to and ownership of coastal resources, a fundamental first step is the allocation and security of access rights to resources. Not only does this address the issue of equitable access within the White Paper for Sustainable Coastal Development (2000), hereafter referred to as the White Paper, but also gives the resource users a sense of ownership over the resources which in turn provides incentive for users to manage the resources sustainably (Jentoft 2000). Secondly there is a need for long-term government support and commitment to co-management efforts. There is an apparent unwillingness on the part of government agencies to devolve power to local levels because of their scepticism that other levels of governance can accept responsibility and be accountable for management of local resources (Hutton and Pitcher 1998). Establishing local organisations with legitimate representation that government agencies will recognise will therefore be a significant challenge in facilitating meaningful partnerships (Hutton and Pitcher 1998). Consequently, empowerment and capacity building of communities will be an essential step to ensuring greater and more meaningful participation in the decision-making process.

Table 1.2: An overview of co-management initiatives in South Africa (from Hauck and Sowman 2001)

Project	**Co-mgmt sector**	**Stage of co-mgmt**	**Type of co-mgmt**	**Scale**	**Resources involved**	**Timeframe**
Amadiba Tourism	Tourism	Planning	Supportive	Local	Cultural & senic; (intertidal)	2 years
Industry-Government	Fisheries (commercial)	Implemented	Consultative	National	Hake fishery	20-25 years
KEN Tourism	Tourism	Collapsed		Local	Cultural & senic; (fish)	5 years
Kleinmond Inshore fishery	Fisheries (Artisanal)	Terminated	Consultative	Local	Inshore fish	1 year
Kosi bay Gillnetting	Fisheries (subs)	Implementation	Co-operative	Local	Fish	7 years
Olifants River Gillnetting	Fisheries (subsistence)	Implementation	Co-operative while operating	Local	Fish	6 years
Pondoland Forestry	Coastal forestry	Pre-Planning		Local	Medicinal plants, trees, grasses	3 months
St. Helena Seaweed	Mariculture	Planning	Advisory	Local	Seaweed	2 years
St. Lucia Gillnetting	Fisheries (subsistence/artisanal)	Terminated	Consultative	Local	Fish	6 years
Sokhulu Mussel	Fisheries (subsistence)	Implementation	Co-operative	Local	Inshore mussels	5 years

One of the themes within the White Paper is not only the need for integration amongst coastal management efforts and a corresponding increase in the capacity building of all spheres of government (Glavovic 2000a), but is also one aimed at creating proactive and meaningful partnerships between government, civil society, non governmental organisations (NGOs) and the private sector (Public Private Partnerships – PPP's). Roman & Azucena (2001) state that one of the key elements of success in environmental governance aimed at sustaining economic, social and ecological development, especially at the local government level, is the creation of such partnerships thereby combining the strengths of government, the private sector and civil society groups. The private sector's interest in maintaining the integrity of coastal systems and in co-operating with other stakeholders in the endeavour to promote sustainable coastal development is central to the continuous flow of goods and services that sustain this sector (Glavovic 2000a). Both Sowman (1993) and Hutton & Pitcher (1998) conclude that although co-management initiatives may have initial costs and require long-term government commitment, greater user participation in management will play a key role in future coastal and fisheries management. In summary, increased emphasis is being placed on promoting sustainable use, decreasing unemployment whilst increasing equity, economic efficiency, stability and user participation in management (Hutton *et al* 1997).

In an overview of the status of coastal zone management (CZM) in South Africa, Sowman (1993) highlighted that the absence of a policy framework to guide CZM efforts and the lack of supporting legislation and appropriate administrative structures for its implementation, were impeding the implementation of comprehensive CZM systems in South Africa. However we are seeing, from the outcome of various International Conventions and through the socio-political environment in South Africa with its dispensation towards participatory democracy, a greater provision and call for more holistic management with some form of user participation. The ability to embrace concepts like co-management within a coastal and fisheries context is now being provided.

1.1.4 Legislation pertaining to coastal resource management

Over the last two decades there have been progressive and substantial changes in international agreements, mandates and treaties with regards to fisheries and environmental management (Table 1.3). Under the influence of these international agreements and the political transition in South Africa, from an authoritarian system of government to a multiparty participatory democracy, a number of national policies and legislative documents have been formulated to regulate and guide the management and use of natural resources in South Africa, including fisheries and the coastal sectors (Hutton & Pitcher 1998, Hauck & Sowman 2001, Mayekiso *et al* 2001, van Stittert 2003) (Table 1.4). Figure 1.4 shows the progression and relationships between these international agreements and the cascading effect they have had to help shape the suite of environmental legislation that exists in South Africa.

A number of conventions, to which South Africa is party, call for the designation of MPAs. The World Conservation Union (IUCN) in 1992 proposed a goal of conserving 20% of the world's coastline through a network of MPAs covering a range of biogeographical zones. This is being regarded as a central component of precautionary fishery management (Clark 1996). MPAs have been widely advocated as a tool for conservation and fisheries managers to maintain or restore regional biodiversity and ecosystem processes (Done & Reichelt 1998). Numerous studies have shown the benefit of MPAs for the protection of targeted fish species (Bennett & Attwood 1991, Buxton 1993, Cowley *et al* 2002) and the subsequent ability to sustain adjacent fisheries through the net exportation of larvae, juveniles and adults (Attwood *et al* 1997, Maypa *et al* 2004). It has however been cautioned that MPAs alone may not guarantee the long-term persistence of targeted species and that they should be used in combination with other management measures as part of an adaptive management scheme (Sumaila *et al* 2000).

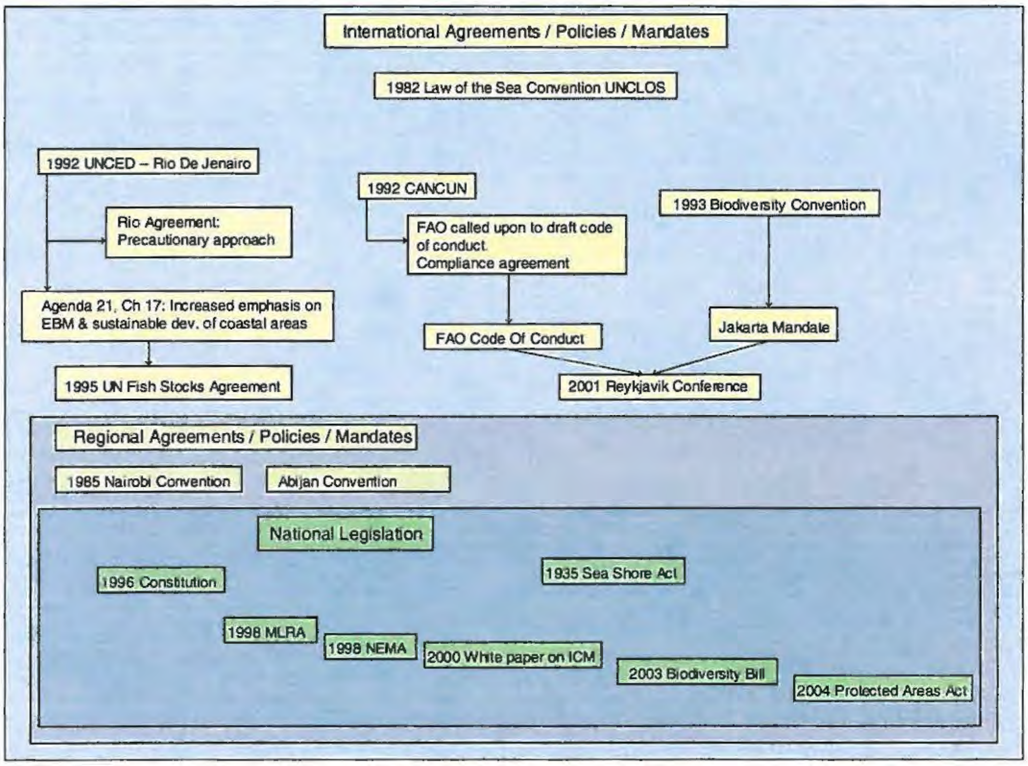


Figure 1.4: The suite of Key International, Regional Policies / Mandates and Agreements that have shaped the suite of environmental laws South Africa has today.

Table 1.3: Key International Conventions that helped shape South Africa's Marine Environmental Legislation. Overall emphasis has moved from a priority on single species or targeted species protection to a broadening of conservation objectives to include a more holistic ecosystems approach with habitat and biodiversity protection being highlighted.

Key International Conventions / Mandates & Treaties	Description
1982 Law of the Sea Convention UNCLOS	Provided for the first time, a universal legal framework for the rational management of marine resources and their conservation for future generations and included the provision for a 200 mile exclusive economic zone (EEZ)
1992 United Nations Conference on Environment and Development (UNCED): Rio Declaration	A set of 27 principles on the environment and development, designed to promote international cooperation for sustainable development.
1992 United Nations Conference on Environment and Development (UNCED): Agenda 21	Of importance to fisheries management is Chapter 17, which identifies the importance of the marine environment, describing it as "an essential component of the global life-support system and a positive asset that presents opportunities for sustainable development." It outlines certain programme areas that include integrated management and sustainable development of coastal areas, including EEZs, sustainable use and conservation of marine living resources of the high seas and strengthening international, including regional, co-operation and coordination.
1992 CANCUN Declaration	Although not the first forum to discuss the notion of responsible fishing, it was the first to do so at the global level. One of the main aspects of the Declaration was that it called upon the FAO to draft, in consultation with relevant international organizations, an international Code of Conduct for Responsible Fishing, taking into account the Declaration.
1993 United Nations Convention on Biological Diversity	The convention recognized the importance of biological diversity, acknowledging that "conservation and sustainable use of biological diversity is of critical importance for meeting the food, health and other needs of the growing world population.
1995 Jakarta Mandate	Outlined an action program for implementation of the Convention on Biological Diversity with respect to marine and coastal biodiversity.
1995 FAO Code of Conduct	The Code of Conduct consists of a collection of principles, goals and elements of action. It represents a global consensus or agreement on a wide range of fisheries and aquaculture issues
2001 Reykjavik Conference	Addressed steps on how to introduce ecosystem-based approaches in to the mainstream of fisheries management thereby acting on the Jakarta Mandate and the FAO Code of Conduct
1995 United Nations Fish Stocks Agreement	Primarily address the management of straddling and highly migratory stocks. It calls for the greater protection of the marine environment in general through the use of the precautionary principle, the protection of habitats of special concern and the use of selective fishing gear to minimise by-catch.
Key Regional Conventions	**Description**
1981 Convention on the Protection, Management and development of the Marine and Coastal environment of the West and Central African region (Abidjan Convention)	Broad objectives included the development, protection and standardized management of the coastal and marine environment in the West and Central African region.
1985 Convention on the Protection, Management and development of the Marine and Coastal environment of the East African region (Nairobi Convention)	Broad objectives included the development, protection and standardized management of the coastal and marine environment in the East African region.

Table 1.4: National Key Legislation Relevant to Coastal Management (including estuaries)

Key Legislation	Description
The Constitution Act 108 of 1996	Is the supreme law of the land. It emphasises cooperative governance and provides the legal basis for allocating powers to different spheres of government. The Environmental Right provides that: "Everyone has the right: a) to an environment that is not harmful to their health or well-being; and b) to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that – i. prevent pollution and ecological degradation; ii. promote conservation; and iii. secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."
Sea Shore Act 21 of 1935	States that the State President has custodianship over the sea and seashore. Thereby the control of development, pollution and waste management is the responsibility of the State.
Marine Living Resources Act 18 of 1998	Aims at increasing the socio-economic benefits to coastal communities through the guiding principles of equity, sustainability and stability. It highlights the need to protect whole systems thereby conserving biodiversity and maintaining the populations of all species at levels consistent with their respective roles in the ecosystem. Advocates the precautionary approach in cases where little information is available.
National Environmental Management Act 107 of 1998	Establishes principles for decision making on matters affecting the environment, institutions that will promote cooperative governance, and procedures for coordinating environmental functions by organs of state.
White Paper For Sustainable Coastal Development for SA 2000	Promotes a people-centred approach to coastal development maximising opportunities for economic and social development through the maintenance of an ecologically sound ecosystem. The white paper sets out a vision, a number of principles and goals for coastal management.
Biodiversity Bill of 2004	Provides for: the management and conservation of the biological diversity of South Africa, the sustainable use of our biological resources and, the fair and equitable sharing of benefits arising out from the use and application of genetic resources and material.
Protected Areas Act of 2004	Provides for the declaration and management of different types of protected areas in South Africa.
The National Water Act (No 36 of 1998)	Provides a framework for management of quality and quantity of water resources in South Africa – estuarine related

South African environmental management has in the past been dominated by a centralised, top-down command and control style with central government, through the Department of Environmental Affairs and Tourism (DEAT), which played a major role in assuming responsibility for management of marine resources. South African fisheries have been managed through two broad forms of control: i) – the management of catch through limits such as daily bag limits, size restriction, catch quota and gear restriction, and ii) – management of effort through limited entry, closed areas and closed seasons. Although government has in the past established scientific working groups to determine the scientific bases for management decisions, and formally recognised various industrial and interest groups, which facilitated consultation and the exchange of information, the direct inclusion of other types of user groups such as fishing communities in resource management was until recently never attempted (Hutton & Pitcher 1998). Although a framework for creating sustainable coastal development protocols at the local level is being provided, these regional and local ICM programs must respond to and provide benefit to their own stakeholders. In other words, under the guidance of the overarching national policies, ICM programs should be adapted and modified to best suit the local conditions and requirements of the social, economic and ecological coastal domains. It must be context specific.

Table 1.5: Provincial and local Policies Relevant to Coastal Management (including estuaries)

Policies	Description
Provincial	
Coastal Management Plan (CMP)	Used as a practical guide to conduct well co-ordinated and integrated coastal zone management. More specific and takes into account distinctive qualities of each province.
Local	
Integrated Development Plan (IDP)	Local plan and policy guideline to guide the implementation of the National and Provincial policies and objectives.

At a provincial level, specifically for the Western Cape, the Department of Environmental Affairs and Development Planning of the Western Cape (DEA&DP) deals primarily with the planning, management and use of coastal natural resources (WCCMP 2003). With the Western Cape Nature Conservation Board (WCNCB) assisting by promoting and ensuring nature conservation and related matters in the province. Each province is also required by the new Coastal Zone Bill to produce a Provincial Coastal Management Plan (PCMP) (Table 1.5). The PCMP aims to present a strategy for both the public and private sectors to create opportunities to not only sustain, but also to enhance livelihoods and to build institutional capacity and raise awareness of the value of the coast. Key benefits of the application of coastal management programmes will be improved planning and allocation of coastal resources and better targeted investment from government and non-government organizations to support sustainable coastal development (WCCMP 2003).

Local authorities in South Africa are, according to the Local Government Municipals Systems Act (Act No. 32 of 2000), legally bound to compile Integrated Development Plans (IDP) for their areas of jurisdiction (Table 1.5). The responsibilities of local government, where capacity exists, are building regulations, local tourism, municipal planning and beaches (Glavovic 2000a). However most of the smaller local municipalities in rural areas lack the resources and capacity to implement these responsibilities. In an attempt to boost their capacity, some local authorities cooperate with nature conservation agencies and are involved in co-management initiatives with community-based organisations and non-governmental organisations. These organisations play a valuable role in a range of coastal management activities including monitoring, research, education and training. Figure 1.5 highlights how local municipal coastal management plans should be formulated under the overarching provincial and national directives with input from various stakeholders through public private partnerships.

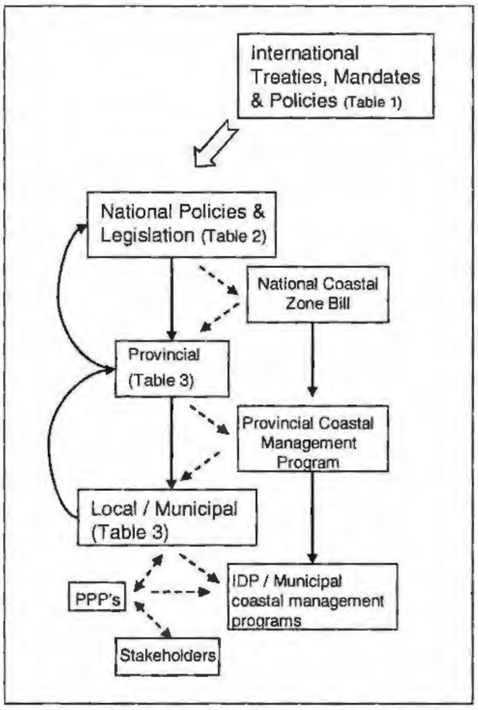


Figure 1.5. The hierarchical cascade governing environmental management in South Africa with the relevant legislation and management programs guiding coastal management at each level.

1.1.5 Rapid Assessments and Indicators

The development of more ecologically and socially inclusive management strategies requires extensive information on the social and economic structuring forces affecting the resource users and on the status of the environment and the fishery itself (Castro 2001, Cochrane 2002, Die 2002). However, in many coastal areas worldwide there is a lack of scientific information on inshore environments and fisheries, as well as a lack of technical expertise and funding to assess the state of the environment and fisheries (Zann 1999). Consequently simple and rapid, but scientifically robust techniques have been developed for assessing resources and/or activities, known as rapid appraisal techniques (Pido *et al.* 1997, Zann 1999). This approach was first introduced in 1978 in a workshop held in the United Kingdom to assess rural development (RRA) (Chambers 1980 cited in Pido *et al.* 1997). Since then it has evolved to encompass a set of techniques or procedures for the quick study of land based resources and/or activities such as agriculture, health and forestry (Pido *et al.* 1997). Due to the complexity of coastal environments, rapid assessment methods specific to the aquatic environment and in particular to fisheries, are only just emerging. These include, amongst a number of other approaches the rapid appraisal of coastal environments (RACE) (Pido and Chau 1992), rapid appraisal of fishery management systems (RAFMS) (Pido *et al.* 1997), rapid appraisal of marine environments to prioritise areas for conservation and management (RAP) (Anon. 2000) and the Rapfish evaluation of fisheries sustainability status (Pitcher and Preikshot 2001).

Alongside the requirement of initial rapid assessments is the need to be able to meaningfully summarise primary data into more manageable and easily interpretable formats. Indicators are becoming an increasingly important feature of the EBM approach and are being used to assess current conditions, simplify and communicate information and monitor progress toward ecological, social and institutional goals of sustainability (Pajak 2000). By simplifying the data, indicators provide a means for any interested party to track progress towards achieving sustainable development within a sector (e.g. fishing) or across sectors (Garcia & Staples 2000). Despite widespread adoption of the general goal of sustainability and EBM approaches, most decision-makers still lack an operational framework with which to assess sustainability (Pajak 2000). By utilizing key indicators that provide an indication of the "state" of each environmental domain within a Rapid Assessment Matrix those areas that receive the highest ranking according to the decision matrix, and thus largely responsible for unsustainable practices, will be revealed for local communities and managing authorities to focus their efforts (Pajak 2000, Wood *et al* 2004).

From the various management concepts discussed in this section a few patterns and trends can be distinguished. Firstly, management is moving away from the single species approach to looking at systems as a whole and managing on an ecosystem level. With this there is an increase in the involvement of people at a grass roots level (various stakeholders) through a more decentralised, enabling, participatory and integrated approach as opposed to the past traditional governmental command and control style. However, two major impediments have been identified in the development of a local BMP. The first being the absence of a developmental framework and poor institutional capacity, the second being the lack of scientifically sound information on which to base management decisions. In lieu of this, two interlinked projects were set up to: (i) gather scientifically sound information on the local fishery resources and their users and (ii) develop a set of indicators from this information that can be used within an assessment matrix relating to fishery management as a component of the overall BMP. With an academic institution providing guidance the projects were initiated and funded by the local Ocean Research Conservation Africa (ORCA) Foundation whose aim is "to create in partnership with the community, a conservation model in Plettenberg Bay to sustain marine and coastal resources through improved management, research and education" (ORCA 2003). The approach taken and the relation of this information to the overall Bay Management Plan is shown in Figure 1.6. Due to the similarity in the overall aims of the two projects, their relation to the overriding management plan, the pre-requisite for the same background information and the same ending point the introductory, indicator and final chapter have been co-written with the same methodology used in the development of local fishery indicators.

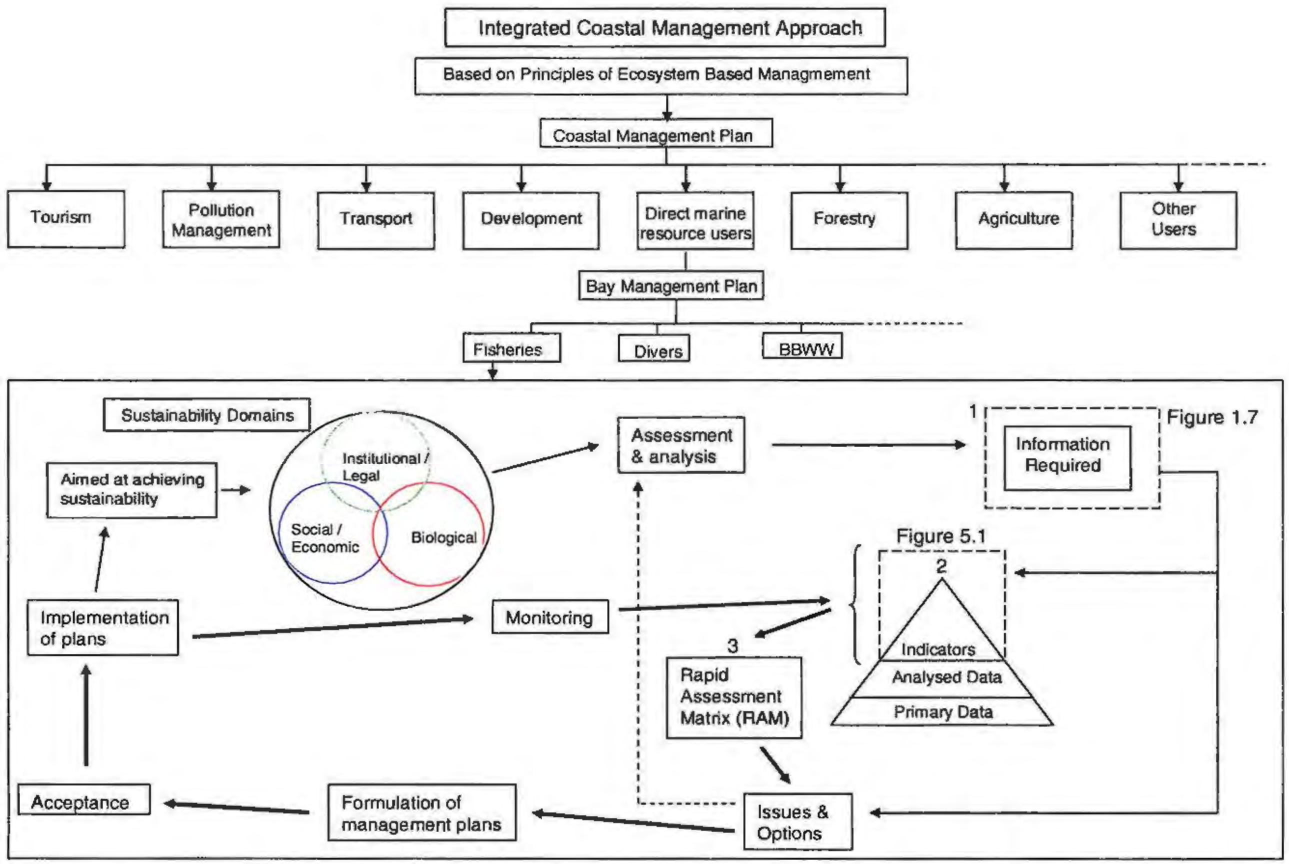


Figure 1.6: Flow diagram showing the manner in which data acquisition, indicators and rapid assessments relate within the fisheries sector, as one sector to be incorporated in a more ecologically and socially comprehensive ICM approach to local coastal governance in Plettenberg Bay. BBWW = boat based whale watching.
1: Baseline assessments on the respective linefisheries.
2: Indicator pyramid: indicators representing specific issues are identified from the analysed primary data (Chapter 5) (adapted from FAO 1998).
3: The indicators can be scored in a rapid assessment matrix to highlight areas of concern and management adapted accordingly. Once the indicators have been accepted they would then be used as a rapid appraisal in a monitoring program. Should they highlight potential issues greater information may be required (dashed arrow).

1.2 Background on Plettenberg Bay:

Plettenberg Bay is a popular coastal town situated along the Garden Route on the Southern Cape coast with an estimated population of 72000 people. However the town experiences huge tourist influxes during Easter and December holiday periods with an expected 35000 and 65000 visitors respectively (Niewoudt 2003 pers coms). Resource use varies from non-consumptive commercial and recreational activities through to consumptive recreational and commercial fishing (Table 1.6).

Table 1.6: Activities directly linked to the marine resource use in Plettenberg Bay include recreational and commercial ventures with both consumptive and non-consumptive facets.

	Consumptive	Non-consumptive
Recreational	Ski-boat fishing Spearing Rock & Surf fishing Estuarine fishing – boat & shore Bait collecting	Jetski Pleasure boating Yachting Surfing Kayaking Swimming
Commercial	Hake Deck Boats Hake Ski-boats Fishing Charters	Boat based whale watching Kayaking Scuba diving

During the project duration the local commercial fisheries included a diminishing number of ski-boat operators, two hake longline quota holders and 18 to 20 operational handline deck boats that target shallow water hake, *Merluccius capensis*. The Bay has an active ski-boat club with few resident fishers and a greater number of holiday members who go fishing on the local reefs between Keurbooms and the Bloukraans Bridge. There are two recreational fishing charter companies that operate regularly in the bay, however during the holiday season the number of "charter" boats increases as some of the commercial ski-boat operators market recreational fishing charters. Spearfishing is not a popular sport amongst either locals or visitors, although spearfishing competitions have been held in the bay during the past

(Niewoudt 2003). Non-consumptive commercial use of the bay at present comprises three Boat Based Whale Watching companies and two Scuba Diving centers.

Aided by the high biodiversity and natural scenic beauty of this region, the town has grown into one of South Africa's most popular up-market holiday destinations for both national and international tourists. Becke (2003) estimated that about 950 000 tourists visited Plettenberg Bay in 2002 with 65% of these visitors being domestic and 35% international (le Roux 2002). As a result of the towns popularity as a holiday destination, the local economy has been shaped into one largely reliant on this tourism for its sustainability and it is estimated that tourism contributes R200 million per annum to the local economy (Becke 2003). This centering of the local economic activity around tourism and holiday related activities has inherently lead to an economy that has marked seasonal influxes or variations, co-inciding with the regular tourist season peaks, specifically around Easter and the Christmas holidays. In addition to the seasonal nature of tourism related jobs, historically disadvantaged individuals face limited access to the resources that contribute to the economic success of the region (Glavovic 2000a). Although other economic sectors such as construction and local fisheries exist it has been highlighted that the towns activities need to be further diversified to ensure employment between seasons with light manufacturing linked to tourism being mooted as a way to generate sustained economic activity (BDM consulting 1997). In the white paper for the sustainable coastal development in South Africa (2000) it was stated that there is an urgent need for effective management of the natural resource base within the Garden Route, while at the same time creating jobs, dealing with urbanisation and developing the tourism potential.

Plettenberg Bay's reliance on tourism to sustain the local economy in turn depends heavily on the coastal goods and services that are responsible for the initial attraction of the tourists. The continued ability for the coastal environment to provide these goods and services ultimately depends on our ability to sustainably manage these assets to ensure the continued productivity of the area. In other words, not only do the benefits enjoyed by the coastal population, and those that temporarily visit, depend on the maintenance of a healthy productive coast but so do future opportunities for social and economic development. A recent report on public preference toward the provision of local coastal management services in Plettenberg Bay (Mollatt 2003) showed that:

1) The Bay has in the past been undervalued as a coastal asset.
2) The majority of respondents from the three sample population groups (local residents, domestic tourists and international tourists), were in favour of a Bay Management Plan and
3) An additional value of between R 15 397 900 – R 20 330 500 was placed on the Bay. This value could be obtained through local surcharges levied at property rates and accommodation in order to provide funding for a Bay Management Plan.

The results of the study completed by Mollatt (2003) not only highlights the value of the Bay as a natural resource but more importantly showed the desire or willingness amongst residents and tourists for the implementation of a localised BMP. With this initial interest it is therefore more likely that the local community will invest into the process and become an integral part in the development, monitoring and re-evaluation phases of the management plan. As previously mentioned, the management plan needs to be based on relevant information concerning the three domains of sustainability. Within Plettenberg Bay there is a lack of this information and the present project was designed to bridge part of this gap in relation to the local nearshore fisheries.

The aim of the current project was therefore to gather baseline information on offshore resource use and reef status within Plettenberg Bay. From this information, indicators were developed to rapidly assess sustainability and highlight areas of concern to be targeted within a BMP. The components dealt with in this project are highlighted on the flow diagram in Figure 1.7. The project was split into two key research areas that were dealt with separately with different sampling methodologies but ran in conjunction with each other. One aspect of the project (Figure 1.7 block A), dealt with resource use (total effort, total catch, CPUE) whilst the second aspect of the project involved a rapid assessment of the reef fish resource by comparing the community structure found on a utilised reef within the Bay to a non-utilised reef within a marine protected area (Figure 1.7, block B). Once this initial data had been collected and analysed, key indicators were developed that could be used in a rapid assessment matrix to indicate "levels" of sustainability. The values obtained from the chosen indicators were scored via a set of reference points or pre-determined criteria on a scale from 0 to 4 representing a state from very poor to good. These scores were placed within a RAM and the scores for each domain summed highlighting sustainability problem areas (Figure 1.7, block C).

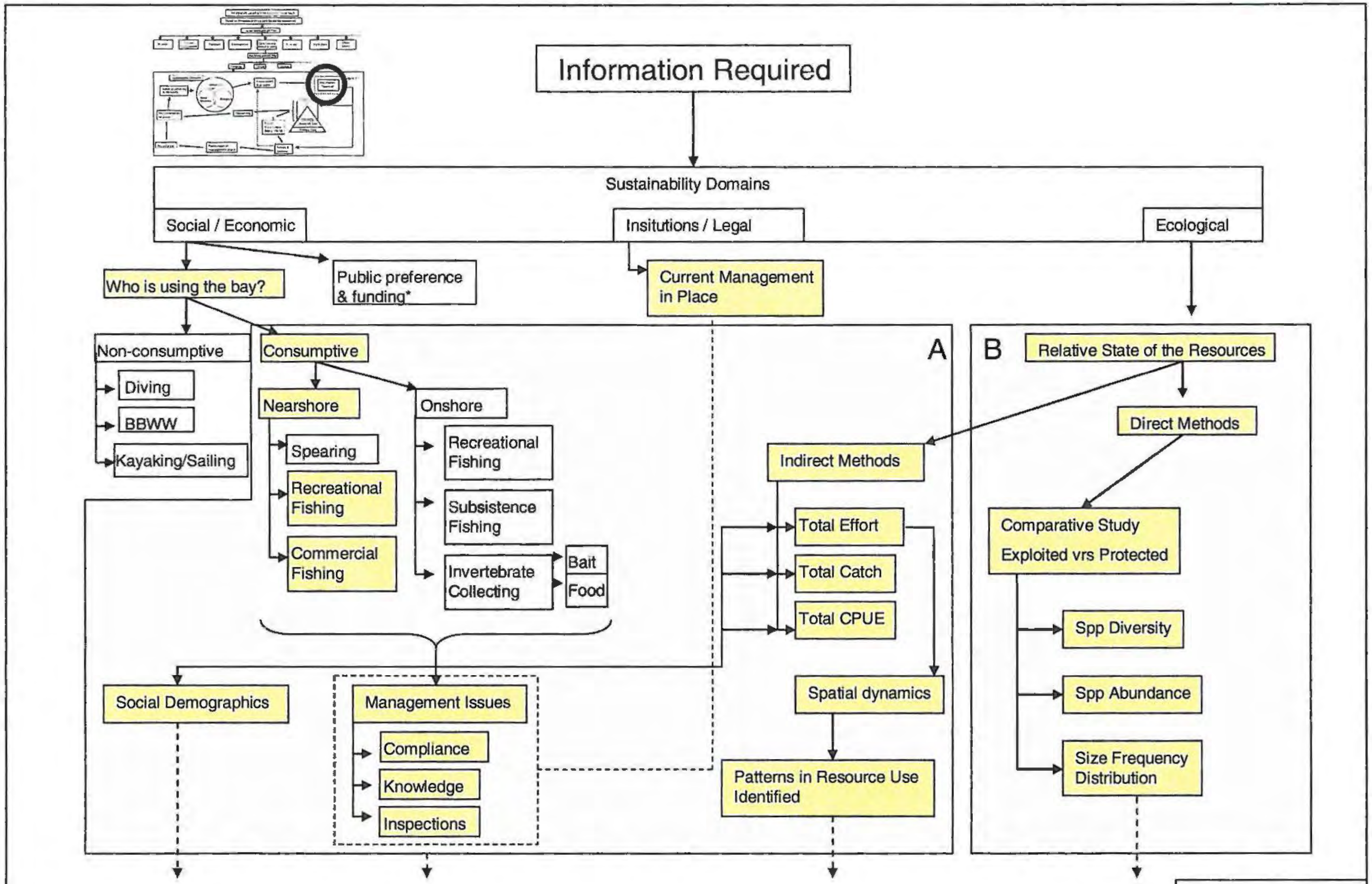
The specific objectives of the project were:

1 – Quantify nearshore resource use (Catch & Effort).

2 – Rapid assessment of the reef fish community assemblage and population structure.

3 – Develop sustainability indicators and provide management recommendations based on the results of a Rapid Assessment Matrix.

4 – Develop a management implementation protocol for Plettenberg Bay based on Integrated Coastal Management concepts.



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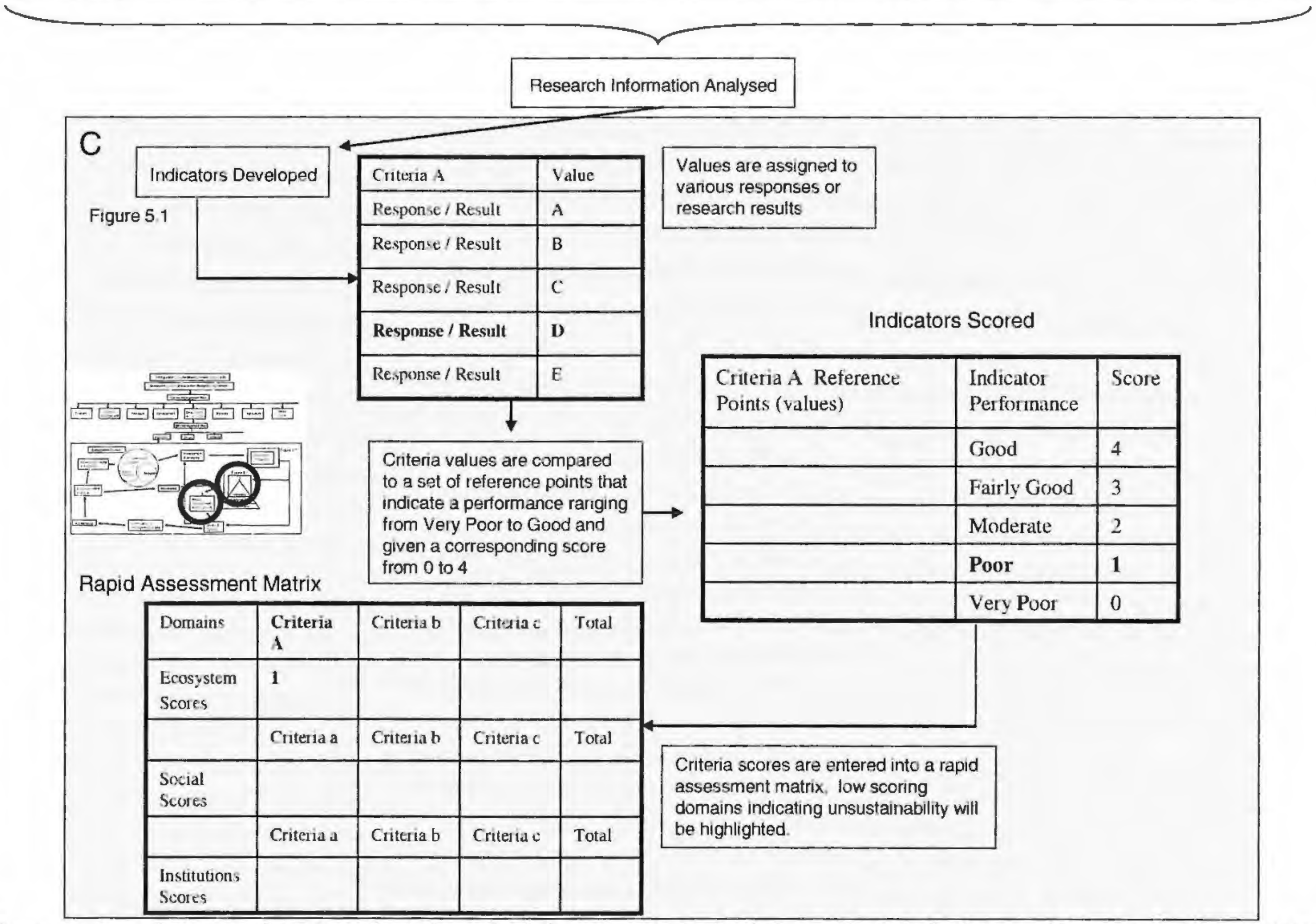


Figure 1.7: The components where research has been directed to gather information and develop indicators for inclusion into a rapid assessment matrix to highlight non-sustainability within the three environmental domains. BBWW = Boat Based Whale Watching. The insert s show the positions this information fills within Figure 1.6. *Results from a separate Economic study (Mollatt 2003).

CHAPTER 2 – STUDY AREA AND OVERVIEW OF METHODS

2.1 STUDY AREA

Plettenberg Bay, (hereafter referred to as the Bay), is situated along the Garden Route of the Southern Cape Coast (Fig 2.1).

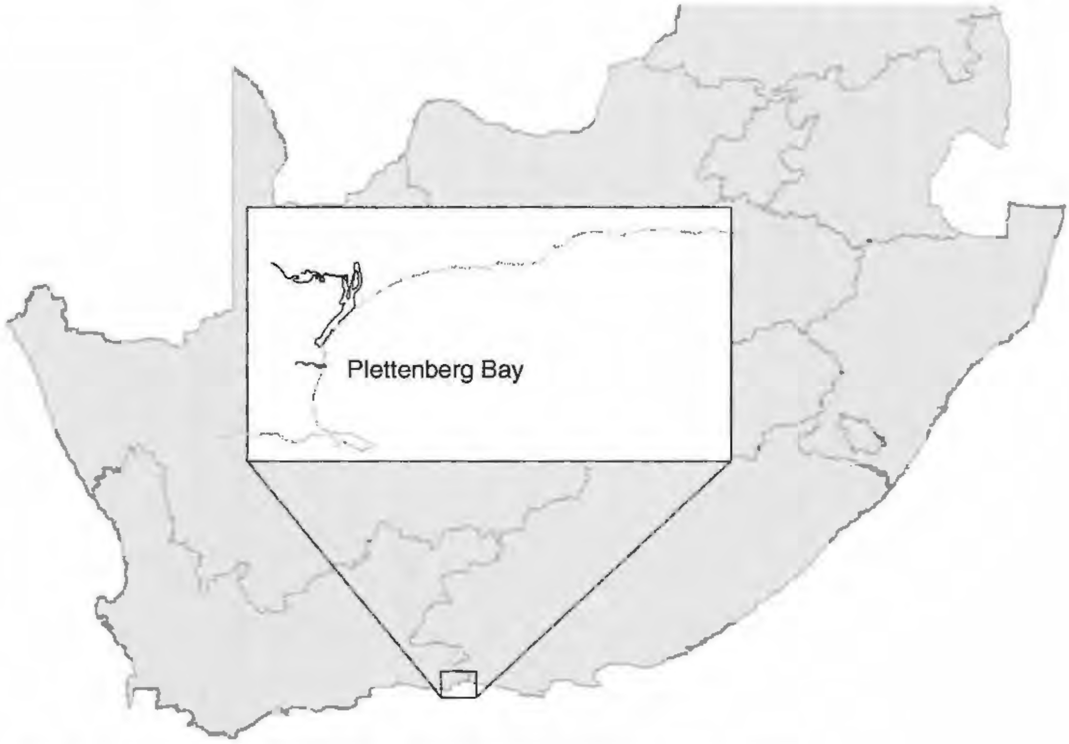


Figure 2.1. Map of South Africa showing the general study area.

The Bay itself is a classic half-heart bay bounded on the South-western side by a rocky headland, the Robberg Peninsula. A series of short, sandy beaches broken by rocky outcrops occurs along the bay up to Keurboomstrand, where the rocky outcrops become dominant towards Nature's Valley at the far eastern side of the bay. Four estuaries are present, namely the Keurbooms estuary which is formed by the confluence of the Bitou and Keurbooms rivers, the Piesang estuary, the Sout River estuary and the Groot River estuary (CSIR 1984). For the purpose of this study the "Bay" is defined as the area inshore from a line taken from Robberg Point across to the beginning of the Tsitsikamma National Park (TNP)(Fig 2.2). The TNP was proclaimed in 1964 and extends 0.8 km offshore between the Groot River mouth and the Bloukraans river mouth, where it's extended 5.6 km offshore and runs up to The Groot River in the Eastern Cape, a distance of 65.75 km (Hockey & Buxton 1989). The neighboring De Vasselot reserve was included in the National Park in 1987 and runs from the western corner of Natures Valley to Grootbank. The Butenverwachting Contractual Park to the west of Grootbank extends the Tsitsikamma National Park to Matjies River (Anonymous 2002). The Tsitsikamma coastline is dominated by high rocky cliffs intersected by steep ravines at the river mouths.

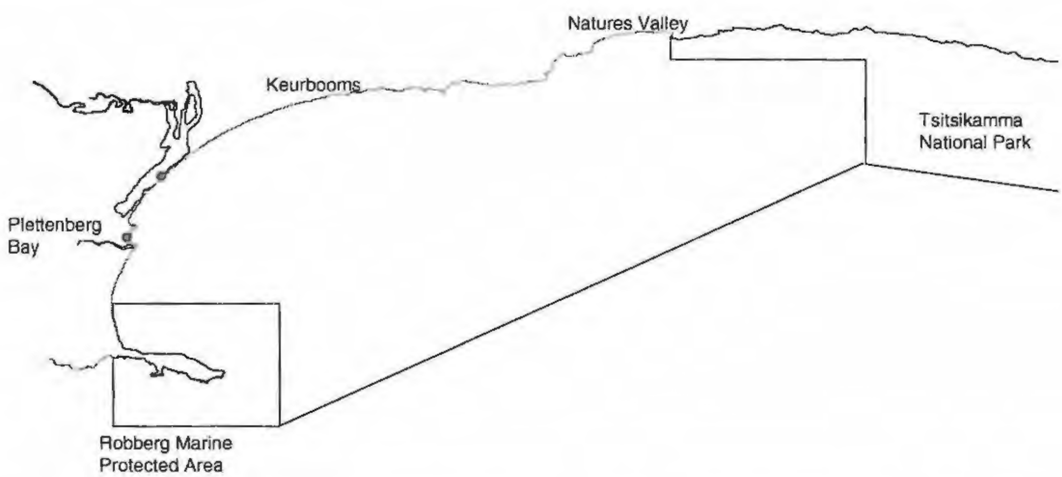


Figure 2.2. Map showing how for the purposes of this study the Bay has been defined as the area shorewards of the line drawn from the corner of the Robberg Marine Protected Area to the outer corner of the Tsitsikamma National Park. The two dots indicate the access points for boats entering the bay.

2.1.2 Oceanography

The following oceanographic description is a summary of the general region encompassing both Plettenberg Bay and the TNP. The major differences between the two areas is 1) A more gradual depth gradient within the Bay and 2) the decrease in swell, wave energy due to the protection afforded to the Bay by the Robberg Spit. No current data specific to Plettenberg Bay is currently available.

The most prominent oceanographic feature of the South, South East and Eastern Coast of South Africa is the Agulhus Current which flows along the continental shelf carrying warm tropical waters southwestwards (Beckley & van Ballegooyen 1992, Schumann 1998). The continental shelf is typically narrow along the eastern coast but moves offshore between East London and Port Elizabeth getting progressively wider towards the Agulhus Bank region (Beckley and van Ballegooyen 1992) thereby forcing the Agulhus current away from the coastline. Off Tsitsikamma the shelf edge lies roughly 100km offshore (Schumann and Beekman 1984 as cited by Hanekom *et al* 1989). Harris (1978 as cited by Schumann 1998) concluded that due to the lack of a dominant current on the continental shelf, wind induced near-shore currents would be more important than oceanic currents in this region. In 1996 Tilney *et al* showed that coastal-trapped waves were in fact the dominant physical process influencing currents within the Tsitsikamma National Park, but they also postulated that wind might play a more important role in the surface mixed layer. This was proven to be incorrect when in a later study using drougues Attwood *et al* (2002) found that wind and current direction were weakly correlated and concluded that overall local winds did not influence the direction of surface water movement in the TNP. Wind direction does however have an effect on sea temperature with seasonal wind induced upwelling occuring along the Cape South Coast (Schumann *et al* 1988, Hanekom *et al* 1989). These upwelling events are induced by easterly winds predominating during summer and are most intense at southern tips of capes (Schumann *et al* 1988). The mean seawater temperature of the region varies seasonally with a winter mean of between 16 – 17^0 C and a summer mean of between 20 and 21^0 C, although this can change by 10^0 C or more during upwelling events (Schumann *et al* 1988). The mean tidal height along the coastline ranges from 0.25 to 2m between the low and high spring tides.

2.2 METHODS

2.2.1 Linefishery

Surveys of resource users be they commercial or recreational, can be used to gather information regarding various aspects of a fishery that can then be incorporated into management policies or used to assess the impact of the management policy on the fishery performance (Cowx 2002). Two distinct alternatives to obtain this information can be used, including off-site recall methods such as mail and phone surveys and on-site intercept methods including roving creel and access point methods (Malvestuto 1983). When setting up a survey method one must take into account the advantages and biases of each approach (Table 2.1), the time period of the project, the manpower available, the key questions being asked and the degree of precision required in the information collected to answer these questions (Cowx 2002, Pollock *et al* 1994). In the present study two survey techniques were utilized, these being boat-based surveys and access-point surveys (APS).

Table 2.1: Advantages and disadvantages associated with various survey techniques (Adapted from Pollock et al 1994).

Approach	Examples	Advantages	Disadvantages
Off-site methods	Mail, phone surveys, log books	Low cost Regional coverage Immediate response (phone)	Non-response Recall bias Prestige bias Avidity
On-site methods	Roving creel Access point	Minimization of response bias Visual assessment of information exchange	High cost Biases based on survey design Interruption of angling experience

In situations where entry or exit to a fishery or water body is restricted, APS offer a number of advantages over other techniques. As opposed to roving creel surveys where interviews are conducted during the fishermen's trip, the access point interviews are conducted as the fishers exit after completing their fishing. This allows for direct calculations of catch and harvest and requires fewer assumptions in the interpretation of data collected (Cowx 2002, Pollock *et al* 1994). Importantly the interviews are conducted on site and immediately after the fishing trip, minimizing the biases that are associated with off-site surveys such as non-response and memory inaccuracies. Furthermore the harvest is inspected by a trained person thereby insuring accurate species identification and biological data recording (Pollock *et al* 1994). Traditionally this survey type has been used to estimate fishing effort, total catch, the days harvest and to gather data on various economic, social and angler attitude concerns (Pollock *et al* 1994).

Survey questionnaires used in this survey were based on the ski-boating questionnaire used by Brouwer (1997) during his assessment of the South African East Coast Linefishery. The survey was divided into various sectors which dealt with specific aspects (Appendix I). Section One gained information relating to the skipper including demographics. Section Two dealt with catch and effort including species targeted, bait used, fishing hours and areas of fishing. The skippers were asked to point out on a grid of the bay the areas they were fishing and the depth that they were fishing at. The position they marked could then be related back to the bathymetry map to gain an idea of "truth" in the positions marked. Section Three covered some economic aspects including equipment investments and trip expenditure. Fisher attitudes and acceptance of regulations and management were dealt with in section

Four including a test on the regulations of three species either targeted or caught. The final section dealt with general questions including club affiliation and their beliefs in the status and overall trend of Linefishing in Plettenberg Bay over their entire life's fishing experience in the Bay. Data were initially captured with Microsoft Excel (2003) and then imported into a database (MS Access 2003).

Each boat skipper was interviewed once with a "first contact" questionnaire. Short re-surveys gaining information on trip catch and effort was completed with subsequent contact of these skippers. Where permission was granted, catch data including species number and length frequencies (Fork Length and Total Length measured to the nearest millimeter) was collected. Any fish used for bait were identified and counted. If there were too many fish to measure or the skipper denied permission to measure the entire catch, all fish were identified and counted but only a random sub-sample was measured.

A fishery independent data source, (beach launching records), was also used to determine total fishing effort. The results from these records were compared to the results from the access-point surveys to help determine the accuracy of the total fishing effort calculated from the APS. To assess the spatial patterns of resource use within the bay, boat-based surveys were conducted during the project period. During these surveys all boats fishing within the Bay on random sampling days were approached and briefly interviewed. The GPS co-ordinates were recorded and later plotted in a GIS software package, ARCVIEW 3.2a.

Access-point surveys were conducted between August 2003 and September 2004, and launch records were obtained from January 2002 through to the end of December 2004.

2.2.2 Reef Fish Community Assessment

With the use of an echo sounder (FURUNO FCV 561 with a 5089 transducer) the position and size of the reef structures within Plettenberg Bay were identified by running parallel transects vertical to the coastline. Initial mapping occurred behind the surf line (5 – 10m) through to the 50 and 60m isobaths with additional mapping occurring in the region of the two study sites (Fig 2.3). At set intervals the GPS position, depth and bottom substrate was logged. Bottom substrate was simply classified as rock or sand. This data were entered into excel and then imported into an Access database that was linked to Arcview 3.2a. From the mapping exercise a selection of reef sites were dived and classified according to rugosity and profile. For comparison two sample sites were chosen within TNP and another two within Plettenberg Bay whose depth range, rugosity and profile were similar. Sampling between sites inside and outside TNP occurred on the same day to limit varying environmental parameters confounding the comparison. The time of sampling inside and outside the TNP was alternated when possible between morning and afternoon, however this depended on other variables and could not be alternated each trip. Although Willis *et al* (2000) warn against the use of a limited number of sites inside and outside a reserve due to spatial patchiness in fish distribution, with the emphasis of the present project on the need for a rapid appraisal approach and the development of possible indicators to identify sustainability trends, it was deemed sufficient to give the required data.

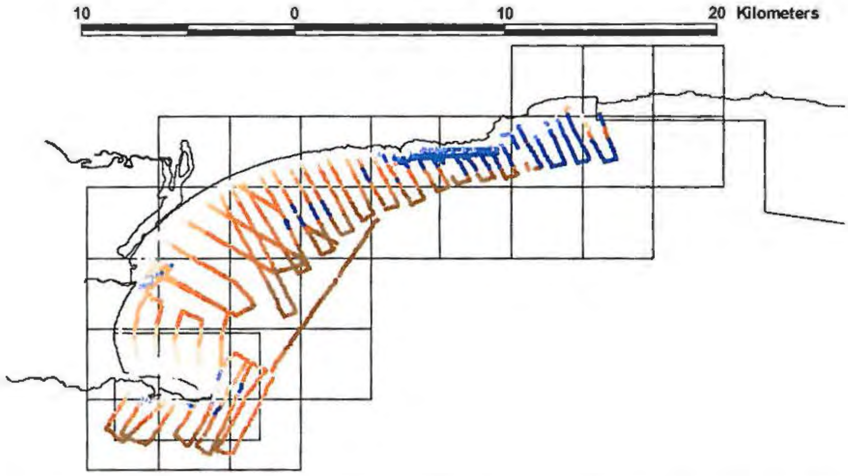


Figure 2.3. Results of the initial mapping exercise to identify hard and soft bottom substrates. Reef areas are denoted with the blue colour. Soft substrates are denoted with the orange brown colour. Darker colours indicate deeper depths.

2.2.3 Sampling methods

As opposed to destructive techniques including rotenone and various netting practices, underwater visual census (UVC) techniques are non-destructive providing information that is independent of fishery data (Barrett 2002). There are a number of UVC techniques that can be loosely classed as either transect (diver swims along a line of known length) or point counts (counts done within a fixed area around a stationary point), each with their own set of inherent advantages and disadvantages. Several authors recommend that the type of survey utilized should be compatible to the species surveyed with different groups of species being sampled by different methods. Strip or fixed width transects have been commonly used in reef fish surveys (Keast and Harker 1977, Brock 1982, Kimmel 1985, Buxton and Smale 1989 and Burger 1990) and allows for the gathering of relative abundance and size information for multiple species, but, is affected by changing visibility, diver bias, time constraints, fish avoidance or attraction (Barrett 2002) and the possibility of crossing different habitat patches or zones (Bohnsack & Bannerot 1986). Stationary point counts such as those done by Kimmel (1985) substitute time for area such that observations are based on species-time whereas instantaneous point counts (Bohnsack & Bannerot 1986), census a fixed area in minimal time. Advantages include the counting of species that are difficult to count on transects due to their interactions with divers, search areas can be reasonably estimated and due to their smaller size they are useful for stratifying counts between different habitats (Barrett 2002).

Of the methods available two sampling methods were utilised in the current study. Instantaneous point counts (due to the generally low visibility and high profile nature of the reefs) to assess community structure in terms of diversity, abundance and size frequencies, and experimental fishing stations to get an independent estimate of abundance and greater accuracy of size frequency distribution.

Sampling was carried out between October 2003 and September 2004 within Plettenberg Bay and between February and September 2004 within the Tsitsikamma National Park.

CHAPTER 3 – ASSESSMENT OF THE NEARSHORE LINEFISHERY

3.1 INTRODUCTION

3.1.1 Linefishery History

The South African Linefishery can he broken into various sectors, namely susbsistence fishers, recreational fishers and commercial fishers with both offshore and inshore components (Table 3.1). Collectively over 200 demersal and pelagic fishes are exploited, of which 95 are regarded as economically important (Griffiths 2000). Management of the fishery due to the large number of users, launch sites and species targeted has been based on the control of effort through input, (numher of commercial participants) and output (bag and size limit) measures (Sauer *et al* 2003). Although the linefishery has a long history dating back into the 16 and 17 hundreds it has only been after the Second World War, with the construction of small boat harbours that growth within this industry really began to increase (Griffiths 2000). Management measures were only introduced in 1940 with the introduction of minimum size limits for certain select species whilst the first comprehensive management framework was only introduced in 1985. However, the level of protection (ie. size and bag limits) set for many of the species was, due to limited scientific data, a result of the subjective perception of its vulnerability to exploitation (Griffiths 2000) rather than hard biological fisheries data, resulting in the validity of the management measures being questioned and considerable compromise between managers and fishers. In December 2000, the then Minister of Environmental Affairs and Tourism declared the linefish resource to be in a state of emergency. Stock assessments (SB/R – spawner biomass per recruit, VPA – virtual population analysis and CPUE – catch per unit effort), conducted since the mid 1990's indicate that most commercially exploited traditional linefishes have been depleted to dangerously low levels, including silver kob, geelbek, red steenbras, red stumpnose and roman (Griffiths 2000).

This precipitated a number of changes in the overall management of the linefishery and a revision of the regulatory limits. As a result the number of commercial fishers allocated linefishery rights has been reduced with part-time (B permits) phased out and multiple access of fishers from other fisheries (e.g. tuna and hake) prevented. Within the new Linefish Management Protocol (LMP) management plans for all linefish species need to be developed with regulations being based on clearly defined objectives and quantifiable reference points that are assessed or evaluated through biologically based stock assessments and historical trends in catch and effort (Sauer *et al* 2003).

3.1.2 Past Studies

In 1994 a two year national survey was initiated to estimate fishing effort and catch composition of the various linefishery sectors, to evaluate socio-economic aspects and to determine fisher attitudes towards the current management measures. The coastline was divided into five regions and within each region aerial surveys, roving creel and access point surveys with structured interviews/questionnaires were employed (Brouwer *et al* 1997, Sauer *et al* 1997). As part of this national survey Brouwer (1997) completed an assessment of the linefishery on the South East Coast including the shore fishers and the recreational and commercial ski-boat sectors. Plettenberg Bay fell within the scope of his study area. Limitations of the national survey due to the large sampling areas, low site specific sampling frequencies and the snapshot nature of the program include insufficient estimates of migratory species catch and insufficient effort estimations by nomadic commercial and reacreational ski-boat fishers whose movements follow these migratory species (Griffiths & Lamberth 2002). More site specific studies include Smale and Buxton's (1985) assessment of the economics and catch and effort of the recreational ski-boat fishers in Port Elizabeth and the similar study carried out for the Port Alfred commercial ski-boat fishery by Hecht and Tilney (1989).

This study focuses on the commercial and recreational ski-boat and deck boat fisheries operating from Plettenberg Bay. Ski-boats are defined as having outboard motors between 45 and 200 horse power each or an inboard engine with tilting propulsion gear, normally between 4.5 – 10m long with either a catamaran or single hull and carry a crew of 2 – 12 fishers. Deck boats are powered by inboard diesel engines, and generally put to sea for up to 5 days at a time (Brouwer 1997). A holistic bay management plan calls for the assessment and inclusion of all resource use hence the deck boat fishery, as part of the hake handline industry, was included in the current study to assess the amount of fishing effort expended within the bay and the catch composition with regards to by-catch.

Table 3.1: Divisions between the various Linefishery sectors and components.

	Inshore	Offshore
Subsistence	Shore fishers	
Recreational	Shore fishers	
	Ski-boats	Ski-boats
	Spearing	
Commercial	Ski-boats	Ski-boats
	Deck boats	Deck boats

3.2 SURVEY METHODS

In order to quantify catch and effort and get an idea of where fishing pressure occurs within Plettenberg Bay a number of sampling methods were utilised (Figure 3.1). Although each method was structured to answer a "key" question, some results could be compared to and used to confirm the results of an alternative method. Specifics of each method are dealt with separately below. Much of the project was designed so that the results could be comparable to other studies in particular Brouwers (1997) assessment of the South East Coast Linefishery.

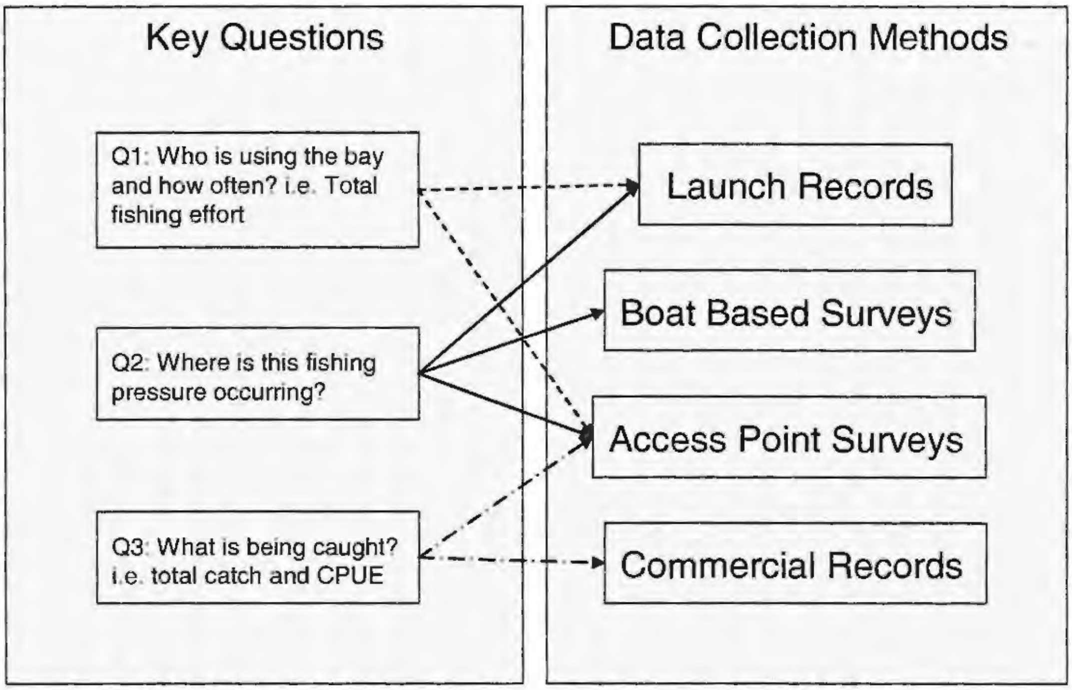


Figure 3.1. The various data collection methods that were utilised in this section of the current project to answer a set of key questions.

3.2.1 Launch Records

Launch records were obtained from the Plettenberg Bay Beach Control office. Dating back to December 1999 paper records have been kept of all vessels launching from the main launch site at Central Beach. Details recorded include the time of launch, the name of the vessel, category of vessel (recreational ski-boat, commercial ski-boat etc), number of people on board, their destination and the time they returned. For the purpose of this study, three years of data were used from January 2002 through to December 2004 and entered onto an excel spreadsheet and imported into a database (MS Access). This was then analysed to give a total number of launches per category of vessel per year, the frequency of destinations (fishing and diving areas) and an indication of total fishing effort per sector (commercial and recreational) within the bay. Effort was calculated in boat days, defined as any day a boat puts to sea for fishing and in angler hours where the time the boat was out to sea was multiplied by the number of fishers / crew onboard. Although effort has been defined as angler hours, the term represents both fishing and traveling time due to the traveling time not being recorded. No correction factor was introduced because traveling time varies in relation to distance to the fishing destination and fishing success. Total traveling time was assumed to remain constant.

3.2.2 Boat Based Surveys

The boat-based surveys were done on a random basis and in conjunction with other research trips. Information gathered on these trips included; an identification and count of each category of boat (Ski-boat, Deck, Semi-rigid), the area of the bay they were fishing in and the time seen. Where possible the boat's name and registration number were noted and the skippers briefly interviewed (Appendix II). Questions asked included information on species caught, species targeted and any other comments in regards to fishing made by the skipper. Whilst one person was doing the interview a second crew member noted the GPS co-ordinates, the depth and bottom substrate (rock versus sand), the vessel name, registration number and number of fishers actively fishing. With the use of ARCVIEW 3.2a the GPS positions were plotted according to vessel category and maps showing the spatial patterns of fishing pressure compiled.

3.2.3 Access Point Surveys

With only two available launch sites into Plettenberg Bay (Figure 2.2) a randomly stratified survey of access points was chosen with sampling beginning at sunrise and ending at sunset. Survey days were randomly chosen with the number randomization function in excel. Although some commercial ski-boats are known to fish overnight, a local municipal by-law prohibits the launching or beaching of any vessels between sunset and sunrise within Plettenberg Bay. For this reason it was felt that a sampling regime from sunrise to sunset would capture total effort for the previous night and that particular day. During early informal interviews with local fishermen and the beach controller, it was highlighted that the majority of boats were launched at central beach with only a few infrequent boats launching out of the Keurbooms river mouth and these were mainly over the busy holiday season. Sampling was therefore randomly stratified between weekdays and weekends and between sites with greater probability being placed on central beach. One weekend day and two weekdays were allocated for sampling at the estuary mouth whereas four weekend and four weekdays were allocated to sampling the Central Beach launch site. Sampling at the second launch site, Keurbooms river mouth, was slightly modified with the clerk being mobile on a small rubber duck. This allowed returning boats to be approached after entering the mouth and before they moved to one of a number of slipways entering the Keurbooms River.

3.2.4 Analysis:

Catch and Effort

Total effort in the recreational ski-boat fishery (including charter trips) was calculated using a method developed by Pollock *et al* (1994) and used by Brouwer (1997).

$$E_{total} = E_{w1} + E_{w2}$$

E_{w1} and E_{w2} were weekend and weekday estimates of effort calculated by:

$$E_w = \frac{\sum_{i=1}^{n} e_i}{(d/p)}$$

Where e_i is the effort expended by the *i*th day calculated as the number of fishing vessels that launched that day (Boat days), d is the number of days sampled and p is the potential number of sample days.

The catch per unit effort (CPUE) was calculated as follows:

$$CPUE = \frac{\sum_{i=1}^{n} (C_i/E_i)}{n}$$

Where C_i is the number of fish retained and E_i is the effort expended by the ith boat trip.

Data were analysed to calculate mean monthly estimates following the "mean of ratios" averaging method (Pollock *et al* 1997), where CPUE data from each boat trip collected on each of the survey days was pooled and averaged to obtain a monthly estimate.

Total catch per month was estimated by simply multiplying the total effort by the CPUE. Total ski-boat effort was calculated in boat days, being defined as a day on which a boat puts to sea to fish. However the number of people fishing on each vessel and the time spent fishing varies. To calculate total effort in terms of fisher days E_{total} was multiplied by the average number of crew in the respective fisheries before being incorporated in the following equation:

$$C_{total} = CPUE \times E_{total}$$

Monthly variances of effort and CPUE were estimated using the standard formula for sample variance (Zar 1984).

The overall CPUE for the entire survey period was calculated as the mean of values for each month of the survey. Total effort and catch for the entire survey period was calculated as the product of the monthly estimates.

The total effort calculated from the APS was compared to the independent estimate of ski-boat effort obtained from the Central Beach launching records. Catch rates obtained from this project were also compared with those obtained in past studies (Brouwer 1997).

3.2.5 Commercial deck Boats

All commercial deck boats operating from Plettenberg Bay supply one of two local fish packing and distribution factories. The fishery was therefore analysed through fishery dependant catch records and independent by-catch observations at each of these factories. It must be noted that the by-catch observed is only the retained by-catch and no information regarding released catch was obtained. Catch records dating back to January 2002 through to September 2004 were obtained from Plett Fish and for the period January 2003 through to September 2004 from Pesca Fresca. Prior to 2002 Pesca Fresca did not have a local packing facility so no catch records could be obtained. The recorded catch was related back to an area of fishing through the central beach launch records, thereby giving an indication as to the total hake and by-catch composition caught within the study area. Traditional access-point surveys as applied to the ski-boat fisheries could not be used to observe commercial catches due to the European Union's strict health and quality restrictions pertaining to the export of hake. Sampling of the by-catch was therefore adapted to comply with these standards and varied slightly between the two factories. At Plett Fish sampling days were chosen randomly with the catch from all boat's offloading on that day being inspected as the fish entered the packing facility. Due to space and factory staff restrictions, by-catch observations at Pesca Fresca could only be done as the fish was packed or sorted for export. As a result all catch from boat's that had offloaded since the previous packing day were inspected. A total of three observations were carried out per month at each of the factories. In addition to recording the hake catch the boat's name and the number and lengths of the by-catch species were recorded. If the by-catch numbers were too numerous to measure each individual, a sub-sample was taken where all fish in x many bins were measured (between 20 and 50% was the minimum sub-sample). All sharks and kingklip arrived de-headed at the factory so measurements were taken from the front of the pectoral fin to the tip of the tail for kingklip and from the front of the pectoral to the precaudal notch, the FL and the TL for the sharks. By-catch sampling at Plett Fish ran from September 2003 through to September 2004 and from October 2003 to October 2004 for Pesca Fresca.

3.3 RESULTS

3.3.1 Launching Records

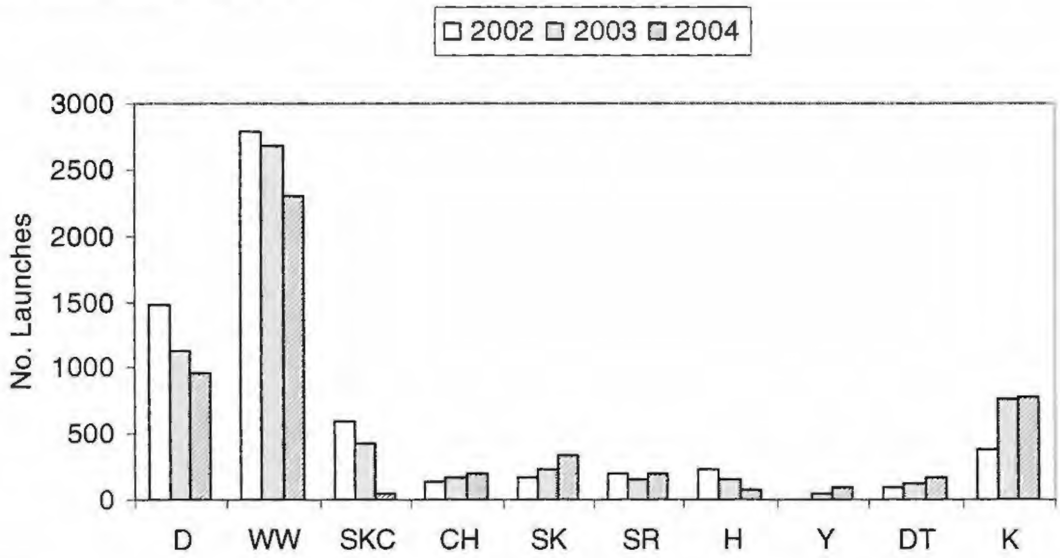
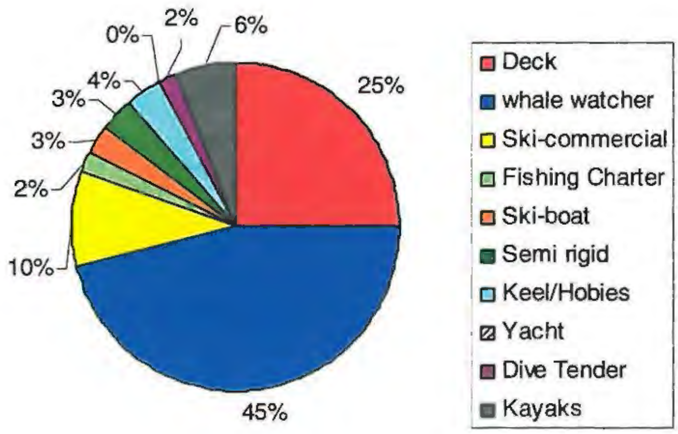


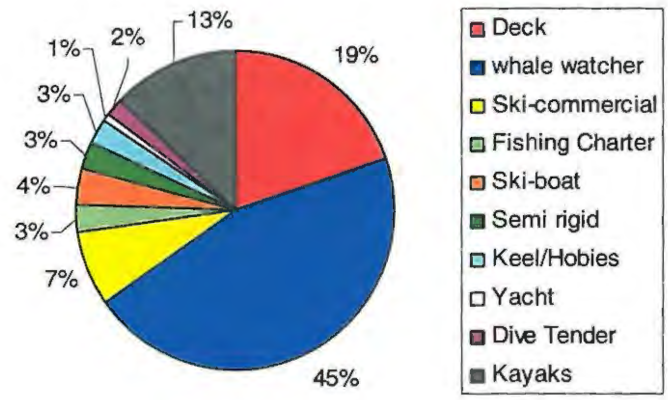
Figure 3.2. Trends in the number of launches per vessel category, from Central Beach, Plettenberg Bay over a three year period. D = commercial deck boats, WW = whale watching, SKC = commercial ski-boats, CH = fishing charters, SK = recreational ski-boats, SR = semi-rigids, H = hobies, Y = yachts, DT = dive tenders, K = kayaks

Over the past three years the commercial boat based whale watching companies have consistently had the greatest number of launches per year (Figure 3.2). Although the number of launches has decreased slightly with 2783 launches in 2002, 2685 in 2003 and 2294 in 2004 the percentage these launches made of total launches per year has only decreased by one percent per year (Figures 3.3a – 3.3c). Commercial deck boats had the second greatest number of launches and showed a similar trend in a yearly decrease in launches from 2002. Of particular note is the dramatic decrease in commercial ski-boat launches over this time period. 591 commercial ski-boat launches occurred in 2002 making up 9% of all launches whilst only 50 launches (1% of all launches) were made in 2004 (Figures 3.3a – 3.3c). During the same period the number of recreational ski-boats and fishing charters increased, collectively making up 11% of all launches in 2004 as opposed to 5% in 2002. The number of kayak trips has almost doubled since 2002 now making up 15% of all launches. Launches by diving tenders have also increased from 98 to 170 during this period. Jetski's or personal watercraft (PWC's) could not be included in the launches analysis as the number of launches made on each jetski was not logged by the beach controller.

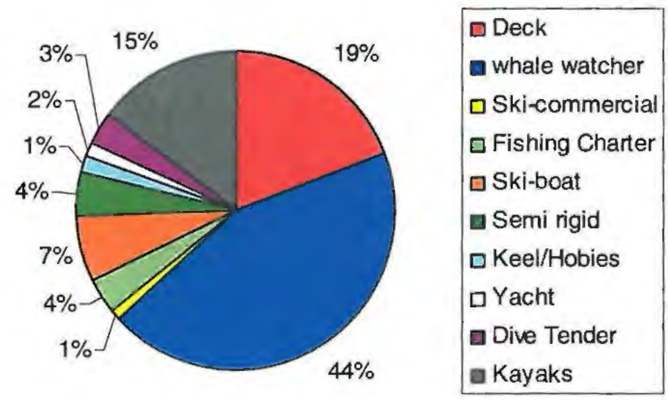
(A)



(B)



(C)



Figures 3.3a – 3.3c. Percentage of total launches made up by each vessel category. A = 2002, B = 2003, C = 2004.

Collectively vessels that could potentially have been involved in fishing (deck, commercial and recreational ski-boats, fishing charters and semi-rigid's) made up 41% of launches in 2002, 37% in 2003 and 35% in 2004. By analyzing each of these trips primary destinations the spatial patterns of fishing pressure within the bay can be seen. Within the bay borders fishing pressure occurs in six broad regions, deeper hake fishing grounds known as Boompies and the shallow 120's and shallower reef areas closer inshore in the Keurbooms and Natures Valley areas. The area known as "The Bridge" lies at the dogleg border of the Tsitsikamma National Park (Figure 3.4). The majority of deck boat fishing occurs outside the bay boundaries that have been set for the current project (Figure 3.5a) as did a fair amount of commercial ski-boat fishing. Nearly all the other vessel types fished predominantly within the bay the majority of which occurred in the Natures Valley region (Figure 3.5b).

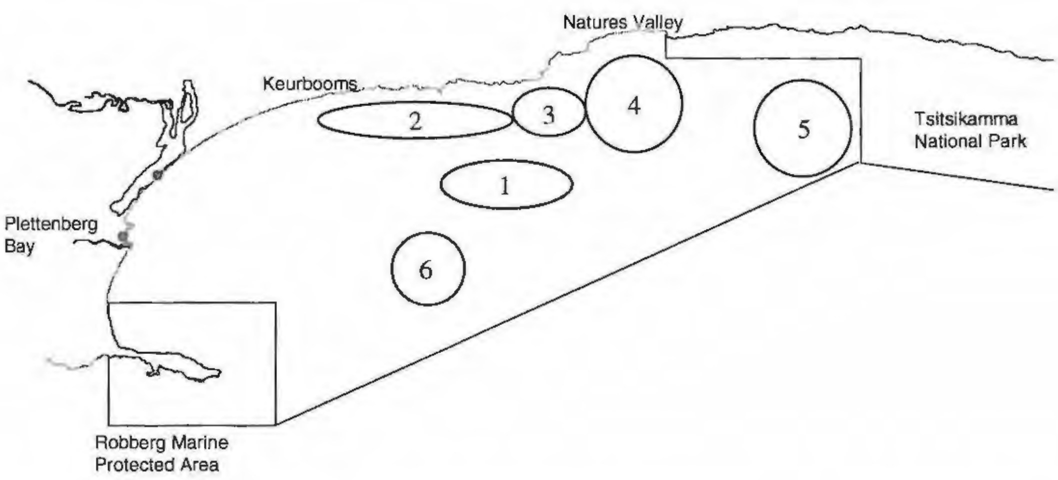


Figure 3.4. Broad scale Spatial distribution of fishing pressure as indicated from the launching records. 1 = Boompies, 2 = Keurbooms, 3 = Salt River 4 = Natures Valley, 5 = The Bridge, 6 = Shallow 120's

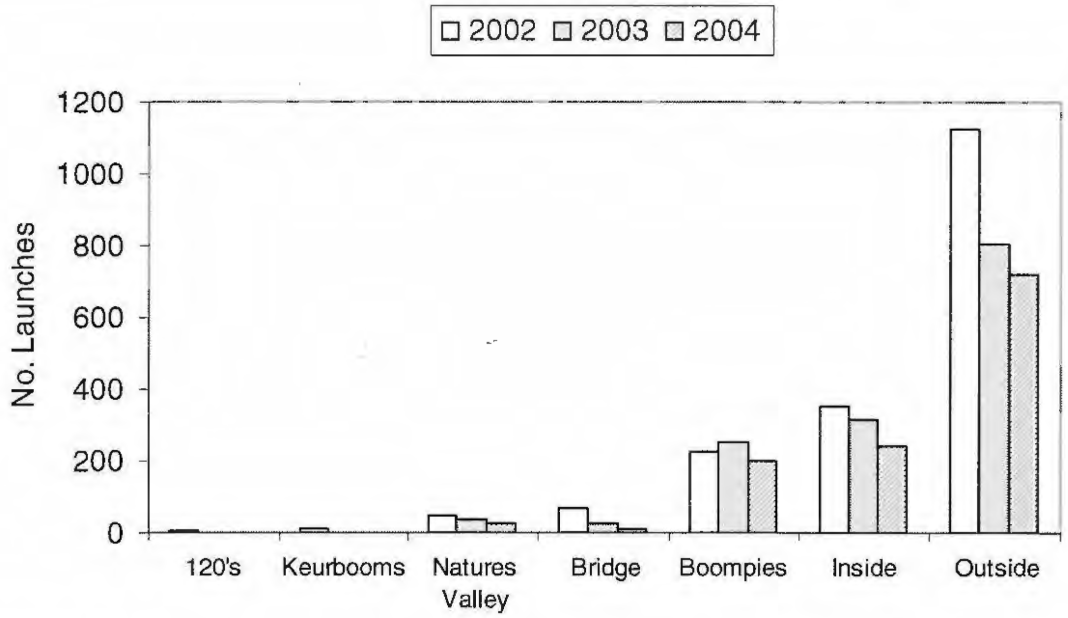


Figure 3.5a. Primary fishing destinations for Deck boats over a three year period. Inside = unspecified fishing destination within the bay (as defined by this study). Outside = fishing destinations outside the bay (as defined by this study).

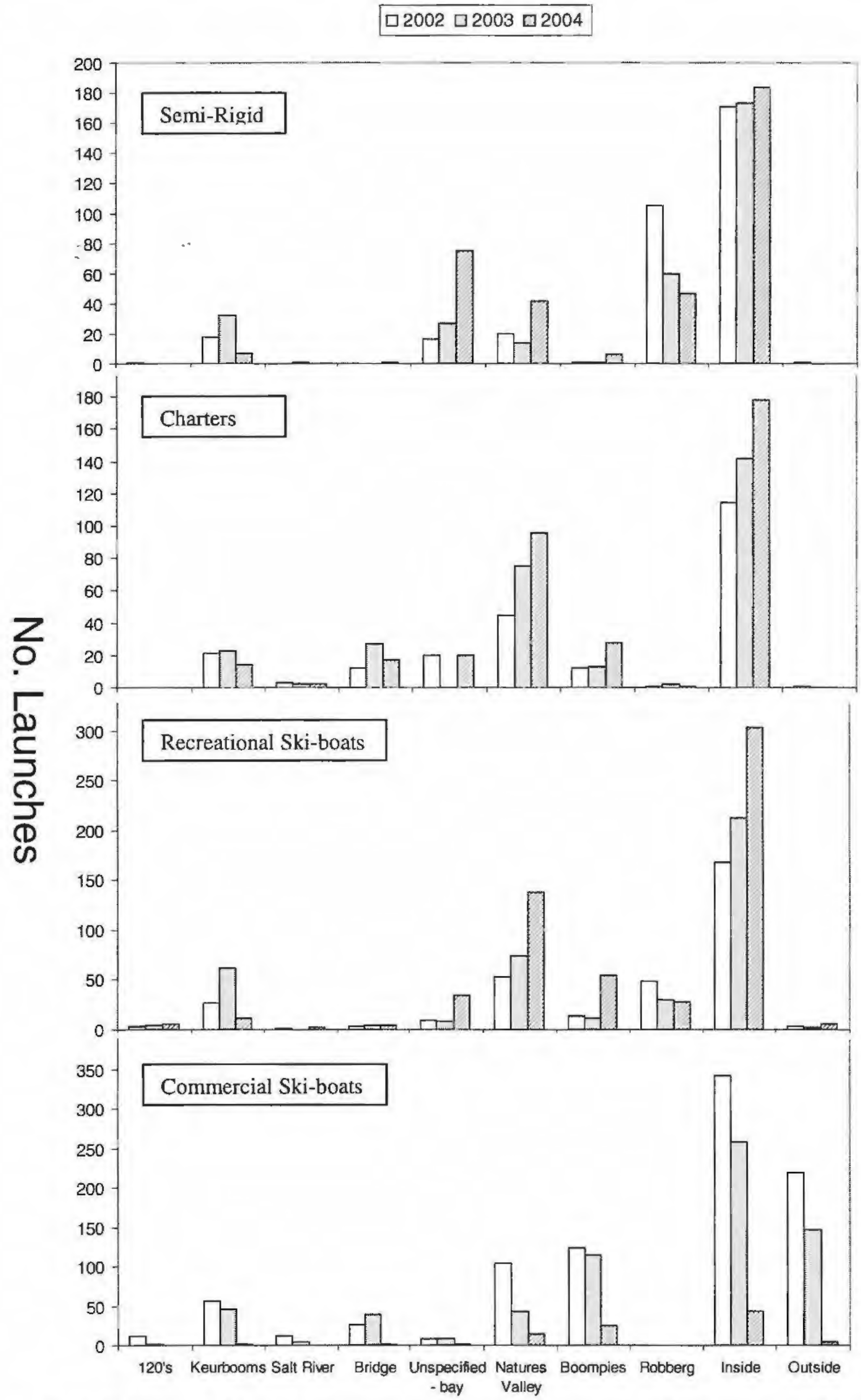


Figure 3.5b Primary fishing destinations over a three year period. Vessels within the unspecified category had simply said they were going out in the Bay. Inside = total fishing within the bay (as defined by this study). Outside = Total fishing outside the bay (as defined by this study).

3.3.2 Boat Based Surveys (spatial distribution of fishing pressure)

During the boat surveys a total of 145 boats were approached and questioned, comprising 27 semi-rigids, 57 ski-boats and 74 commercial deck boats. The GPS position of each boat was plotted with Arcview 3.2 and the resulting spatial distribution of the various boat types can be seen in figures 3.9 to 3.11. The pattern of distribution and hence areas of fishing pressure are immediately apparent. All semi-rigids seen were close inshore (Figure 3.6), and trolling for *Lichia amia*. Ski-boaters had a greater distribution away from the launch site and generally fished over reef. Although most fishing occurred in depths of 15 to 40, meters there were periods when ski-boaters targeted the shallow water hake (*Merluccius capensis*) and fished at greater depths of around 60 to 70 meters (Figure 3.7). Commercial deck boats were primarily found fishing in depths of between 50 and 80 meters and were targeting *M. capensis*. The majority of commercial activity was in an area directly offshore of the Salt River Point. A second area off Natures Valley showed a sudden increase in fishing pressure over a few days when squid (*Loligo vulgaris reynaudii)* was available in the bay and included vessels from Cape St. Francis which had squid fishing licenses. Due to the separate licenses issued to squid and linefishers it is assumed that the impact on reef fish by these vessels would be minimal to non-existent. For that reason they have been eliminated from the effort calculations but included in Fig. 3.8 to show overall spatial patterns of resource use in Plettenberg Bay.

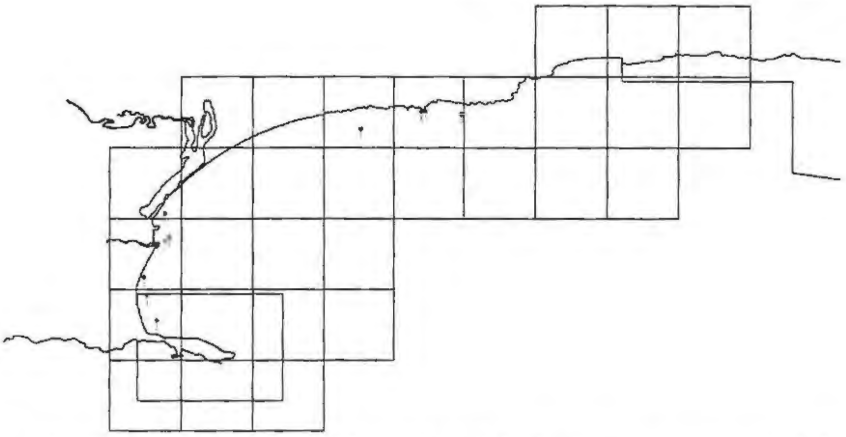


Figure 3.6. Spatial distribution of all semi-rigids that were approached during the boat surveys. n = 27

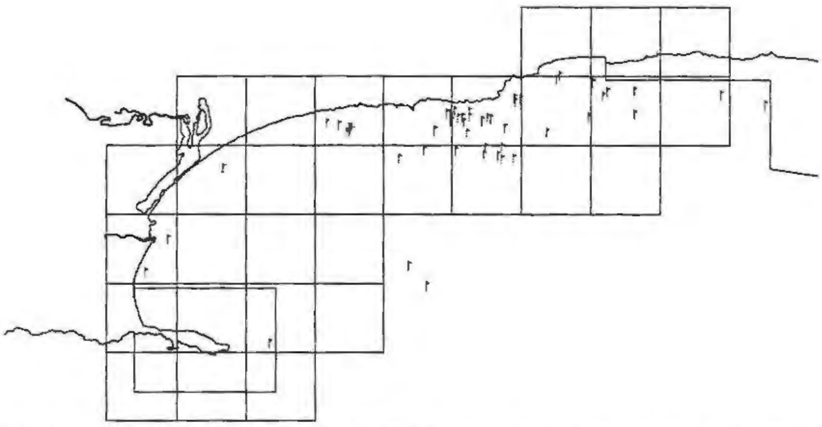


Figure 3.7. Spatial distribution of all Ski-boats that were approached during the boat surveys. n = 57

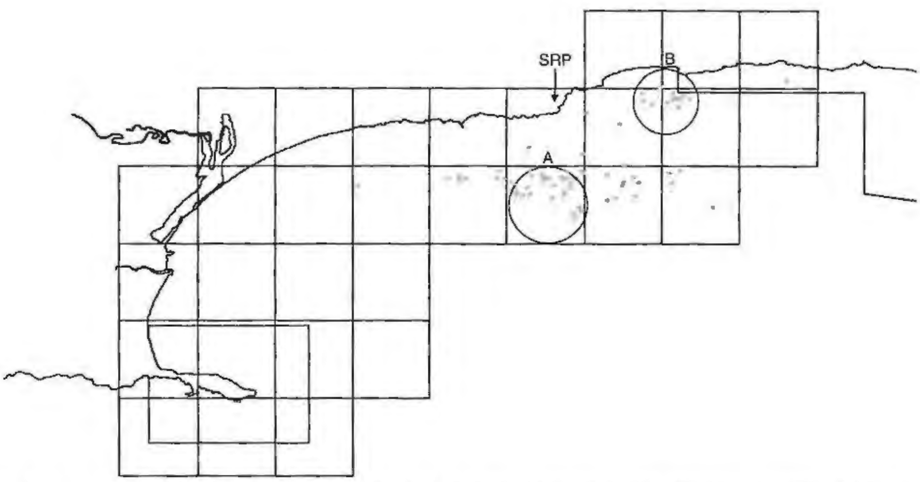


Figure 3.8. Spatial distribution of all Deck boats that were approached during the boat surveys. Circle A represents the concentration of fishing effort directly off Salt River Point (SRP). Circle B is the area off Natures Valley where chokka boats were approached. n = 74

A further 86 boats were counted but not approached due to time and or fuel constraints during the sampling trips. Although no GPS data were gathered, the type of vessel and a general position was noted on the grid map developed. The number of boats seen in each grid block was used to graphically represent the amount of fishing pressure (Figure 3.9). Most of these vessels were deck boats and their distribution pattern is similar to Figure 3.8 with the majority of boats being seen off the Salt River Point.

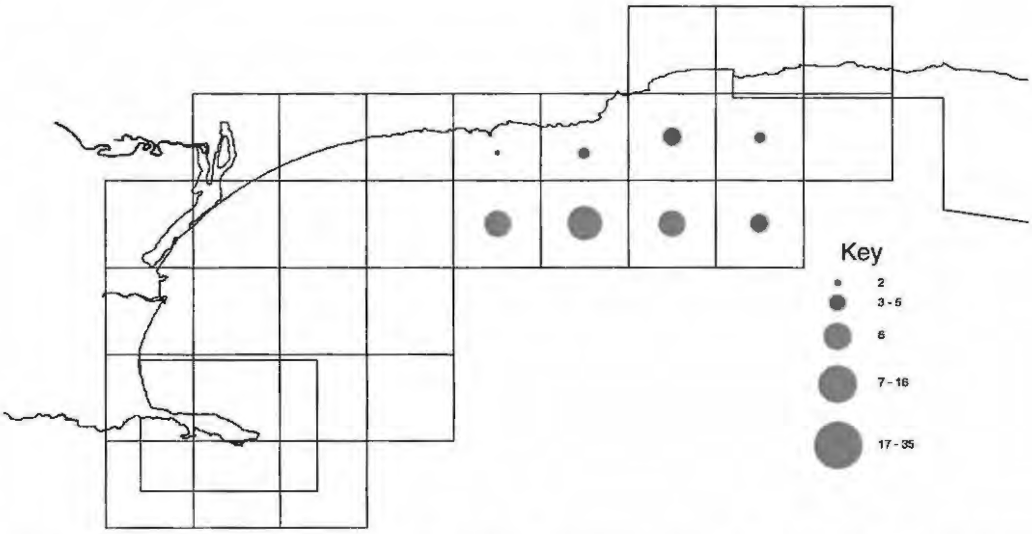


Figure 3.9. Spatial distribution of all boats that were counted during the boat surveys but which were not approached. Circles represent numbers of vessels.

The distribution of fishing pressure revealed through the access point surveys is shown in Figure 3.10a. The general pattern is similar to that obtained from the boat based surveys and indicates that a fair amount of fishing pressure occurs along the boarders of the TNP. Most of the fishing targeting *L.amia* occurs along the Robberg Beach, whilst reef fishing occurs from Keurbooms to Bloukraans. Although the accuracy of the information relies on the truthfulness of the interviewed skipper, the results are thought to be a true indication due to similar pattern gained from the boat based surveys. Furthermore, each skipper was asked to simply mark a cross in the block that they had been fishing in and to indicate the corresponding depth. This could then be compared to the results of the mapping exercise and inconsistencies in depth and grid block quickly seen with those points being removed. A total of 85% of the points corresponded favorably whilst 7.1% were considered incorrect and a further 7.9% could not be validated as no mapping had occurred in these regions. A random GPS point falling within the corresponding block was assigned to each correct survey mark. The positions are therefore not actual fishing spots but rather indicate areas of concentrated effort. A summary of the spatial patterns in fishing pressure is given in Figure 3.10b.

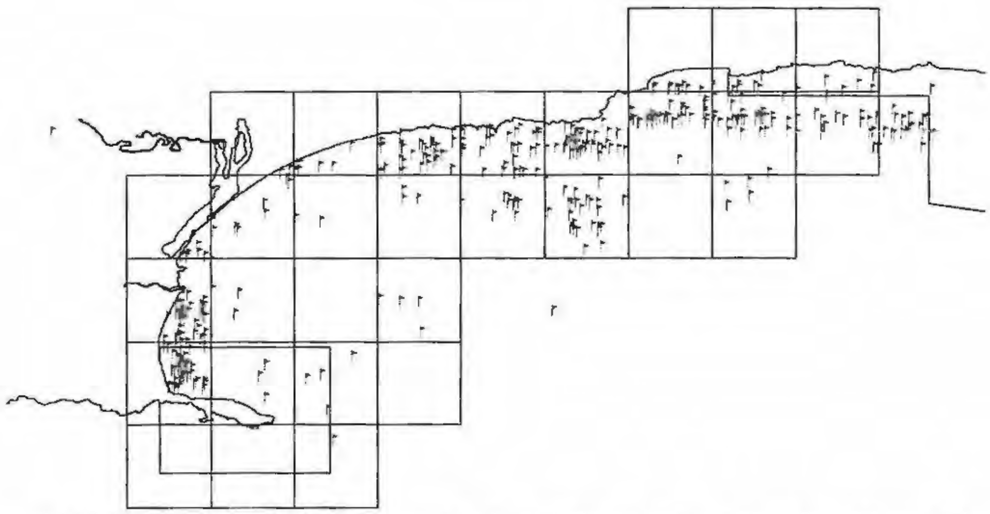


Figure 3.10a. Spatial distribution of all Ski-boats that were interviewed during the access point surveys. Skippers were asked to mark down their approximate position on the grid and a random GPS point within that block was then assigned.

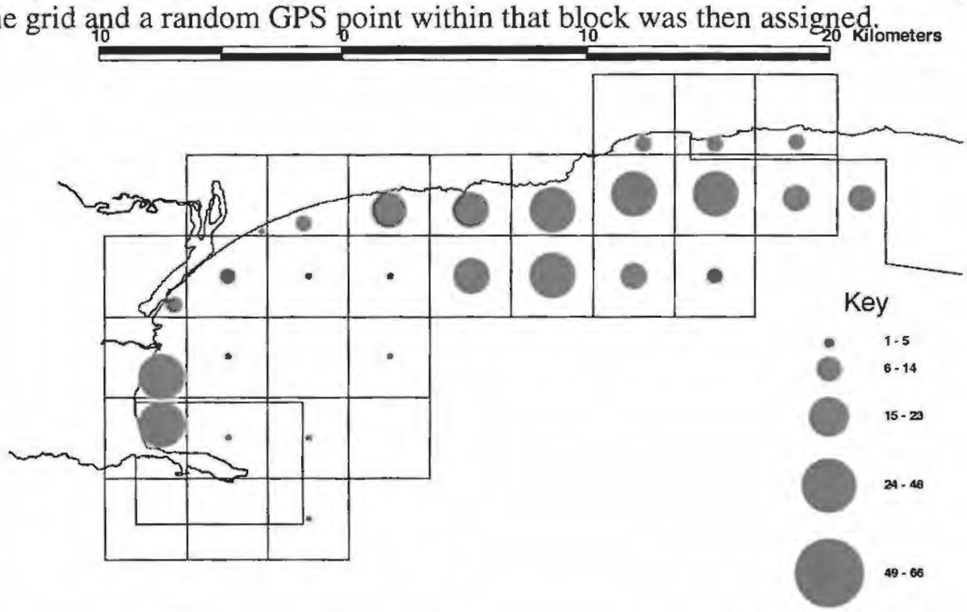


Figure 3.10b. Spatial distribution of fishing pressure with all sectors combined. The circles represent the amount of fishing pressure in terms of numbers of vessels.

3.3.3 Access Point Surveys

3.3.3.1 Fishers

Over the 132 days of sampling, 60 questionnaire interviews were conducted (5 in the commercial sector, 5 in the charter and 50 in the recreational sectors). A further 185 interviews were conducted pertaining to catch and effort information only with 4, 79 and 102 interviews being done in the respective sectors (Table 3.2).

Table 3.2 Numbers of interviews conducted per fishing sector over the sampling period.

Sector	Initial Surveys	Re-Surveys	Total
Commercial	5	4	9
Charter	5	79	84
Recreational	50	102	152

A breakdown of the total number of interviews conducted per month during the sampling year immediately shows the holiday influx of visitors to Plettenberg Bay with December, January and April having highest number of fisher contacts (Figure 3.11). Although four times less effort was placed on sampling the estuary it seems the majority of ski-boats utilize Central Beach as the primary launch site (Figure 3.12). Although vessels were seen launching out through the Keurbooms River Mouth during the sampling period, these turned out to be mostly pleasure cruises or fun rides and no fishing rods were seen onboard.

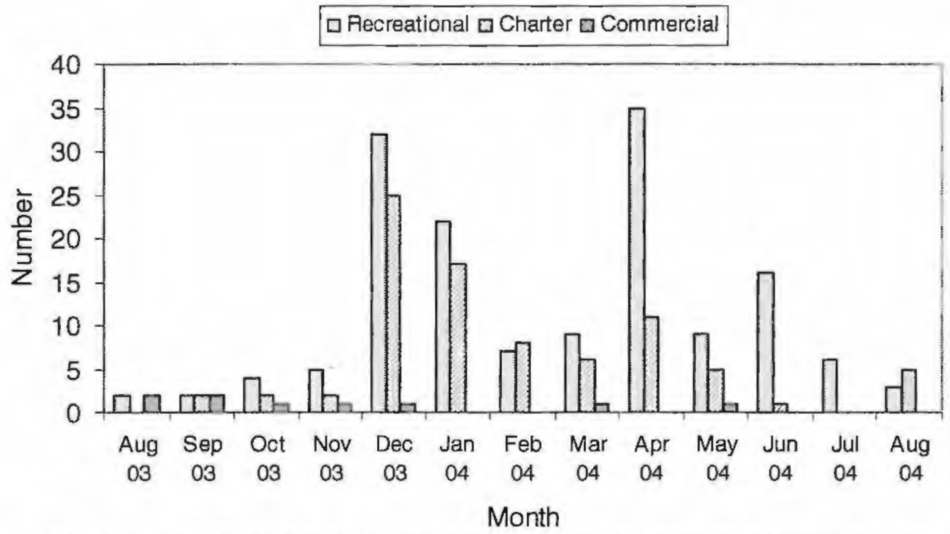


Figure 3.11 The total number of interviews conducted per month per sector showing the peaks during December, January and April for both recreational and charter vessels.

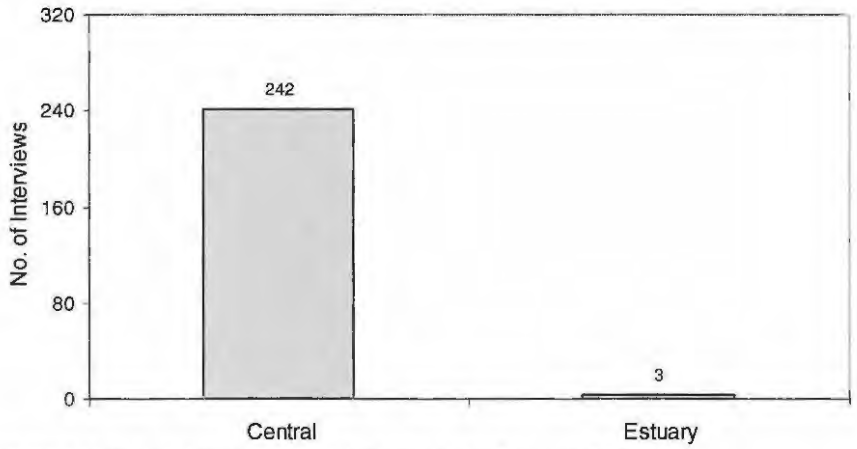


Figure 3.12 Total interviews conducted at each Access Point.

3.3.3.2 Description of skipper details

Before going into the details it must be stated that although the sample number of charter and commercial operaters interviewed is small this does not represent a sub sample and in fact represents a hundred percent coverage of the entire population of these two sectors. For this reason the data has been kept separate and not pooled.

The age distribution of skippers shows three peaks. The main peak falls within the 40 – 45 year old category and two slightly less pronounced peaks at 25 to 30 years and 50 to 55 year categories (Figure 3.13) (Table 3.3). The mean skipper age compares favorably with Brouwer's study (1997), where the mean age of recreational skippers was 46 and 42 for commercial skippers.

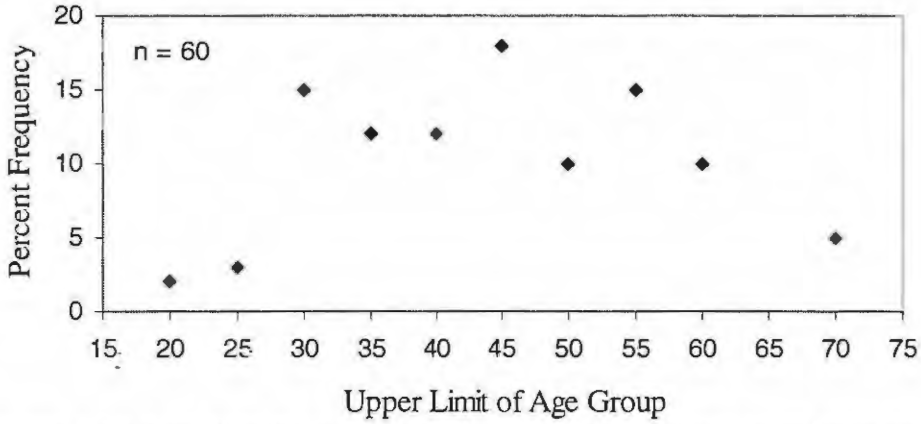


Figure 3.13 Age distribution of skippers. All three sectors have been combined due to small sample sizes of commercial and charter skippers

Following the same South Eastern Cape trend (Brouwer 1997), the sex and race ratios of skippers in all sectors were highly skewed towards white males with only one female skipper from the charter sector and three coloured males from the commercial sector interviewed (Table 3.3). Given all the efforts to try and address equity in the fishing business in South Africa the lack of transformation may be surprising. Details on the sex of crew members was only gathered during the initial contact surveys but showed the same skewed sex ratio in favor of males (Table 3.4). No age data were collected on ski-boat crew. All commercial skippers interviewed had full time employment as skippers but also had some other form of income. Income levels for commercial skippers were in general one bracket lower than the majority of recreational and charter skippers who all had incomes in the upper bracket. Two charter skippers relied on fishing charters as their primary income but all had other sources of income. Only one person stated they had no income due to unemployment whilst four skippers were retired and on pension (Table 3.3). With education levels ranging from Std 1 to Std 10, commercial skippers were generally less educated than both charter and recreational skippers. Most charter skippers had a matric whereas 68% of the recreational skippers had a higher degree or diploma (Table 3.3).

Table 3.3 Summary of Skipper profile information broken into the three sectors interviewed. (Percentage)

		Age	Sex		Race		Language		Employment Status			Income Level**						Education Level^				
Sector	n	Range	Male	Female	Mixed	White	English	Afrikaans	Employed	Unemplyed	Retired	0	1	2	3	4	5	1	2	3	4	5
Commercial	5	30 - 60	100		60	40	40	60	100	N/a	N/a			20	60	20		20	20	20	40	
Charter	5	25 - 40	80	20		100	40	60	100							100				20	60	20
Recreational	50	20 - 70	100		100		64	36	90	2*	8	2*			8	82	8			4	28	68

**Income brackets (per week)
0 = No income
1 = R1 – R115
2 = R116 – R346
3 = R347 – R808
4 = R809 – 6929
5 = Pension

^Education Level
1 = Std 1 – Std 4
2 = Std 5 – Std 7
3 = Std 8 – Std 9
4 = Std 10
5 = Higher (Degree / Diploma)

* Ex full time commercial linefish operator whose license was not reissued.
Mixed = Cape coloured

Table 3.4 Number of male and female crew members taken from initial surveys

Sex	Commercial	Charter	Recreational
Male	33	18	158
Female	0	3	7

The occupations of interviewed recreational fishers fell into four main categories: i) Managerial, executive and administration, ii) Professional & Technical, iii) Services and iv) Retired (Table 3.5). Although there are slight differences in the percent frequencies these were also the top four categories of interviewed recreational ski-boaters during the NMLS (Brouwer 1997).

Table 3.5. Distribution of occupations of ski-boat skippers interviewed within Plettenberg Bay compared to the National average and the South Eastern Cape (Brouwer 1997). NEA = Not Economically Active).

Occupation	National Average	South Eastern Cape	Plettenberg Bay
Retired	12.7	15.8	7.1
Unemployed and NEA	43.5	0	1.7
Professional & Technical	5.9	15.8	35.7
Managerial, exec. & admin	2.7	20.2	41.1
Clerical & Sales	6.2	8.8	0
Transport eg. Truck driver	2.3	1.8	0
Services	6.5	25.4	10.7
Agricultural	2.2	2.6	3.6
Artisan/apprentice	3.2	0	1.7
Foreman, supervisor, & mining	1.3	3.2	0
Operations & semi-skilled	4.0	6.1	0
Labourers	9.4	0	0
Student/scholar		0	0

Of all the skippers interviewed a total of 74% belonged to an organized ski-boat or angling club. Commercial skippers surprisingly had the lowest average number of years experience but had the greatest number of fishing trips per year with an average of 65 (Table 3.6). Recreational skippers had the greatest experience fishing within Plettenberg Bay and in total experience. Although charter skippers were relatively new to Plettenberg Bay with an average of 5 years experience they were the second most frequent fishers over the year (Table 3.6). This would be expected due to charter operations being a part of their income and secondly a large proportion of the recreational fishers were holiday visitors therefore only fishing for certain months of the year (Table 3.7). The apparent discrepancy between the number of trips per month and annually is a result of the questionnaire phrasing, (the question was asked in the manner of "how many times have you been out in the last week, month, year?"), along with high inter-monthly variability in launches. Most visitors were from Gauteng and on holiday for an average of 22 days of which about half would be spent fishing. When asked the importance of ski-boat fishing as a recreational past time during their stay most gave it an 8 out of 10 ranking and said it was highly important (Table 3.8). Sixty four percent said that they would do some other form of angling during their stay, most of which would be rock and surf angling (Table 3.9).

Table 3.6 Experience and frequency of fishing of interviewed skippers from each fishing sector.

Commercial (n = 5)	Yrs experience	Experience in Plett	Frequency of fishing trips		
			Week	Month	Year
Min	5	3	0	1	40
Max	15	15	4	5	100
Avg	9.60	9.00	1.60	2.80	65.00
SD	4.22	4.95	1.52	1.79	25.00
Charter (n = 5)	Yrs experience	Experience in Plett	Week	Month	Year
Min	4	4	1	2	10
Max	25	8	7	12	90
Avg	12.40	5.40	2.80	4.80	35.40
SD	9.50	1.52	2.49	4.21	32.80
Recreational (n = 50)	Yrs experience	Experience in Plett	Week	Month	Year
Min	2	0	0	0	1
Max	55	55	6	14	120
Avg	28.75	18.60	1.56	3.44	26.85
SD	13.60	15.52	1.42	3.74	30.47

Table 3.7 Province of residence of recreational skippers interviewed. (n = 50).

Area	Percent
Local Residents	57
Gauteng	29
Limpopo	5
Western Cape	3
Orange Free State	2
Kwa-Zulu Natal	2
Foreign	2

Table 3.8 The importance of recreational ski-boat fishing for visitors, the number of days spent in Plettenberg Bay and the number of days that will be spent fishing. The importance rating is given on a scale from 1(almost no importance) through to 10 (extremely important).

	Importance rating	Days spent in Plett	No. days fishing
Min	1	2	1
Max	10	45	45
Avg	8	23	10
STD	2.19	11.26	9.65

Table 3.9 Percentage of recreational ski-boat skippers who are involved in other forms of fishing whilst on holiday.

Other Fishing	%
None	36
Estuary	15
Rock & Surf	33
Both	16

3.3.3.3 Fisher Attitudes and Knowledge

The vast majority of fishermen interviewed indicated support for the types of control measures currently used in the linefishery with marine reserves being the most accepted form and minimum size limits the most contentious when all sectors were combined (Figure 3.14). Interestingly 96% of recreational skippers and 100% of commercial skippers indicated compliance with the minimum size limits as opposed to only 60% of the charter skippers. Overall the recreational skippers indicated the greatest level of compliance amongst all regulations although there was more disagreement as to the effectiveness of these regulations (Table 3.10). In comparison to Brouwer (1997), the commercial skippers in Plettenberg Bay showed similar attitudes towards the current management strategies as the rest of the Eastern Cape (Table 3.10). There is a large difference in the indicated compliance of commercial skippers towards the minimum size limits between the two surveys. 100% of skippers in the current survey indicated compliance with size limits as opposed to only 42% during Brouwer's study. Knowledge of the regulations amongst commercial skippers was similar in both surveys. Brouwer (1997) made no distinction between charter vessels and recreational vessels with these two sectors being combined. In contrast to Brouwer's (1997) study which showed bag limits to be the least tolerable management strategy, the current survey shows that within Plettenberg Bay minimum size limits are the most contentious. The responses to questions assessing the level of compliance indicate that there is greater compliance amongst fishers interviewed during the current study for all regulations.

Although most skippers indicated support and compliance a large percentage in all sectors did not know what the various limits were (see Table 3.10).

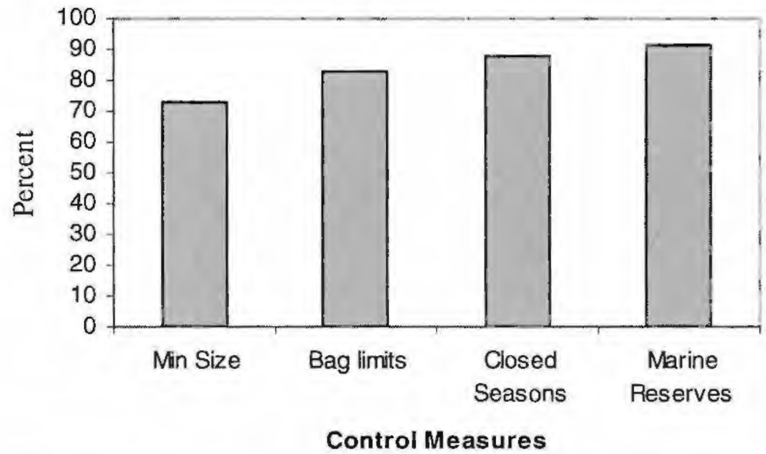


Figure 3.14 Overall support for current control measures in the Linefishery

When tested on their knowledge of the regulations governing the fish species they targeted or caught most often, 42%, 53% and 59% of commercials, charter and recreational skippers respectively did not know the minimum size limits for those species, whilst 42%, 20% and 44% respectively did not know the bag limits. Knowledge of closed seasons was higher for both charter and recreationals, however this could be an artifact of the sampling questionnaire as most species on which the test was based did not have a closed season. Commercial skippers knowledge was similar to Brouwer (1997) whereas the recreational and charter skippers knowledge was less for both size and bag limits and greater for closed seasons.

Table 3.10 Percentage of commercial, charter and recreational anglers that agree, obey and have knowledge of the current regulations governing linefish resources. Results are compared to the NMLS (Brouwer 1997).

	Frequency (%) – Present Study								
	Plettenberg Bay								
	Commercial			Charter			Recreational		
Parameters	Agree	Obey	Knowledge	Agree	Obey	Knowledge	Agree	Obey	Knowledge
	n = 5			n = 5			n = 50		
Size Limit	100	100	58	80	60	47	66	96	41
Bag Limit	80	80	58	100	80	47	77	96	36
Closed Season	80	100	58	100	100	93	83	100	75
Reserves	80	80	-	80	100	-	88	98	-
	Eastern Cape Coast – Brouwer 1997								
	Commercial			Charter & Recreationals					
	n = 96			n = 118					
Size Limit	83	42	54	82	30	50			
Bag Limit	75	88	61	62	56	55			
Closed Season	86	85	70	90	79	54			
Reserves	92	92	-	93	84	-			

The frequency of inspections by fisheries inspectors was overall very low. Only 43% of recreational and 40% of the charter operators had ever been inspected. Commercial inspections were higher at 80 %. This may however be misleading due to the low sample size. Two out of the five commercial operators had never been inspected when fishing in Plettenberg Bay. Of those fishers that had been inspected, the majority (70%) indicated that only a single inspection had occurred in more than 50 fishing trips. Knowledge was again poor when asked who was responsible for managing the offshore resources in South Africa with only 40% indicating central government (Figure 3.15). Recreationals gave the broadest answers with only 44 % giving the correct answer, one commercial skipper and 3 of the charter skippers answered correctly (Table 3.11).

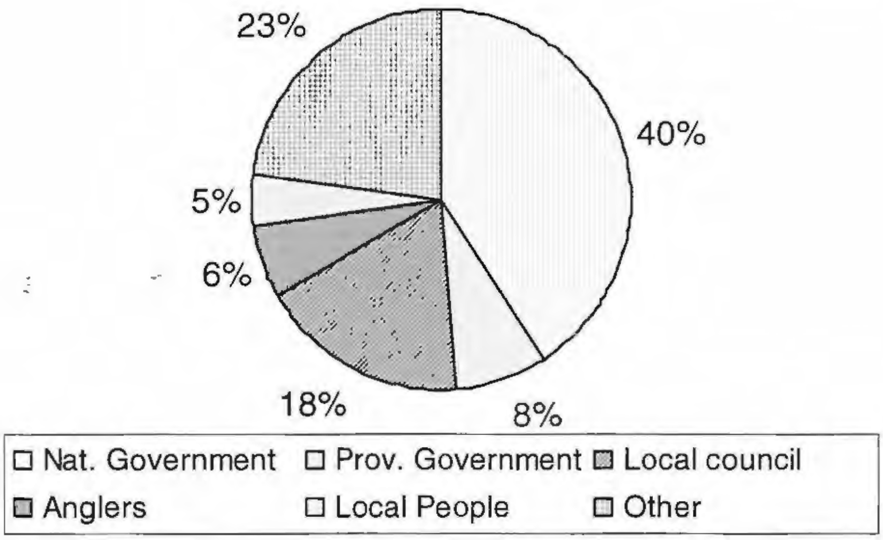


Figure 3.15 Combined percentage of authorities thought to be responsible for managing South Africa's fishery resources.

Table 3.11 Frequency of various answers given by each sector as to who is responsible for management of South African fish resources.

Sector	Frequency (%)					
	Nat. Government	Prov. Government	Local council	Anglers	Local People	Other
Commercial	20	20	20	20	20	
Charter	60		20	20		
Recreational	44	8	18	4	2	24

Just over half the skippers interviewed (60%) reported that fishing had deteriorated within Pletteberg Bay. Twelve percent thought that there had been no change in fishing and 28% could not answer. Anyone who had less than 5 years experience fishing within Plettenberg Bay was placed within this last grouping as it was thought that due to natural yearly variability they would not be able to answer with any degree of confidence as to long term changes. Fewer and smaller fish being caught were the most common reasons as to how fishing had deteriorated (Figure 3.16). Within the NMLS, 91% of recreational and 80% of commercial ski-boaters were of the opinion that there had been a decline in the fishery, primarily through a decrease in catch rate (Brouwer 1997).

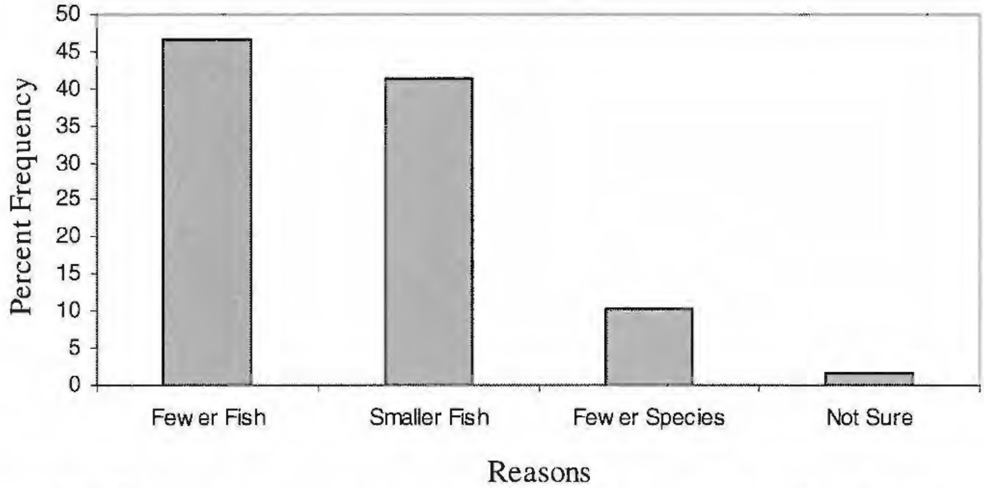


Figure 3.16 Reasons given as to how fishing has deteriorated within Plettenberg Bay.

Various reasons were offered to explain the deterioration (Figure 3.17) of fishing within Plettenberg Bay, with commercial overfishing followed by recreational fishing cited as the major causes. Interestingly in contrast to Brouwer (1997) where trawling was cited as the primary reason for the deterioration, within the current survey it was only the third major cause along with seals competing with fishermen.

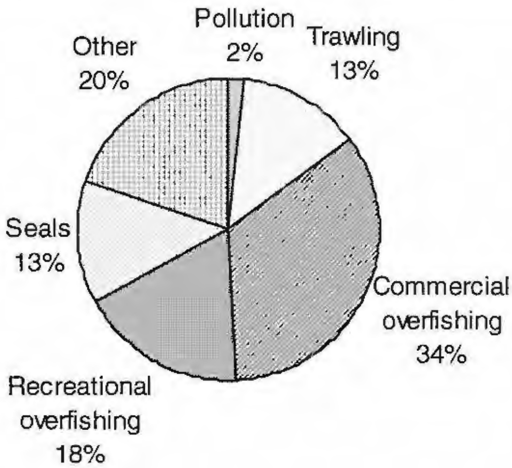


Figure 3.17 Primary reasons given by interviewees for the decline in fishing within Plettenberg Bay. Sectors have been aggregated.

3.3.3.4 Fishing Effort

Not surprisingly fishing effort within Plettenberg Bay shows distinct seasonal trends with an increase in pressure from both recreational and charter fishers over the

December and January christmas holiday period and again in April with the Easter holidays (Figure 3.18 & Figure 3.19). Recreational fishing effort also shows a slight peak during June. Within the Eastern Cape the NMLS showed that the recreational ski-boat fishery had a peak in effort during April and October (Bouwer 1997). Commercial ski-boat fishing effort during the sampling period was minimal with commercial boats only being encountered on nine occasions.

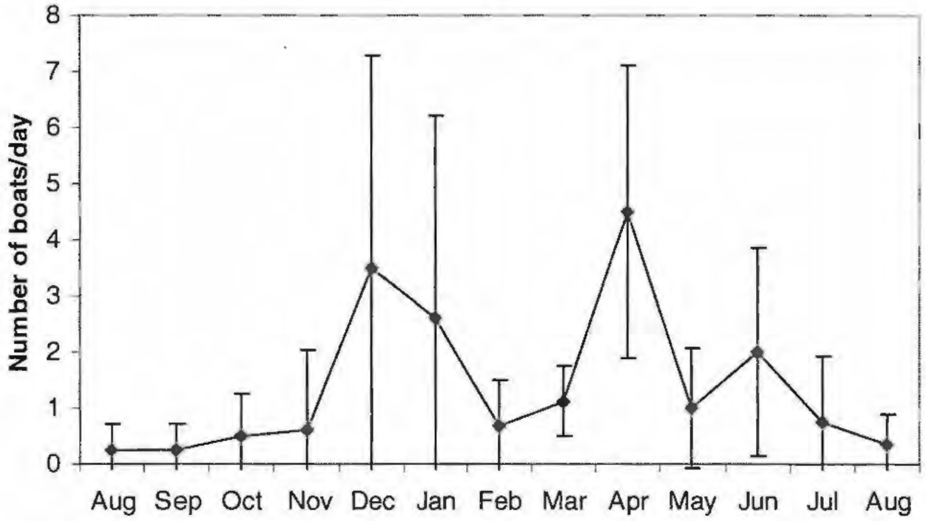


Figure 3.18. Average daily Recreational ski-boat fishing effort per month (±SD) for Plettenberg Bay.

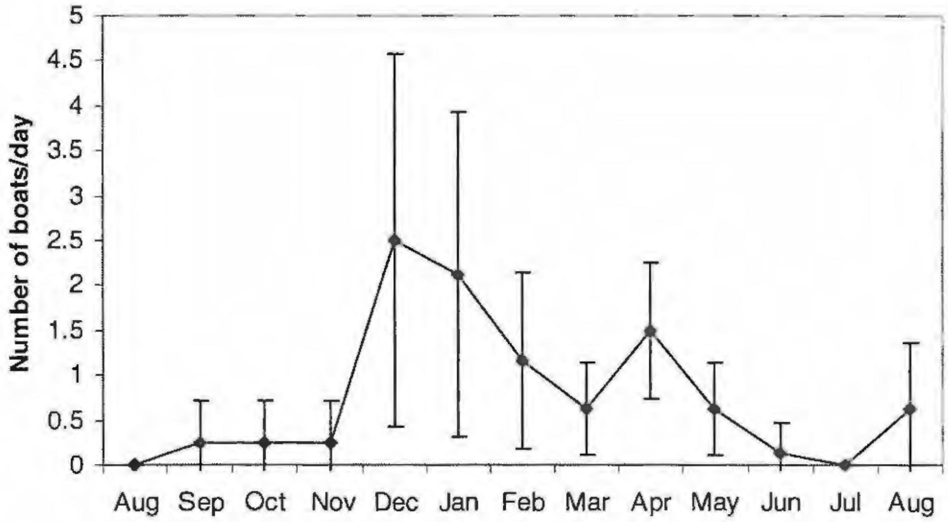


Figure 3.19. Average daily Charter fishing effort per month (±SD) for Plettenberg Bay.

Ski-boat fishers in both the recreational and charter sectors usually started fishing between 07:00 and 08:00 in the morning (Figure 3.20). Recreational fishers also had a number of late afternoon fishing sessions starting between 15:00 and 16:00. These fishing sessions were invariably aimed at targeting game fish specifically *L. amia*. Commercial fishers generally started earlier than the other sectors between 05:00 and 06:00 when fishing during the day and between 16:00 and 17:00 when fishing overnight. On average commercial fishers fished for far longer periods (12h:00min±6.18) than both recreational and charter fishers at 3h:58min±1.58 and 4h:20min±1.14 respectively (Table 3.12). Commercial boats also had on average more crew members (7 ±2.11) than charters (6 ±2.24) and recreationals with 3 ±1.13 (Table 3.13). All sectors generally only had one rod per person (Table 3.13).

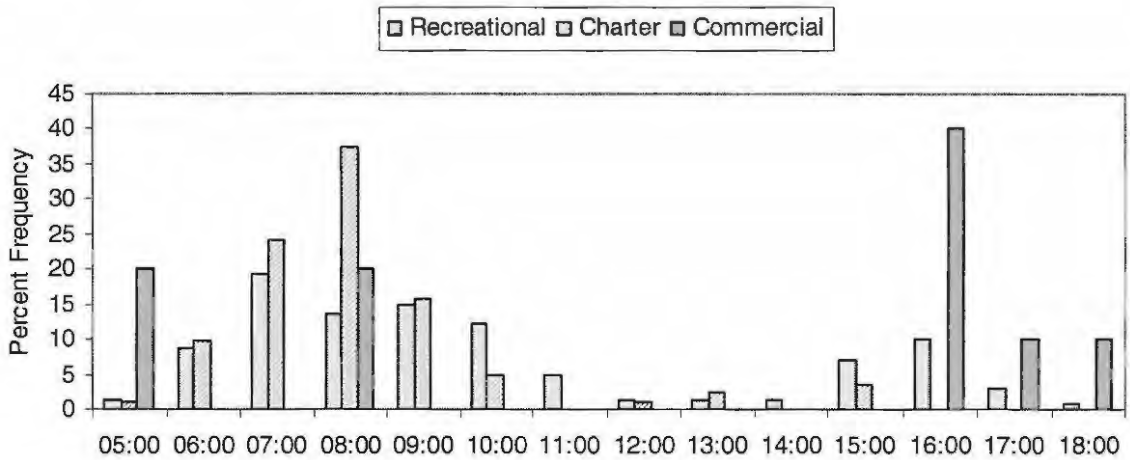


Figure 3.20. Average starting times of Ski-boat fishers in Plettenberg Bay.

Table 3.12. The total and average hours spent fishing of interviewed fishers from the three ski-boat sectors.

	Recreational	Charter	Commercial	Total
Total Hours	623.1	343.5	120	1086.15
Average	3 h 58	4 h 2	12 h 00	4 h 19
Stdev	1 h 58	1 h 14	6 h 18	2 h 36

Table 3.13. Average number of crew members and rods per fishing trip for each ski-boat sector.

	Recreational		Charter		Commercial	
	No. Crew	No. Rods	No. Crew	No. Rods	No. Crew	No. Rods
Average	3	3	6	6	7	7
Stdev	1.13	1.16	2.24	2.11	2.11	1.87

Due to the low number of commercial ski-boats encountered during the sampling period, commercial, recreational and charter boats were all treated as one category for the total effort calculations. The total fishing effort calculated for the ski-boat linefishery was estimated to be 890 boat days.year^{-1} or 3560 fisher days.year^{-1} or 16090 fisher hours.year^{-1}. In comparison the effort calculated from the launching records indicate a total fishing effort of 736 boat days.year^{-1}, 2944 fisher days.year^{-1} or 14660 fisher hours.year^{-1}. Overall there was a 17% overestimation in total yearly effort in terms of boat days and fisher days per year but only an 8% overestimation in total fisher hours per year. There was on average a 27% difference in the estimated and recorded effort per month (Figure 3.21). There was no trend in terms of calculated effort either continuously over estimating or underestimating the monthly effort. (Figure 3.22a and Figure 3.22b). It must be noted that the launch records do not indicate those recreational ski-boat or semi-rigids that were simply out for a bay cruise and were not fishing. The launch records are therefore likely to give an overestimation of the true fishing pressure and in turn the total estimated fishing pressure from the APS is an overestimation of the actual situation.

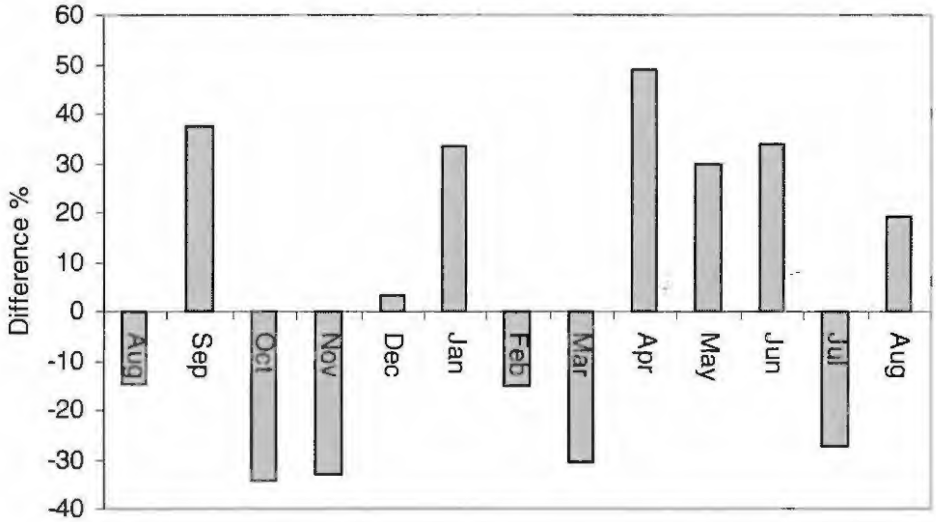


Figure 3.21. Differences in the monthly total fishing effort (boat day.year^{-1}) between calculated and recorded estimates. Negative values indicate months where calculated effort was less than the recorded effort.

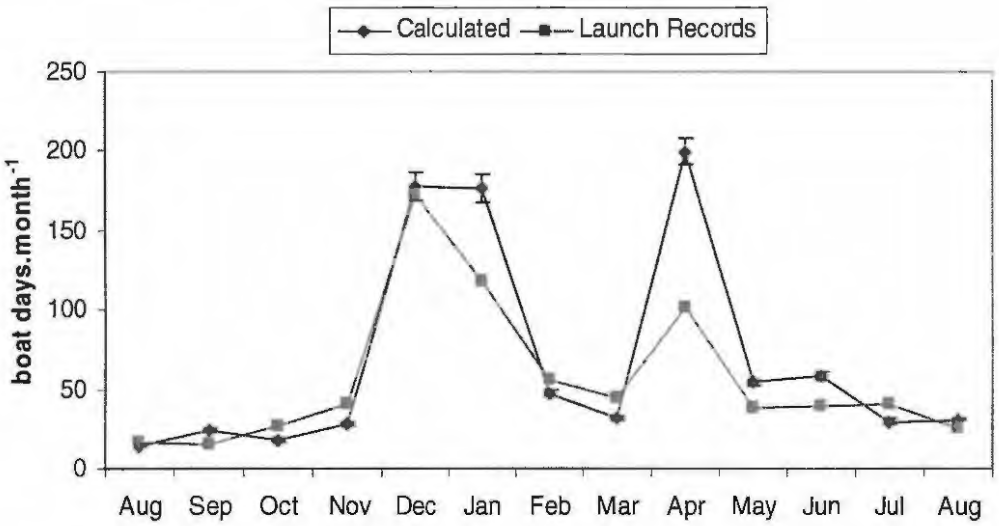


Figure 3.22a. Comparison of monthly effort calculated from the APS and recorded by beach control (boat days.month^{-1}).

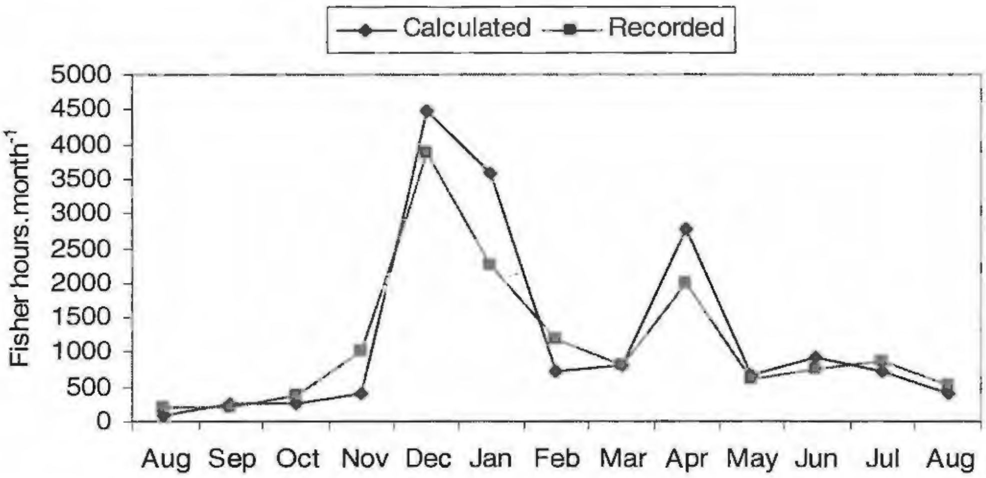


Figure 3.22b. Comparison of monthly effort calculated from the APS and recorded by beach control (fisher hours.month^{-1}).

3.3.3.5 Catch composition

Commercial ski-boats catches comprised primarily of the shallow water hake (*M. capensis*) with greater number of silver kob or geelbek being caught when they are abundant in the bay. Catch composition of the recreational (including charter) ski-boats was more variable with a greater number of species targeted (Figure 3.23). Four species were targeted most frequently, kob *A. inodorus* (25%), garrick *L. amia* (19%), geelbek *A. aequidens* and hake *M. capensis* at 18% each. Overall ski-boat catches were made up of 14 species of elasmobranches from 10 families and 29 teleost species from 9 families (Appendix III). In terms of numbers, hake was the most frequently caught, making up 19% of all fish inspected. Although silvers *A. argyrzona* were targeted less than 1% of the time they comprised the second most number of fish caught at 18%. Kob, roman and geelbek comprised 16%, 14% and 11% respectively (Figure 3.24). Garrick only made up 1% of the total fish encountered despite it being targeted 20% of the time.

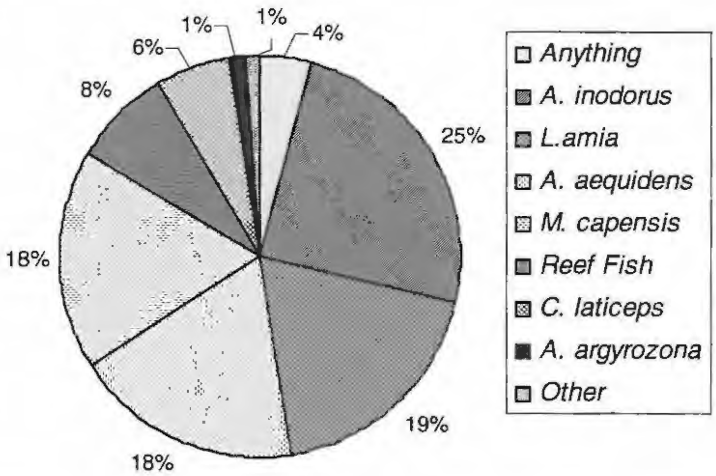


Figure 3.23. Frequency of trips targeting different species. n = 250

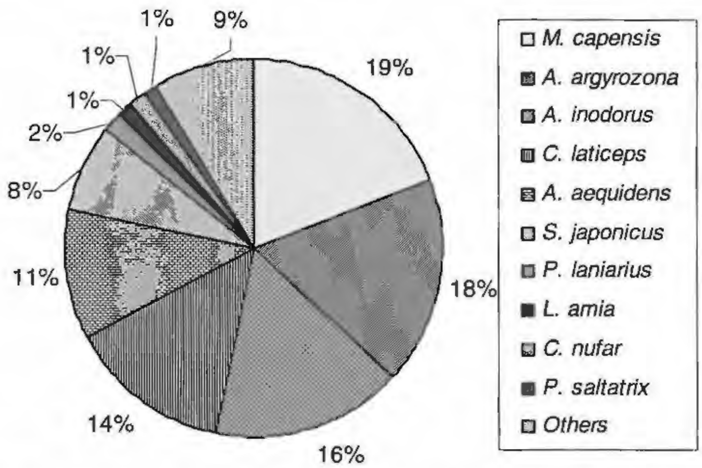


Figure 3.24. Top ten species caught (by number) for the recreational ski-boat fishery including charters. n = 3298.

The total catch by recreational and charter vessels during the study period is estimated at 13 667 fish or 13491 kg of fish. The average weight of fish caught was less than a kilogram except during December, January and February where there was an increase in large geelbek and kob in the catch. Corresponding to the increase in fishing pressure there are two main peaks of increased catch over the Christmas and Easter holiday periods (Figure 3.25). Although there is a dramatic increase in fishing pressure during December and January the CPUE in term of fish per angler, (fish.fisher^{-1}.day^{-1}), does not increase (Figure 3.26). However there is an increase in the kilograms per angler (kg.fisher^{-1}.day^{-1}) again due to the large individuals of geelbek and kob caught during this period. CPUE (fish.fisher^{-1}.day^{-1}) was highest during the winter months of May, June and July. Overall the recreational and charter fishers' CPUE was 3.00±5.54kg.fisher^{-1}.day^{-1} or 4.71±4.117 fish.fisher^{-1}.day^{-1}. This is less than Brouwers (1997) estimate of 12.1±5.3kg.fisher^{-1}.day^{-1} or 6.3±3.7fish.fisher^{-1}.day^{-1}.

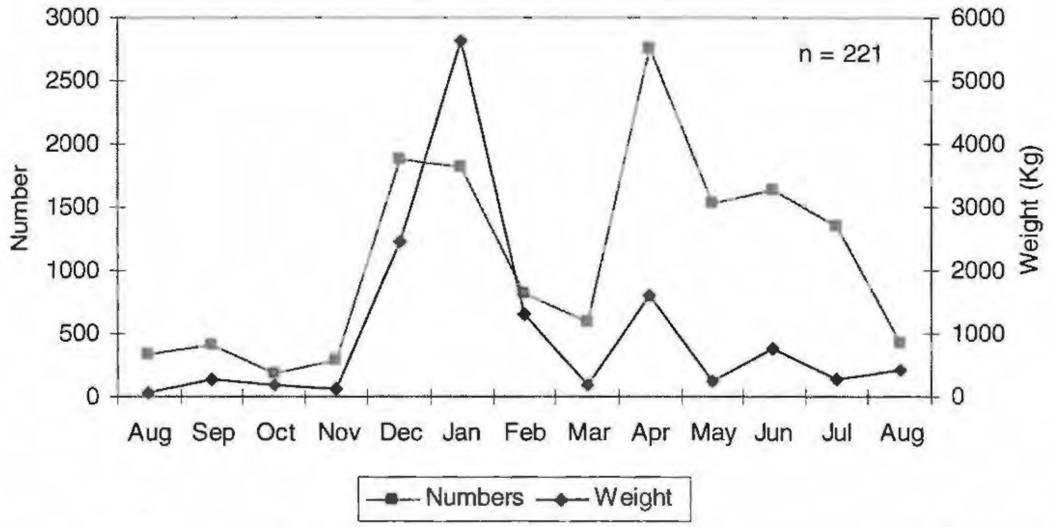


Figure 3.25. The estimated total catch of fish during the study period in both numbers and kilograms.

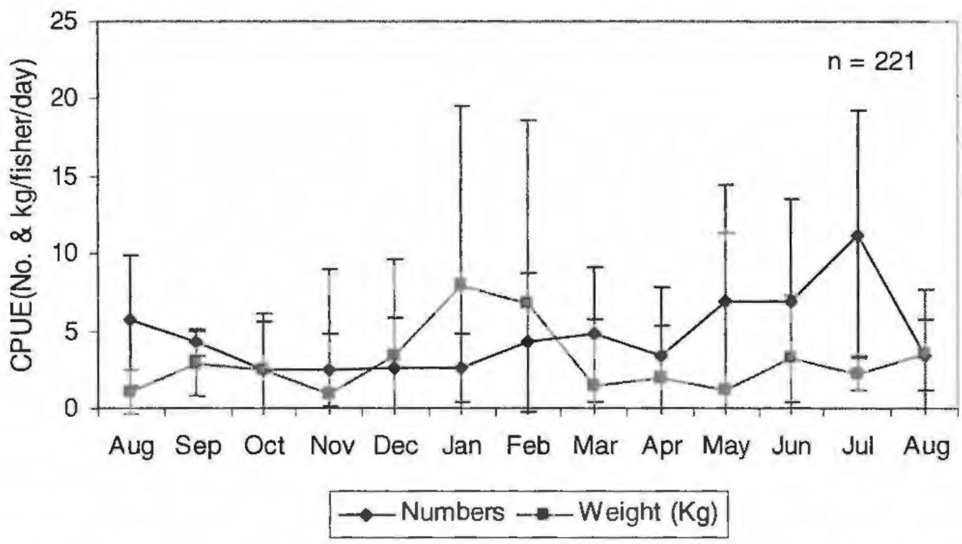


Figure 3.26.The average CPUE (±SD) within the Recreational and Charter linefishery. CPUE is given as the number of fish per angler per day (fish.fisher^{-1}.day^{-1}) and the kilograms per angler per day (kg.fisher^{-1}.day^{-1}).

3.3.3.6 Effort

Due to the high number of trips targeting geelbek and kob, and the large numbers of roman caught, directed effort, catch and CPUE was worked out for these three species. The directed fishing effort for kob and geelbek is very similar due to the large number of interviews which indicated both species as being their primary targets (Figure 3.27). Targeting of reef fish, specifically roman was more evenly distributed throughout the year with a main peak during December and a dip during May and August.

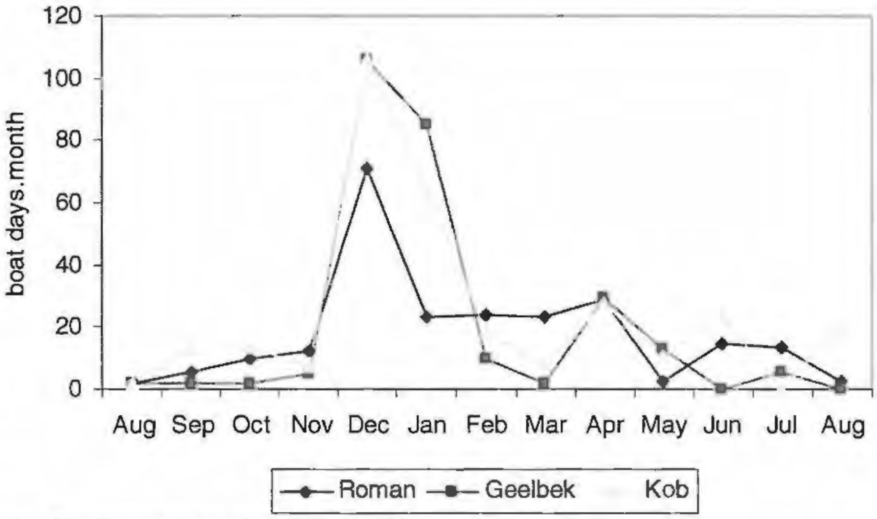
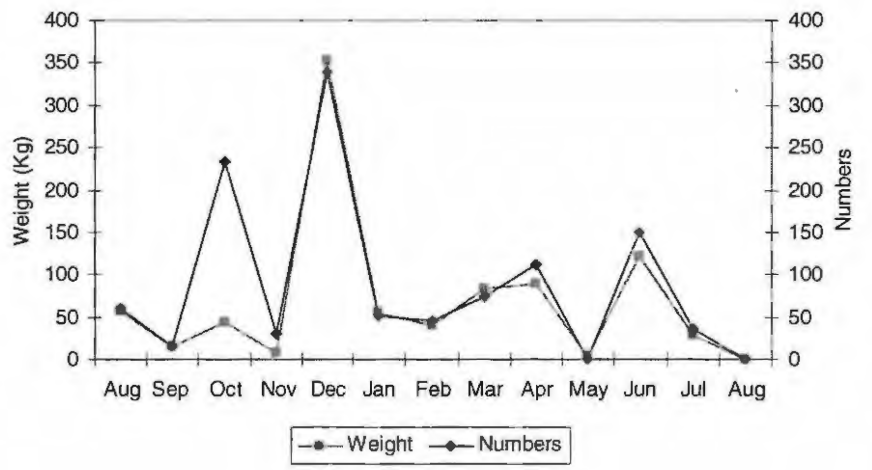


Figure 3.27. Estimated total directed fishing effort.

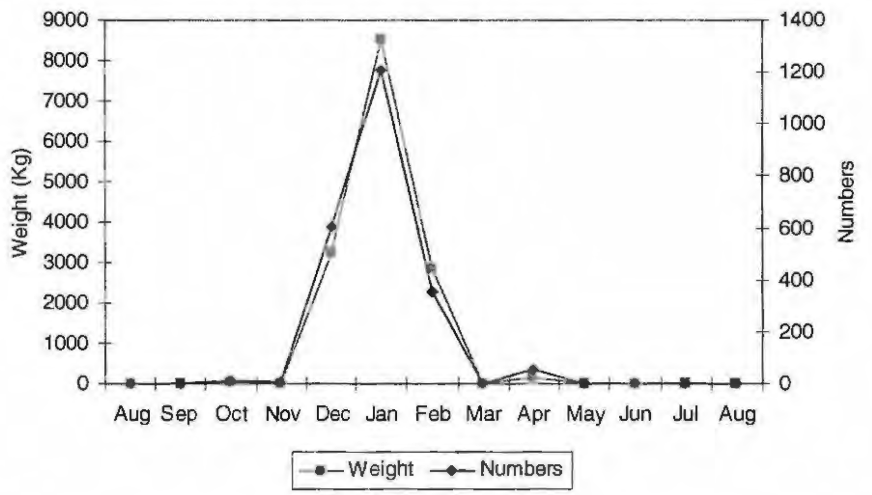
The monthly total catches for roman peaked during December and June corresponding to increases in pressure (Figure 3.28a), however the CPUE remained reasonably steady with peaks in September and June (Figure 3.29a), the yearly average being 0.91±0.67kg.fisher^{-1}.day^{-1} or 0.97 ±0.77 fish.fisher^{-1}.day^{-1}. Both geelbek and kob had peaks in total catch and CPUE during January (Figure 3.28b&c and Figures 3.29b &c). Individual fish caught during the December / January period were generally larger individuals causing a dramatic increase in the total weight of these species caught. The variance is high indicating large differences in the amount of fish caught each trip during this time. The yearly average CPUE is estimated to be

8.47 ± 8.57kg.fisher^{-1}.day^{-1} or 1.24 ± 1.16 fish.fisher^{-1}.day^{-1} for geelbek and 2.05 ± 3.78kg.fisher^{-1}.day^{-1} or 1.10 ± 1.80 fish.fisher^{-1}.day^{-1} for kob.

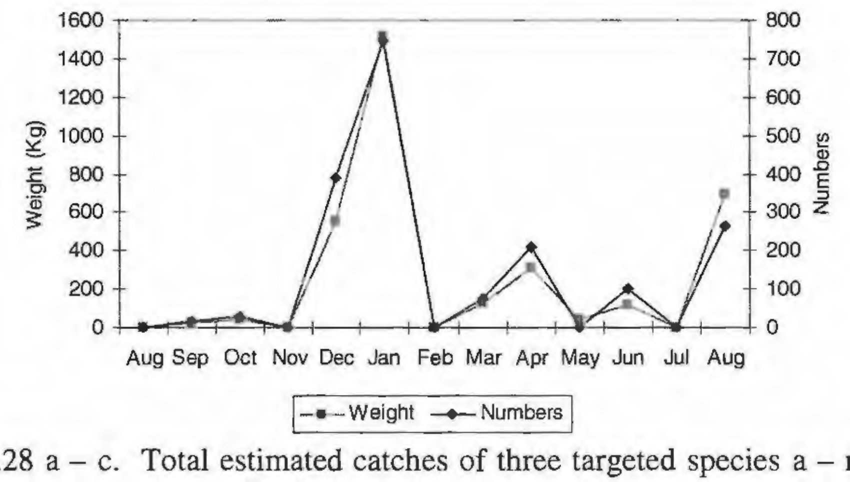
(a)



(b)



(c)



Figures 3.28 a – c. Total estimated catches of three targeted species a – roman, b – geelbek and c – kob. Recreational and charter fisheries have been combined.

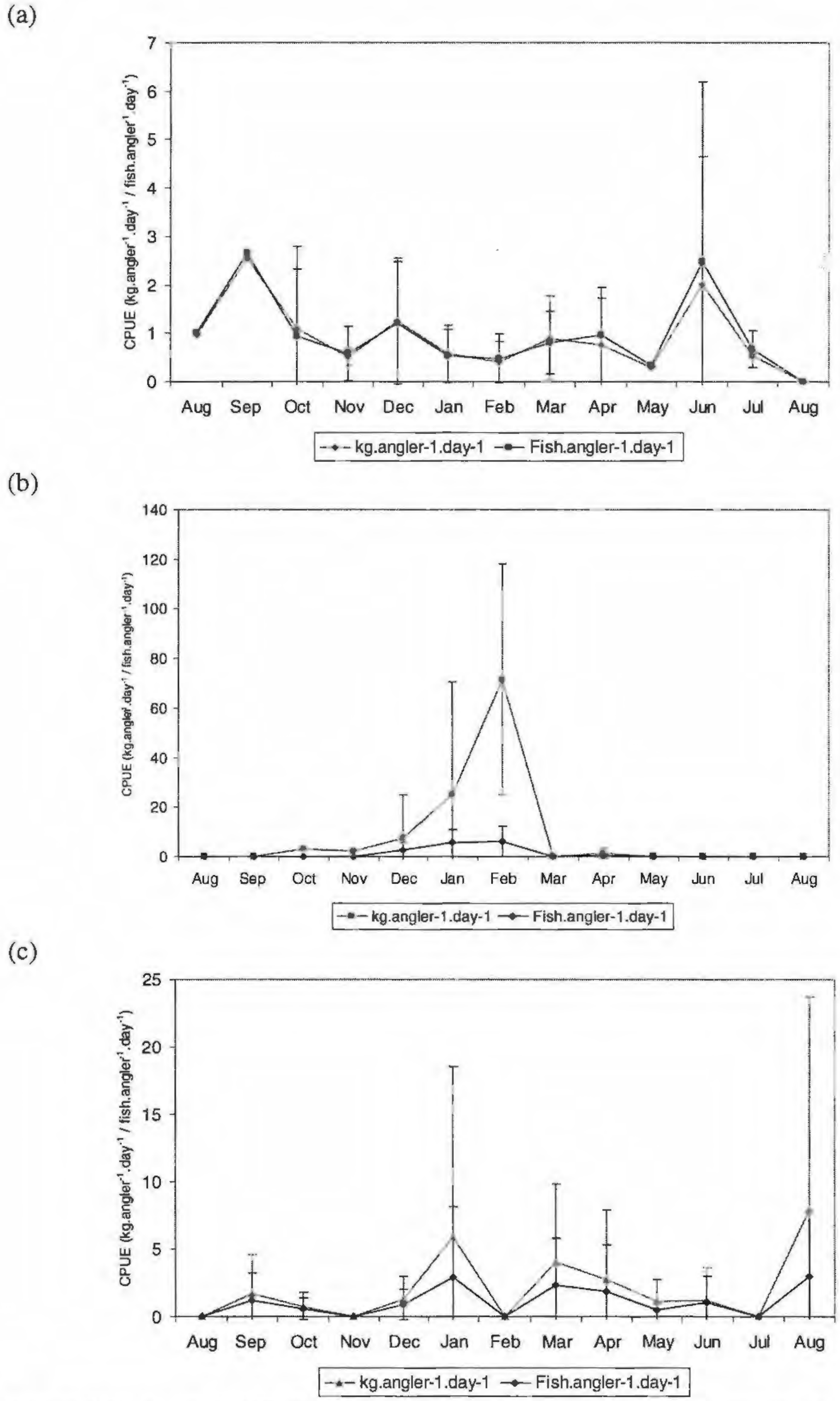
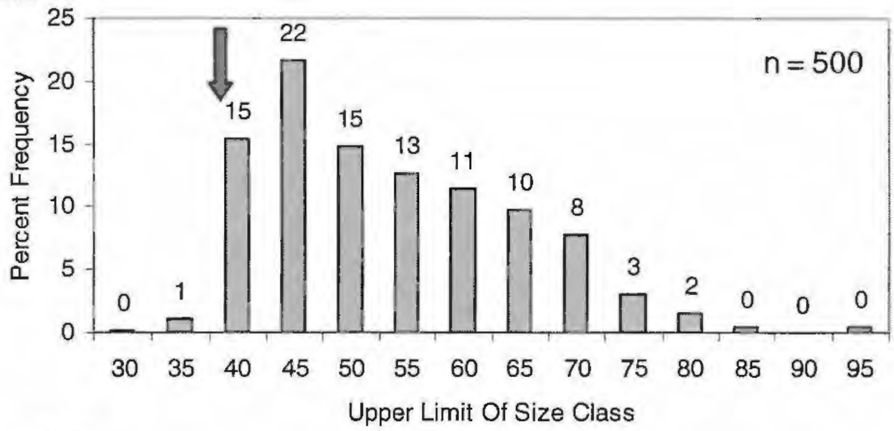


Figure 3.29 a – c. CPUE estimates for three targeted species a – roman, b – geelbek and c – kob. Recreational and charter fisheries have been combined.

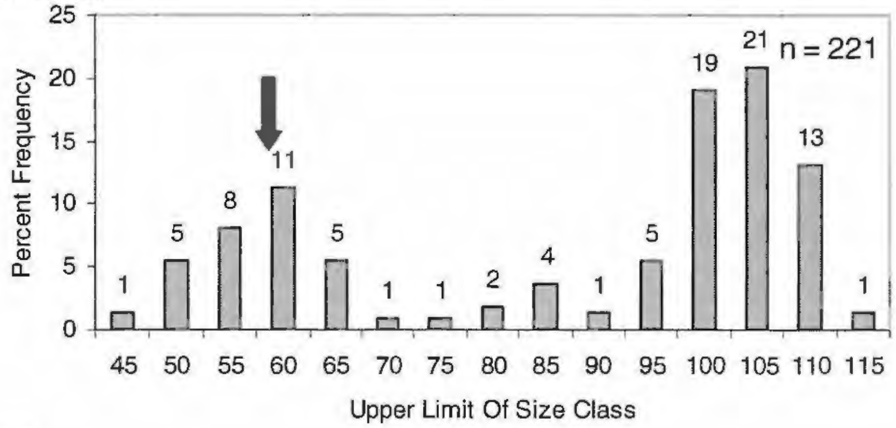
3.3.3.7 Size Classes

Twenty two percent of kob caught were between 40 and 45 cm TL, which is just above the legal minimum size limit of 40cm. Sixteen percent of the kob measured were undersized, whilst 71% fell between the 40 and 65 cm total length (Figure 3.30a). Twenty five percent of all geelbek caught and measured were below the legal minimum size limit of 60cm. The size frequency distribution is bimodal with peaks between 55 and 60cm and 100 to 105cm. In all, 59% of geelbek were larger than 90cm total length (Figure 3.30b). Following the same trend as kob most of the roman (43%) and santer (27%) were just above the minimum size limits of 30cm. Fourteen pecent of roman and 13% of santer were undersized (Figure 3.30c & d). Only 3 % of the silver caught and measured were undersized with most fish falling in the 30 to 40cm size classes (Figure 3.30 e).

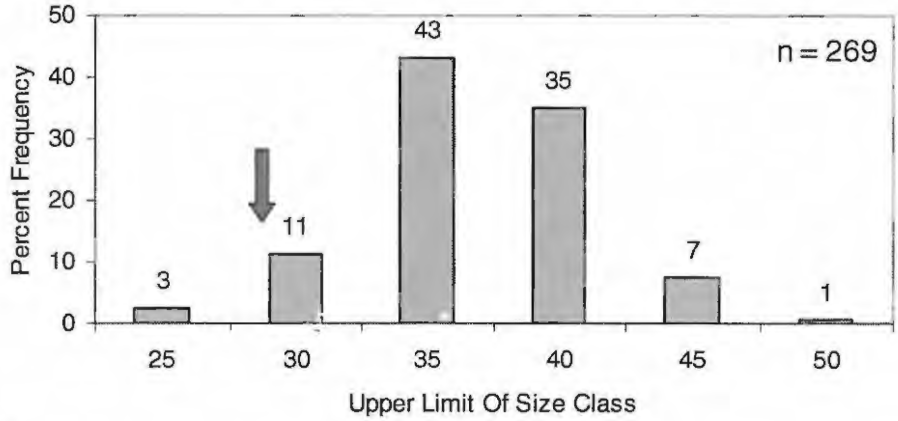
(a) Kob



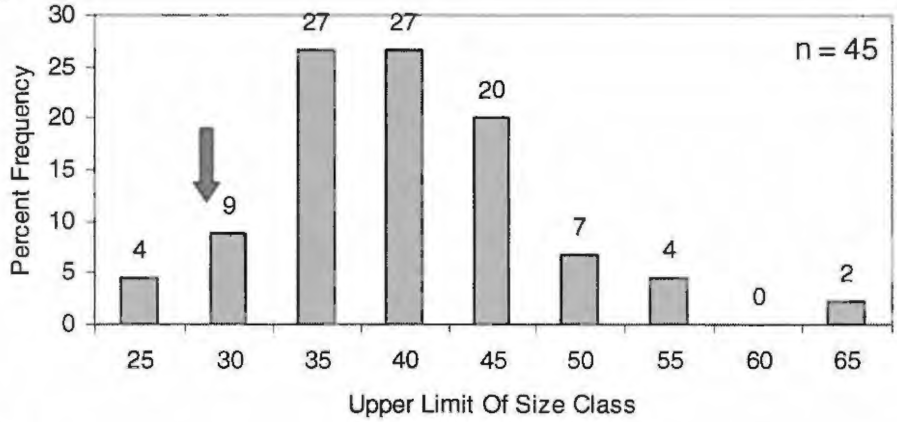
(b) Geelbek



(c) Roman



(d) Santer



(e) Silver

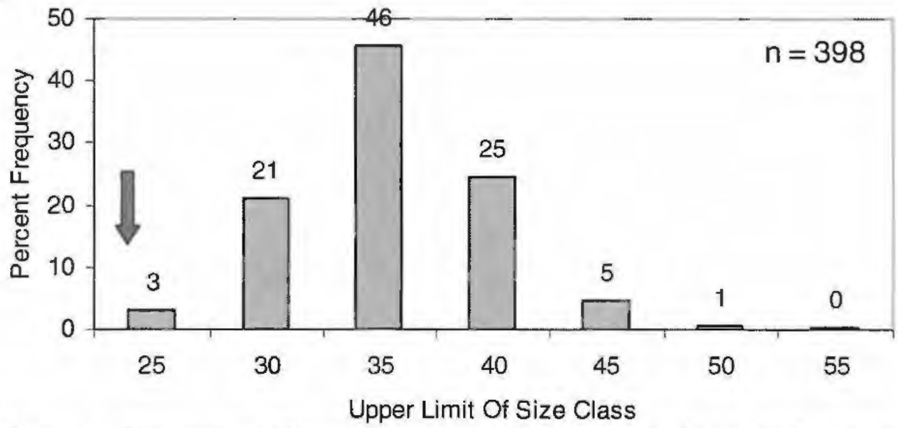


Figure 3.30 a – e. Frequency of size classes caught by recreational and charter fishers. The arrows indicate the minimum size limits.

3.3.3.8 Commercial Deck Boats.

Most commercial fishing within the bay occurs during winter, specifically June and July (Figure 3.31). The amount of fishing effort was consistently higher during these months for all three years. Correspondingly the monthly total catches were also higher during the winter months (Figure 3.32) and contributed a greater proportion of the total monthly catches (Figure 3.33). During 2002 a spike of increased fishing pressure is seen during April, however the total catch during this period was quite low at only 3.25 tons. The total weight of hake indicated to be caught within the bay was 736.249 tons in 2002, 789.282 tons in 2003 and 451.217 tons in 2004, making up 12.44, 28.53 and 31.41 % of the total catches of hake caught by the commercial operators (who offloaded in Plettenberg Bay and supplied one of the two local packing factories) during these years respectively (Table 3.14).

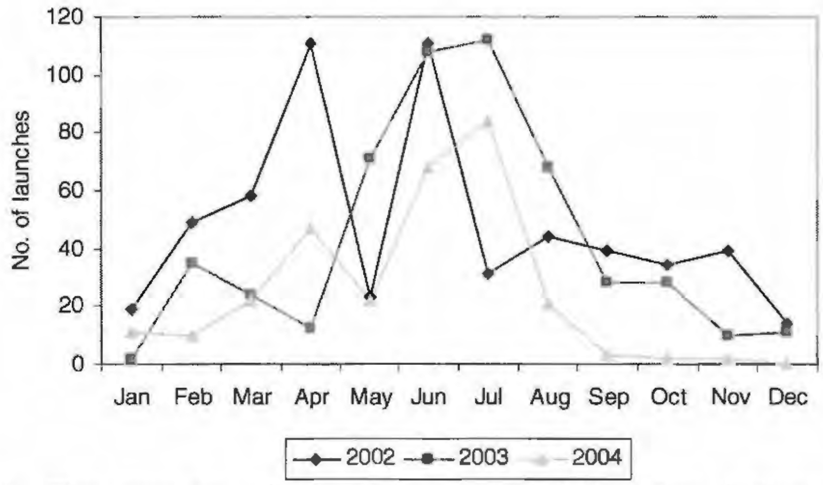


Figure 3.31. The number of logged commercial launches indicating fishing destinations within Plettenberg Bay.

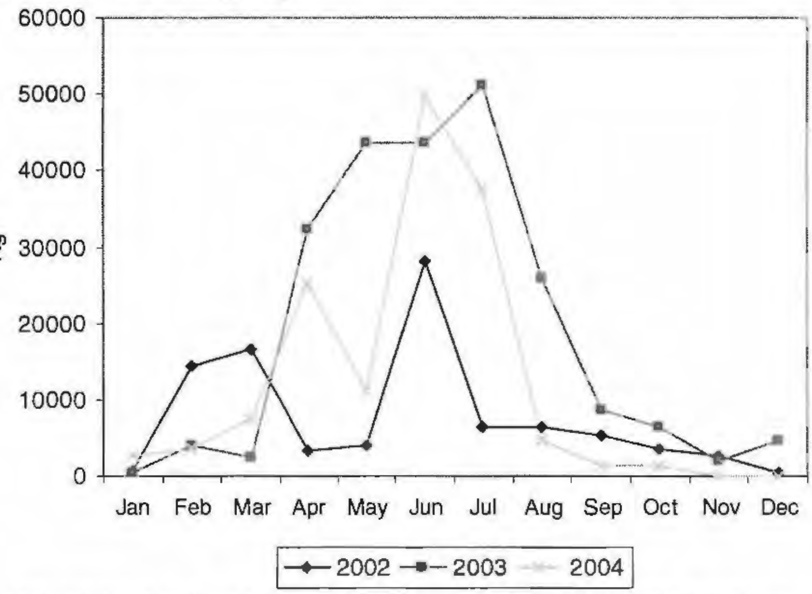


Figure 3.32. Monthly total catches of hake caught within Plettenberg Bay. Note. Catches in 2002 are only taken from one fishing factory due to no packing facilities at the other factory prior to 2003.

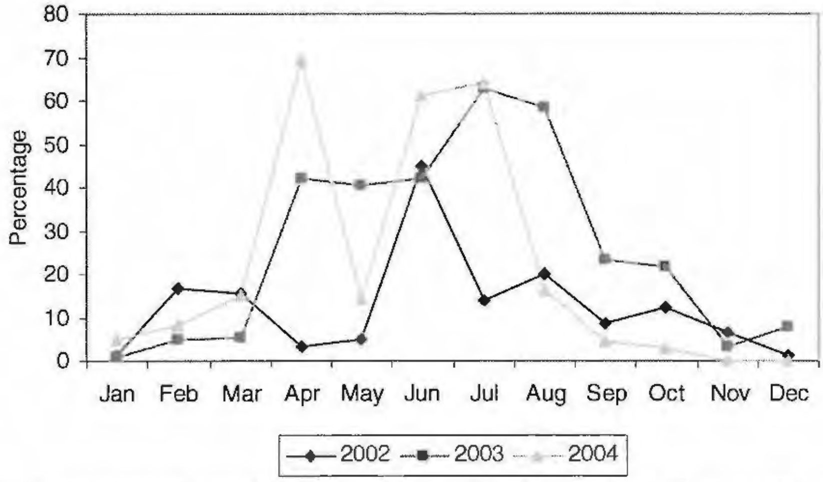


Figure 3.33. The percentage hake caught within Plettenberg bay make up the total monthly hake catches.

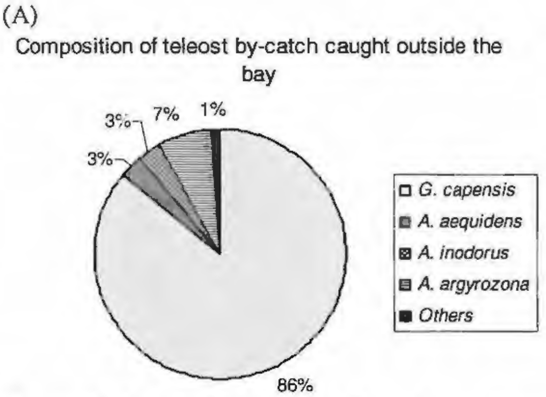
Table 3.14 Percent of total hake catch made up by fish caught within Plettenberg Bay. (Figures only include those boats that offloaded in Plettenberg Bay).

Year	Hake caught in Plett (Kg)	Total yearly hake catch	Percentage of Total Catch
2002	91595.34	736249.8	12.44
2003	225189.2	789282.5	28.53
2004	141748.1	451217.6	31.41

During the by-catch inspections at the two packing facilities, the catch from a total of 167 boats was inspected. Launch records indicate that 62 of these boats had been fishing within the bay. Analysis of the by-catch composition between these boats and the rest (indicated to having been fishing outside the Bay), shows some differences in species composition and abundance in both fish (Figure 3.34 A & B) and shark species caught (Figure 3.35 A & B). Within the Bay the proportion of kingklip caught drops from 81% to only 28% whilst the proportion made up of geelbek increases from 3% to 72%, highlighting the "targeting" of this species during periods of abundance. Total monthly geelbek by-catch caught follows the same pattern as recreational with an increase in summer (Figure 3.36 C). Furthermore, when geelbek are readily available a number of the deckboats targeted this species illegally – their catch comprising predominantly of geelbek thereby exceeding the 10% allowable by-catch. Monthly catches of kob (Figure 3.36 D) shows an increase in kob caught during winter with an overall increase caught during 2004. Both kingklip and silver catches (Figure 3.36 A & B) show a large amount of variation but a general decrease during winter (June, July and August). No roman were sampled during the by-catch inspections and the monthly catch records show that few roman were caught (Figure 3.36 E). There is however a peak in winter during July corresponding to an increase in the number of boats fishing within the Bay.

Although the hound shark (*Mustelus. mustelus*) is the predominant shark species caught both inside and outside the Bay, the proportion this species makes up within the Bay increases from 38% to 51% whilst the Soupfin (*G. galeus*) decreases from 32% to 16%. No blue sharks or mako were caught within the Bay whilst the proportion of bronze whalers increased from 11% to 29%. Monthly catches of sharks (Figure 3.36 F) shows an increase during late autumn and early winter (April, May, June) possibly co-inciding with the start of the sardine run thereby the attraction of greater numbers of sharks, or concentration of sharks particularly bronze whalers into the area.

(A)



(B)

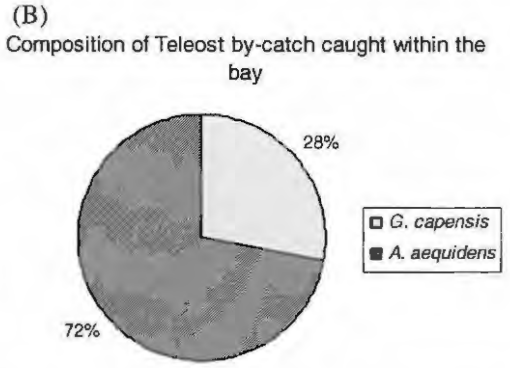


Figure 3.34 Differences in the teleost by-catch caught by commercial hake handline fishers outside the Bay (A) and inside the Bay (B).

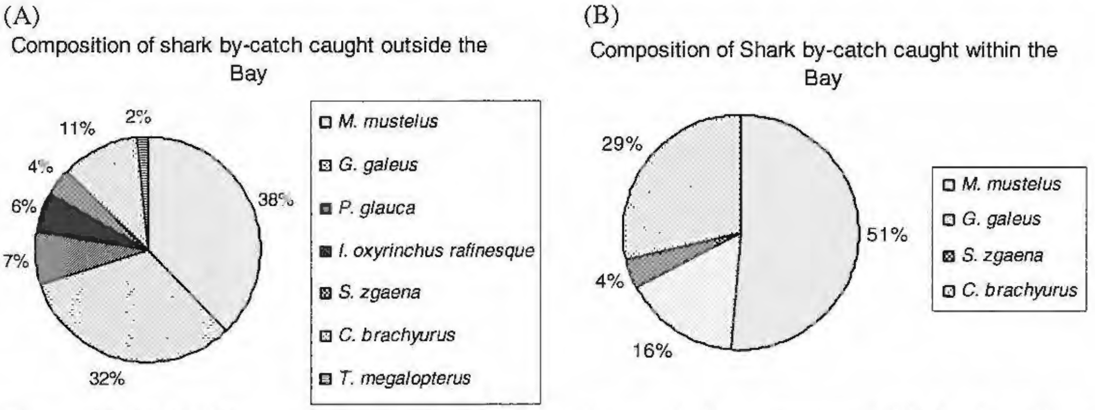


Figure 3.35. Differences in the shark by-catch caught by commercial hake handline fishers outside the Bay (A) and inside the Bay (B).

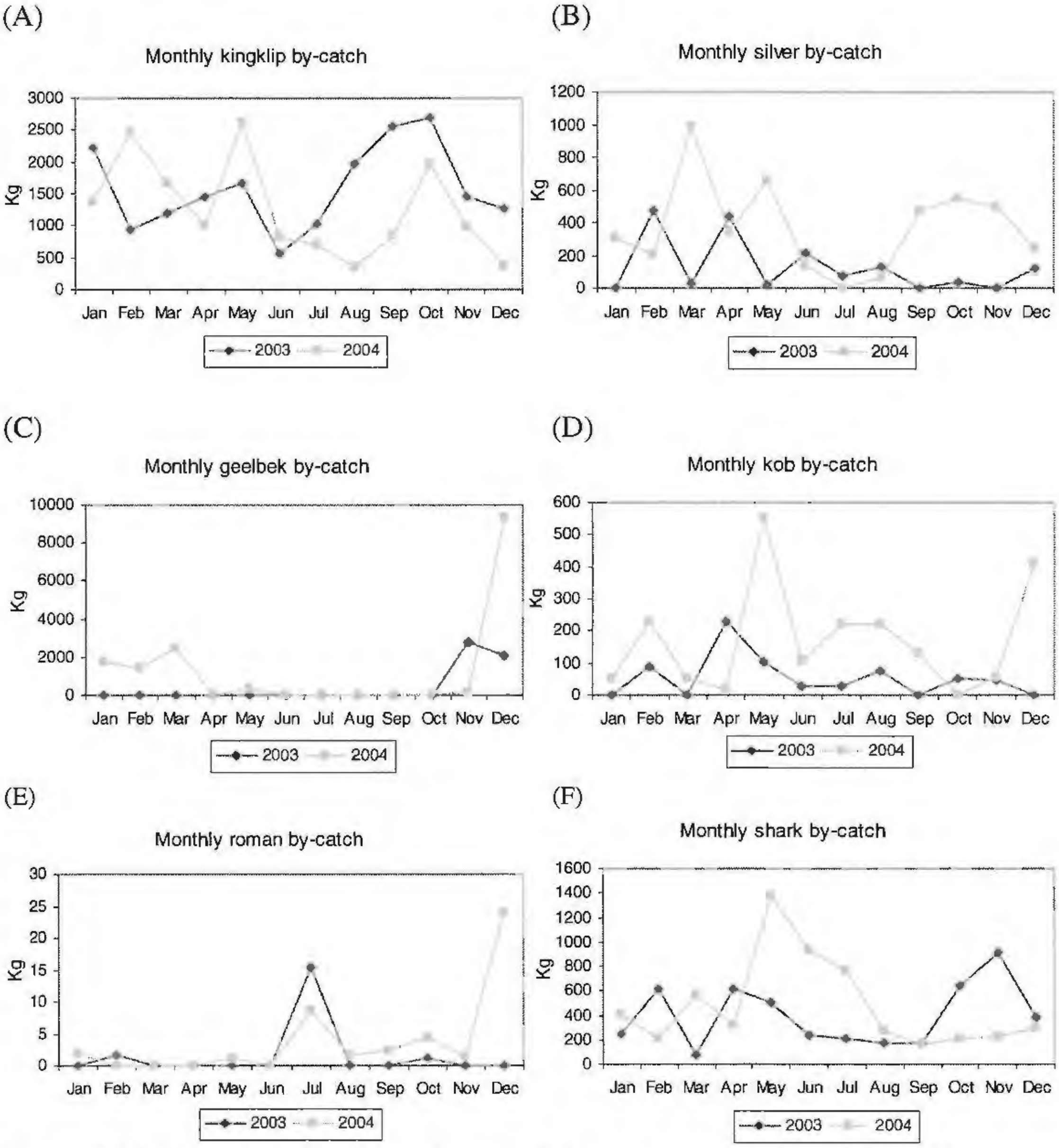


Figure 3.36. Monthly by-catches of certain fish species (A – E) and sharks (F) over a two year period. Data has been obtained from records kept by Plett Fish and Pesca Fresca with the monthly totals combined from each facility to give a total.

3.4 DISCUSSION

Access Point Surveys (APS) have a number of advantages over other fishery survey methods (see Chapter 2) and have been used in a number of studies to estimate fishing effort, total catch and gain insight on economic and social concerns (Malvestuto 1983; Fabrizio *et al* 1991, Osborn & Spiller 1991). Although Essig & Holliday (1991) noted that access point surveys and roving creel surveys (not used in this study) had the lowest source of potential error when compared to other survey methods, Hayne (1991) highlights that during APS one must rely on the truthfulness of anglers in their reporting on where and when they were fishing.

In this regard the use of both boat based surveys and APS to analyse spatial patterns of resource use was worthwhile, each method had its own set of advantages and in combination validated the results. Boat based surveys had the advantage of giving an exact position of a fishing boat, however, this was only a "snap shot" and gave no indication as to other sites fished during the outing. In comparison the access point surveys did not give accurate GPS positions for the spots fished, but gave a greater indication as to patterns in spatial fishing effort by including multiple fishing spots. On the whole all three methods used in this study, (boat based surveys, launch records and APS) showed distinct spatial and temporal patterns in fishing effort with clear differences between the recreational and commercial sectors.

In the past the commercial linefishery has been maintained through effort subsidization in the form of part-time commercial access, multiple access to other fisheries and through a high exchange rate in permit ownership to new entrants

(Griffiths 2000). The division of the linefishery into the three sectors (hake handline, traditional and tuna) the closure of multiple access and the decrease in allocated handline permits have all limited this subsidization. The drop in commercial ski-boat fishers operating within Plettenberg Bay may be directly attributed to the limited number of permits allocated. The recreational fishery, as shown by these results, is expected to increase due to the introduction of new individuals whose motivation for fishing is not the same as commercials. The latter fish purely for financial gain whilst the former fish for a variety of reasons including recreation, competition, food and, in some cases for illegal financial gain (Brouwer 1997). Not surprisingly the importance of ski-boat fishing as a recreational activity for those interviewed has been highlighted during the study scoring an overall 8 out of 10 amongst the fishers. Future studies should however include a specific section in the questionnaire that deals with angler motivation. Fedler & Ditton (1994) warn us that by ignoring angler motivations, managers might not be providing an appropriate balance of angling opportunities to meet public needs fully.

Not only has the division of the linefishery limited effort but it has also minimized the past species overlap between the various fishery sectors (Sauer *et al* 1997). The difference in species targeted has resulted in distinct spatial patterns in fishing effort, with commercial operators (targeting hake) fishing over greater depths, whilst recreational and charter boats targeted a wider range of reef dwelling species found in shallower water. The amount of effort occurring along the borders of the Tsitsikamma National Park is also not unusual. Due to the protection afforded to species by Marine Protected Areas, fishers may congregate around the borders in the hope of catching "surplus" fish.

Recreational and charter fishing within Plettenberg Bay follows a distinct seasonal trend that is an artifact of the distribution of holiday periods rather than seasonal weather patterns. Smale & Buxton (1985) state that the principal fishing periods for the recreational ski-boaters in Port Elizabeth appeared to be related to three factors: holidays, favourable weather and the seasonality of target species. Their study showed that effort varied seasonally, being highest during December through May and lowest between June and November. This summer versus winter trend was also noticed by Brouwer (1997) as a general trend for the Eastern Cape Linefishery. Due to the predominantly holiday nature of the fishing effort within Plettenberg Bay, the seasonality of target species cannot be a large determining factor in the current study. There was however amongst the local fishers a switch in targeted species between the seasons, with hake, silver and panga being targeted more frequently during winter and kob, geelbek and roman being targeted during summer. The most commonly targeted species during the April holiday period was garrick.

Commercial effort in general increases in the Bay during winter when hake could be found in shallower water. Of concern, and in need of further research, is the large proportion of the hake caught during this period that were females with eggs. The movement of hake into the Bay could therefore possibly be a part of a spawning aggregation or migration. If this is proved correct it would make sense to limit the number fish harvested during this period. The by-catch has also been shown to differ when fishing inside the Bay, in particular geelbek, when abundant, is targeted in the Bay. The numbers of sharks caught is of general concern as their life-history traits inherently make them susceptible to overfishing.

Historical trends in catches of both the recreational and commercial sectors of the traditional linefishery have shown significant decreases in CPUE, a decrease in the mean size of species caught and changes in species composition of catches (Crawford & Crous 1982, Smale & Buxton 1985, Hecht & Tilney 1989, Buxton 1993, Brouwer 1997). The current overall CPUE for Plettenberg Bay as estimated from the APS is less than that worked out by Brouwer (1997). Specifically in terms of $Kg.person^{-1}.day^{-1}$ there has been a four fold drop from 12.1±5.3 to the current 3.0±5.54. Numbers of fish per person per day has not dropped to the same degree indicating a greater proportion of catches being made up by smaller fish. Results show that in general the individual weight of caught fish was under a kilogram. The frequency histograms of the fish sizes caught per species also show large numbers of smaller fish being caught. The seasonality of target species mentioned in the above paragraph relates directly to the movement behaviour of the various species. Traditional linefish can be loosely categorized according to three broad movement patterns: 1) resident reef fish showing minimal spatial movement (Buxton & Allen 1989, Griffiths & Wilke 2002), 2) nomadic reef fish that show spatial movement but without pattern (Wilke & Griffiths 1999) and 3) migratory fish whose spatial movements are predictable (Griffiths & Hecht 1995). The seasonal variability and bimodal size frequency distribution of the geelbek is attributed to the seasonal migratory nature of this species (see Griffiths and Hecht 1995), whilst the fluctuation in CPUE for kob is thought to be a result of the aggregating nature of this species with greater catches being made when fishers find an aggregated shoal. On the other hand, the steady CPUE of roman is due to this species being resident. It becomes obvious that resident species would benefit the most from localized management plans that protect the adult population whereas migratory speices may be better protected by seasonal or area closures during times of greater vulnerability to fishing (e.g. spawning migrations into estuaries).

As throughout the rest of South Africa (Sauer *et al* 1997), the majority of skippers interviewed showed concern and were aware of changes occurring in the linefishery, many believing the local fishery had deteriorated with fewer and smaller fish being caught. Although 18% perceived recreational fishing had contributed to this decline, the majority (34%), blamed commercial overfishing. The increase in blame attributed to seals as a cause for the decline in the linefishery is probably due to the increasing local seal population found on the Robberg Peninsula.

Despite the overall fishing experience and concern expressed over the changes in catch composition during this time, knowledge of the current regulation measures amongst the resource users was poor, being below the Eastern Cape and Kwazulu-Natal averages (Brouwer 1997, Sauer *et al* 1997). Knowledge of bag limits was worse than in any of the four study regions assessed during the NMLS. Furthermore few fishers knew who was responsible for managing the offshore resources in South Africa. Brouwer (1997) found a clear correlation between knowledge of the regulations and the frequency of inspection, the more frequent the inspections the greater the knowledge. Fishery inspections within Plettenberg Bay were almost non-existent with most skippers having never been inspected. The lack of law enforcement not only contributes to the poor knowledge base amongst the fishers but can also promote non-compliance. Although most fishers interviewed accepted the current management regulations as being necessary and agreed with them and the majority stating that they always comply, the validity of these results is however in question. Firstly they depend on the honesty of the interviewed fisher and secondly the lack of knowledge by default prevents compliance, if you do not know what the regulations are, you cannot comply with them. Compounding the problem, most incorrect answers given regarding minimum size limits were in fact smaller than actual regulations, meaning those who thought they were complying would still be keeping undersized fish.

Recommendations

The multi-user, multi-species nature and susceptible life history traits of many of the species targeted complicates management of the South African linefishery. However the objective here is not to manage the whole fishery: rather to manage only those fishers operating within Plettenberg Bay, ideally through behavioral change, and secondly to be able to rapidly assess management measures to gauge their overall efficiency. The results of this section of the project have highlighted four management "issues" that will be dealt with below.

The first issue relates to the very poor user knowledge regarding the current management regulations. An aggressive and sustained educational drive needs to be initiated to alleviate this problem. Three methods are proposed: the erection of simple visual signs depicting the regulations at key access points, the dispersal of "info-packs" to the fishermen and the introduction of regular fishery related presentations at the local fishing clubs.

The second issue deals with catch inspections and related compliance. There has to be an increase in the number of random monthly catch inspections carried out. Aspects that need to be addressed in Plettenberg Bay include the sale of fish by recreational fishers, the keeping of undersized fish, specifically geelbek and kob, the illegal targeting of traditional linefish (again specifically kob and geelbek) and sharks by commercial operators with hake handline permits, the chumming for sharks using mammal blood, fishing within the marine reserves specifically within the borders of TNP around Bloukraans and the selling of hake and shark by recreational fishers under commercial vessel names.

The third issue deals specifically with charter operators. It is recommended that the charter fishing business needs to be addressed and formalized at both a local and national level with the allocation of long term, location specific charter fishing rights. The number of permits allocated in different locations should be limited depending on the total reef area within the region of operation. Once successful in obtaining the permit, the holder would then be governed by recreational limits preventing the legal sale of fish caught.

The fourth issue deals with the formulation and introduction of a continuous monitoring programme. It is important that a monitoring program be implemented where total effort, directed effort and catch data is regularly collected.

Although the importance of a long term monitoring programme of greater complexity has been highlighted, of equal importance is the adoption of a monitoring programme that only collects a limited amount of data that can be used as an indication of the overall sustainability state of the fishery. In this regard and in light of the issues highlighted within this project a number of indicators are proposed that could be used to measure sustainability within the three major sustainability domains (Chapter 1). Within the social domain the percent fishers who know the current regulations, the percent fishers who admit to non-compliance and the percent of the catch comprised of undersized fish have been identified as possible indicators. The number of boats inspected within the last year is proposed as an institutional indicator. For various reasons, explained in full in Chapter 5, the roman is proposed as an indicator species within the ecological domain. In relation to this species the following indicators may be used to assess sustainability: the targeted CPUE and the size frequency distribution caught. A full description of the above indicators, the method and rationale involved in their selection is given in Chapter 5.

CHAPTER 4 - REEF FISH COMMUNITY ASSESSMENT

4.1 INTRODUCTION

Of the some 2200 species comprising the southern African fish fauna, about 13 percent are endemic. This species richness is attributed to the variety of habitats found along South Africa's coastline and our positioning between the Indian, Atlantic and Southern Oceans thereby becoming the recipient of species from each of these three separate faunas (Smith & Heemstra 1986). By using distributional patterns of macroalgae (Bolton & Anderson 1990), invertebrates (Emanuel *et al* 1992) and fish (Hockey & Buxton 1989) the southern African coast can be divided into five biogeographical provinces – the cool temperate Namib province and Benguela provinces on the west coast, a warm temperate south coast province and a warm sub-tropical east coast province. Although there is still some debate as to the specific location of the divides between each region both Plettenberg Bay and Tsitsikamma National Park lie within the centre of the warm south coast temperate province. Documentation on the marine ichthyofauna within Tsitsikamma National Park began with the publication of *Fishes of the Tsitsikamma Coastal National* Park (Smith & Smith 1966). This work has been added to by Buxton and Smale (1984) with their preliminary investigation into the ichthyofauna found in the park and Burgers' (1990) study on the species diversity, relative abundance and community structure of the littoral ichthyofauna. In summarising ichthyological research in the park over a 20 year period Wood *et al* (2000) give an updated check list of the ichthyofaunal species assemblage found in the park.

In general, community level ecological studies start with a species list, however, to further understand how the community is structured it is necessary to know the relative abundance, size distribution patterns, species diversity, richness and species evenness of the community assemblages (Burger 1990). Due to the direct impact of fishing and the importance of community-scale interactions between populations (forming the basis of ecosystem structure and function), community assessments are seen as the first step in the building of an ecosystem assessment (Rochet and Trenkel 2003).

In the absence of human induced pressures, fish community assemblages on both spatial and temporal scales are typically a result of the physical environmental parameters encountered (Davidson & Chadderton 1994, Buxton & Smale 1989) modified by biological interactions of populations such as predation, competition, mutualism and recruitment (Garcia-Charton & Perez-Rusafa 1999). Local abiotic factors that have been shown to have an effect on the distribution of species within a community assemblage include: depth (Buxton & Smale 1989, Friedlander & Parrish 1998, Lechanteur & Griffiths 2002, Burger 1990), rugosity (Friedlander & Parrish 1998) and profile (Buxton & Smale 1989). The importance of local water temperature fluctuations in affecting apparent reef-fish assemblage composition has also been highlighted with a decrease in abundance of certain species during cold water periods (Buxton & Smale 1989, Lechanteur & Griffiths 2002). Many of these same studies have also shown the impacts fishing pressure has had on either individual species or the fish community as a whole. The impact of fishing on a community depends on the selective nature of the fishing towards component species, the importance of those species in maintaining community structure (Beddington &

May 1982, Russ & Alcala 1998) and importantly the intensity of the exploitation (May 1984 as cited by Russ & Alcala 1998).

By preventing various forms of human exploitation, specifically fishing (Attwood & Bennett 1995b), marine protected areas can provide a reference point to test hypotheses about the specific impact of fishing pressure on reef fish assemblages. By comparing utilised areas to protected areas on either a spatial scale, with fishing grounds outside a reserve area (Russ & Alcala 1989) or on a temporal scale where fishing is either stopped or resumed, specific effects of fishing on abundance and age structure of fish populations or upon community structure can be assessed (Russ & Alcala 1998). The aim of this part of the project was to firstly compare the reef fish community structure in terms of density, biomass and species richness of a fished reef within Plettenberg Bay to a protected reef within the adjacent marine protected area, and secondly to determine which aspects of the results could be used as indicators to monitor or rapidly assess the state of these fish communities over time.

4.2 METHODS

Two independent survey methods were utilised in this study: instantaneous stationary point counts (Bohnsack & Bannerot 1986, Thresher & Gunn 1986) and experimental angling (Figure 4.1). Due to fish mobility, their quick adjustment to biotic and abiotic factors, and their behavior such as schooling and territoriality reliable abundance estimates gathered via UVC techniques are extremely difficult to obtain. Instead of providing absolute population sizes these types of surveys give an idea of relative abundance (Kimmel 1985, Thresher and Gunn 1986). In consideration of these biases and to give a separate estimation of density with regards to certain important angling species, experimental angling was carried out during the same sampling period and at the same study sites as the diving.

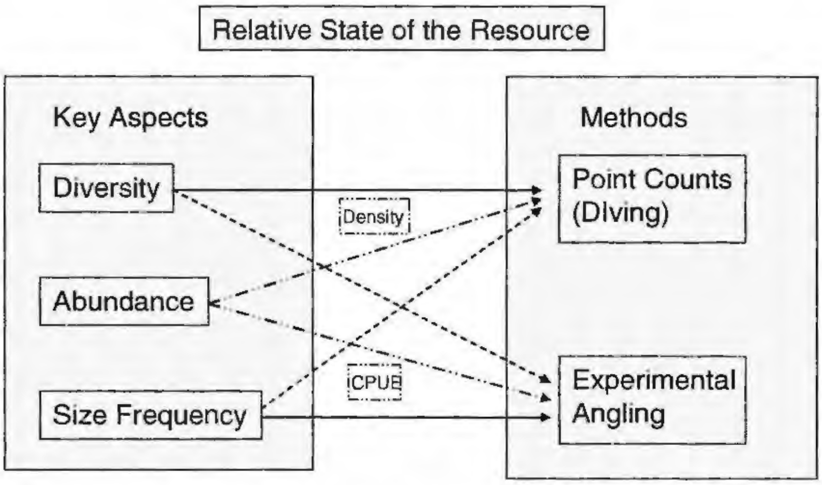


Figure 4.1 The two data collection methods utlised in this section of the current project to determine key aspects in relation to the overall state of the reef fish community structure. Abundance of species in terms of density (m^2) and CPUE was assessed via the point counts and the experimental angling respectively.

4.2.1 Diving Surveys.

Instantaneous point counts were undertaken in the following way. The required depth, depending on whether a deep sample site (16 m to 20 m) or a shallow site (8 m to 12 m) was being surveyed was determined using sonar equipment aboard the dive boat and a shot line dropped onto the reef. Two divers descended to the reef, one staying at the shot line, whilst the other swam out a 10-m swim line marked at 1-m intervals. The 10 m mark became the central pivot point for one stationary point count with 4 such counts completed on 1 dive. The radius of each point depended on visibility but ranged between 3 and 5 m, the meter interval marks on the swim line aided in area estimation. If visibility was below 3 m the dive was aborted. Instantaneous counts along with size class estimations for each species seen within this radius were noted. After completion of one point count the diver swam back to the central shot line and swam out 10m in the opposite direction completing the second point count. The third and fourth points were set perpendicular to the first two (Diagram 4.1). Depth, temperature and a description of the topography and substratum characteristics were recorded for each dive site. Rugosity was determined subjectively (low – few to no holes or small crevices, medium – presence of holes and crevices, high – lots of holes, crevices and or large caves) and profile was described as low if the reef had no rise above 1.5 m, medium if the reef rose sharply between 1.5 and 3 m and high if the reef rose sharply >3 m above the surrounding area. To verify accuracy of estimated fish lengths, practise estimation was conducted prior to sampling using pieces of wood cut to various lengths and set at 3 and 5 m distances. Sizes of live fish were also estimated before being speared and measured. Fish size was estimated in 50 mm size classes from 100 mm to 500+ mm. Data were collected between November 2003 and September 2004 for Plettenberg Bay and between February and September 2004 for Tsitsikamma National Park. Comparative dives were completed within this second time period. This was done to avoid confounding the comparisons between sites with any seasonal effects. However, the results of the entire data set (which includes the comparative data set) has been included to try and show the differences in results achieved between the two sampling sets and argue as to whether it was necessary to place so much effort on comparative (same day) sampling. Due to the harsh sampling environment in relation to weather and water conditions sampling could not be stratified according to month and occurred whenever diving conditions were suitable.

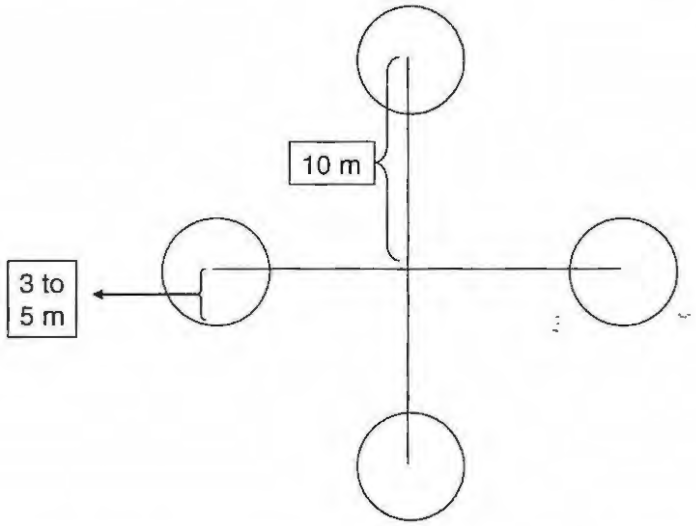


Figure 4.1. Layout of the instantaneous point counts. Four counts were done each dive 10m away from a central pivot point. The sampling radius depended on visibility but ranged from 3 to 5 meters

4.2.2 Experimental angling.

The required depth range was obtained with the use of sonar and the boat anchored. At each sample point two fishers were utilized with the same fishers being used at each site for the comparative study. Fishing rig configuration was standardised with each rod having two barbless hooks on 25 cm trace tied to two swivels above a 30g lead weight, the distance between the swivels was 30cm. One rod was equipped with size 1.0 hooks, aimed at smaller size classes whilst the other had size 5.0 hooks and was aimed at targeting larger size classes. Bait consisted of either squid or pilchard. Only one bait type was used on a sampling trip with bait being alternated between trips. Fishing lasted half an hour and during this time all fish caught were identified, measured to the nearest mm (FL and TL), the air bladder punctured and the fish released. Sampling was carried out between November 2003 and September 2004 for Plettenberg Bay and between February and September 2004 for Tsitsikamma National Park. Comparative fishing stations were completed within this second time period.

4.2.3 Data Analysis

4.2.3.1 Abundance – Diving:

Due to frequent zero counts, numerical count data on fish abundance are often skewed, thereby not satisfying the assumptions of normality and homogeneity of variance that are required by ANOVA (Stephens *et al* 1984, Willis *et al* 2000). For this reason abundance comparisons for all common species was modelled using the Poisson distribution in a generalized linear model analysis of variance procedure. Generalized linear models apply linear regression techniques to nonlinear data with heterogenous variances (Willis *et al* 2000). Within these models the dependant variable consisted of abundance, (species counts) and the possible independent variables consisted of four categorical variables comprising Area Zone (inside the TNP or outside in Plett), Profile, Rugosity and Time Period of sampling and three continuous variables including Depth, Water Temperature and Visibility. These variables represent the characteristics that could potentially affect the structure of local fish assemblages. The initial categorical reef profile was simplified into two classes, High and Low, with the Medium class being incorporated into the High class. Rugosity was similarly simplified into High and Low categories. For time period, sampling days were broken into three, three hour sessions – 07:00 to 10:00, 10:01 – 13:00 and 13:01 – 16:00. The time of sampling was thereby classified as being either One Two or Three representing morning, midday and afternoon sessions. If sampling fell over two time periods the time period where most of the sampling took place was used.

Each species modelled began with an exploratory analysis of how the continuous and categorical variables individually affected the abundance of that species. Scatterplot matrix graphs with Lowess (locally weighted scatterplot smoothing) curves fitted were plotted to investigate the relationships between abundance and the continuous variables - depth, temperature and visibility whilst Mann-Whitney U tests were used to investigate the effect of rugostiy, profile and area of sampling on abundance and Kruskal-Wallis tests were performed on time period of sampling and abundance. The results of these analyses were used to hypothesise a relationship between the presence-absence and abundance of the various species and the independent variables. The most appropriate and robust statistical model for each species was chosen from the priori model using Akaike's Information Criteria (AIC). The final model therefore consisted of only those variables that were highlighted as having a significant affect on the presence-absence and abundance of each species from which an all effects analysis could be run.

4.2.3.2 Abundance – Fishing:

Relative species densities were expressed as fish hr^{-1} of fishing effort, and then modelled using a mixed effects model. Only two categorical variables (Area Zone and Time Period) and two continuous variables (Depth and Water Temperature) were used in the initial model building.

4.2.3.3 Size Frequency Distribution:

Chi-squared and Mann-Whitney U tests were used to test whether there was a significant difference in the size of fish between TNP and Plett from all sampling stations and the comparative subset of both the diving and fishing samples. Non-Parametric testing was used as initial length and natural-log transformed data did not satisfy the requirements of normality for parametric testing ($p < 0.05$).

Mann-Whitney U tests were used to test whether there was a significant difference in the expected size of fish caught during the angling surveys between TNP and Plett from all sampling stations. Student t-tests and ANOVA could not be used due to the assumptions of normality and homogeneity of variance not being met.

To investigate the difference in fish community structure between the two areas, abundance data were logged and subjected to a hierarchical classification using the Bray-Curtis similarity index of group average clustering strategy and ordination by non-metric multidimensional scaling (MDS). Prior to analyses the data were simplified with the removal of all pelagic or known nomadic species. Both analyses were run in Primer v5. The following species diversity indices were calculated for each sample site and compared: Margelef species richness index $d = (S-1)/\ln N$

Shannon-Weiner overall index $H = -\Sigma(n_i/N)\ln(n_i/N)$

Pielou evenness index $e = H/\ln S$

Where S is the total species number, N is the number of individuals of all species and n_i the number of individuals in each species.

4.3 RESULTS

Sampling effort for both diving and fishing was not equally distributed throughout the study period (Table 4.1). This was largely due to adverse weather and sea conditions for certain months, combined with logistical problems. Due to the protected launch site and the generally better sea conditions, (specifically swell), sampling could occur more frequently within Plettenberg Bay than in the Tsitsikamma National Park.

Table 4.1 Number of dives and fishing stations completed each month within the two sampling areas. Number in brackets denotes the number of comparative sampling stations. Plett = Plettenberg Bay, TNP = Tsitsikamma National Park

Sampling Effort Breakdown per Month												
		Nov 03	Dec 04	Jan 04	Feb 04	Mar 04	Apr 04	May 04	Jun 04	Jul 04	Aug 04	Sep 04
Diving	Plett	5	3	4	5(2)	0	3(3)	1	9(8)	6(6)	15(12)	4(3)
	TNP	0	0	0	2(2)	0	3(3)	0	8(8)	6(6)	12(12)	5(3)
Fishing	Plett	9	3	6	4(4)	2(2)	6(5)	5(4)	12(8)	9(6)	11(5)	11(5)
	TNP	0	0	0	4(4)	2(2)	5(5)	7(4)	9(8)	7(6)	5(5)	5(5)

In total, 91 dives comprising 364 counts covering 24 002 m^2 of reef and 120 fishing stations representing 120 hours of fishing were completed. Of these 68 dives and 78 fishing stations were comparative (ie sampling had occurred on the same day between Plett and TNP). With the exception of the total number of dives, there was no statistical difference between the numbers of sampling stations done in each area (Plett vs. TNP) and the three time periods of morning (1), midday (2) and afternoon (3) (Table 4.2).

Table 4.2 The number of dives and fishing stations completed in each time period between the two sampling areas. Bracketed numbers indicate the number of comparative sampling stations. All dives (chi-square: 7.8, df: 2, p-value < 0.05). All fishing (chi-square: 5.494, df: 2, p-value > 0.05). Comparative dives (chi-square: 0.666, df: 2, p-value > 0.05). Comparative fishing (chi-square: 2.519, df: 2, p-value > 0.05).

Sampling Effort Per Area per Time Period				
		Time Period		
		1	2	3
Diving	Plett	12 (12)	24 (7)	17 (15)
	TNP	18 (15)	8 (7)	12 (12)
Fishing	Plett	19 (12)	22 (5)	35 (22)
	TNP	20 (17)	8 (7)	16 (15)

4.3.1 Diving - Point Counts:

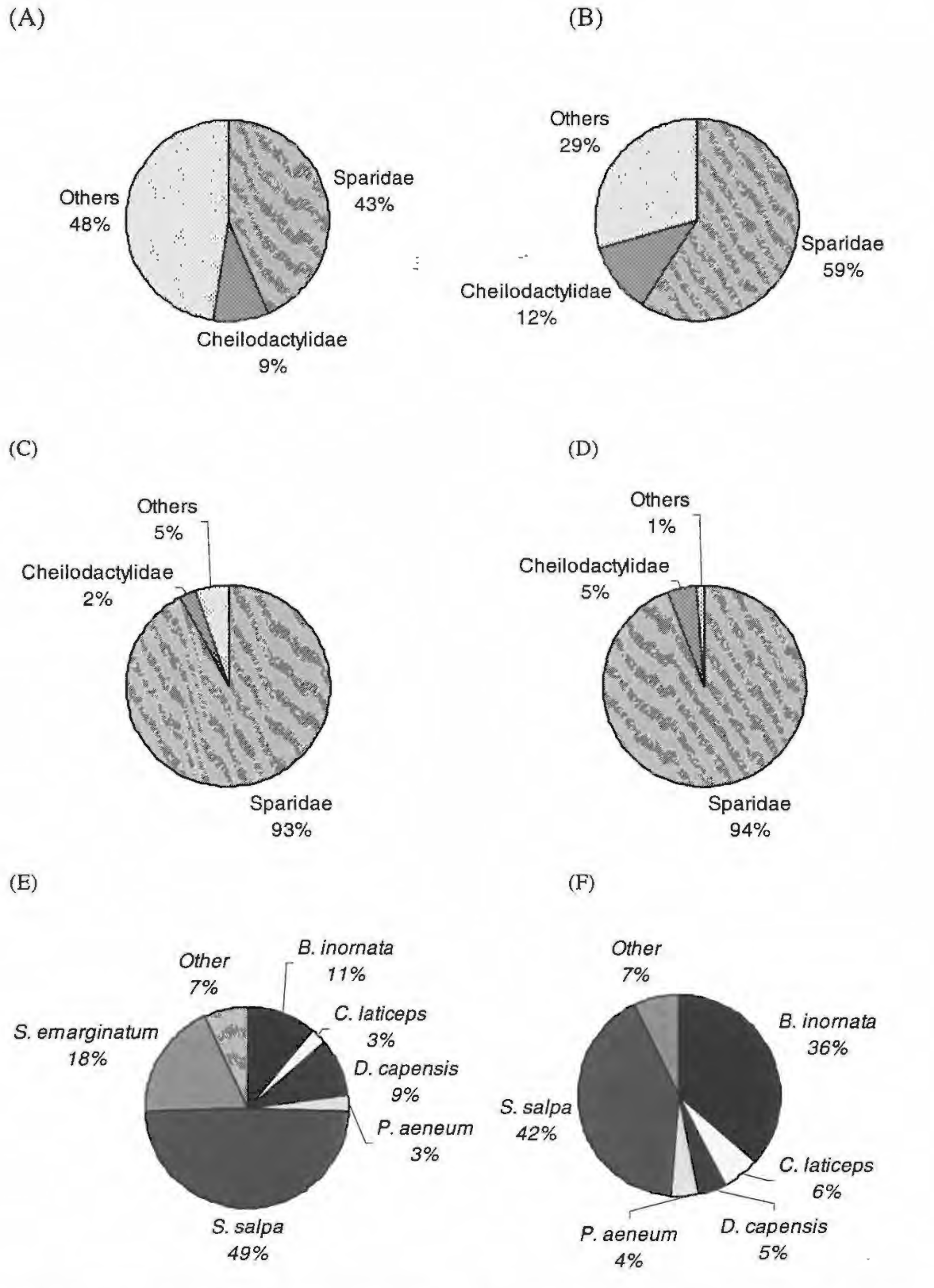
Table 4.3 provides a species checklist of the fish recorded during the diving surveys. Overall 24299 fish representing 54 species and 23 families were counted, 46 species from 19 families were recorded within Plettenberg Bay and 34 species from 11 families within the Tsitsikamma National Park. The family Sparidae dominated suprabenthic species diversity in both areas making up 43.5% and 92.1% of the species and total fish numbers within Plettenberg Bay and 58.8% and 94.3% respectively within TNP. Cheilodactylidae with four species comprising 8.7% and 11.8% of the total species in each area made up 2.5% and 4.6% of total fish numbers within Plettenberg Bay and TNP (Figures 4.1 A - D). Within the family Sparidae, *S. salpa* was the most dominant species making up 49% of the total fish within this family in Plett and 42% in TNP. *B. inornata* made up only 11% within Plett and 36% within TNP. In contrast *S.emarginatum* formed 18% of all sparid fish counted in Plett but made up less than 3% in TNP. *C. laticeps* made up 3% in Plett and 6% in TNP (Figure 4.1 E & F).

Table 4.3 Fishes recorded during the diving surveys.
* = Species only recorded within TNP
^ = Species only recorded within Plettenberg Bay
S = Subtidal reef
P = Pelagic
# = Endemic to southern Africa (Namibia to Mozambique)

Family / Species	Common Name	Distribution
CARCHARHINIDAE		
Triakis megalopterus	Gully Shark *	S #
SCYLIORHINIDAE		
Haploblepharus edwardsii	Puffadder Shyshark ^	S #
Poroderma africanum	Pyjama Shark	S #
Poroderma pantherinum	Leopard Catshark *	S #
LAMNIDAE		
Carcahrodon carcharias	Great White Shark *	P
ARIIDAE		
Galeichthys feliceps	Barbel ^	S #
TRIGLIDAE		
Chelidonichthys kumu	Bluefin Gurnard ^	S #
SERRANIDAE		
Acanthistius sebastoides	Koester	S #
Epinephilus marginatus	Yellow Belly rockcod ^	S
Serranus knysnaensis	African Seabass ^	S #
POMATOMIDAE		
Pomatomus saltatrix	Shad	S P #
HAEMULIDAE		
Pomadasys olivaceum	Pinky ^	S
SPARIDAE		
Argyrozona argyrozona	Silver ^	S #
Boopsoidea inornata	Fransmadam	S #

Cheimerius nufar	Santer	S
Chrysoblephus cristiceps	Dageraad *	S #
Chrysoblephus gibbiceps	Red Stumpnose	S #
Chrysoblephus laticeps	Roman	S #
Cymatoceps nasutus	Poenskop ^	S #
Diplodus cervinus hottentotus	Zebra	S
Diplodus sargus capensis	Blacktail	S
Gymnocrotaphus curvidens	Jan Bruin	S #
Lithognathus lithognathus	White Steenbras *	S #
Lithognathus mormyrus	Sand Steenbras	S
Pachymetopon blochii	Hottentot ^	S #
Pachymetopon aeneum	Blue Hottentot	S #
Pachymetopon grande	Bronze Bream	S #
Pagellus bellottii natalensis	Red Tjor Tjor	S
Petrus rupestris	Red Steenbras	S #
Porcostoma dentate	Dane *	S
Rhabdosargus globiceps	White stumpnose	S #
Rhabdosargus capensis	Cape Stumpnose	S #
Sarpa salpa	Strepie	S
Sparodon durbanensis	White Musselcracker	S #
Spondyliosoma emarginatum	Steentjie	S #
CORACINIDAE		
Dichistius capensis	Galjoen *	S #
PARASCORPIDIDAE		
Parascorpis typus	Jut Jaw	S #
MULLIDAE		
Paupeneus rubescens	Blacksaddle Goatfish ^	S
SCIAENIDAE		
Atractoscion aequidens	Geelbek ^	S P
Umbrina canariensis	Baardman ^	S
CHAETODONTIDAE		
Chaetodon marlei	Doublesash Butterfly	S #
OPLEGNATHIDAE		
Oplegnathus conwayi	Cape Knifejaw	S #
CARANGIDAE		
Seriola dumerili	Greater Yellowtail ^	S P
Lichia amia	Garrick ^	S P
CHEILODACTYLIDAE		
Cheilodactylus fasciatus	Red Finger	S #
Chirodactylus brachydactylus	Two Tone Fingerfin	S #
Chirodactylus grande	Bank Steenbras ^	S #
MUGILIDAE		
Liza richardsonii	Mullet ^	S #
CLINIDAE		
Pavoclinus gaminis	Grass Klipvis	S #
TETRAODONTIDAE		
Arothron nigropunctatus	Blackspotted Blaasop ^	S
CLUPLEIDAE		
Engraulis capensis	Anchovy ^	S
POMACENTRIDAE		
Abudefduf sordidus	Spot Damselfish ^	S #
SCOMBRIDAE		
Scomber japonicus	Mackerel	S

Table 4.4 shows the average species densities between Plett and TNP. Densities are given as fish/m^2 and fish/100 m^2, the results of the current study are compared to the results recorded by Buxton & Smale (1989) and Burger (1990). Comparisons between the current and past studies are limited due to different sampling strategies, they do however provide a rough reference. Whilst Burger (1990) utilised transect counts as opposed to the stationary point counts used in the current study Buxton & Smale (1989) used both methods. Although density estimates for fransmadam within Plettenberg Bay are similar to those of Burger (1990) the density estimates for TNP taken from the current study are almost four times as great. In contrast steentjie estimates were similar for TNP but the current estimates for Plettenberg Bay were almost nine times greater. Present roman densities within TNP are almost twice those of both Buxton & Smale (1989) and Burger (1990). The density estimates of red steenbras compare favourably with those of Burger (1990) and Buxton and Smale (1989). Burger recorded density estimates of 0.0045 fish/m^2, whilst Buxton and Smale recorded densities of 0.002 fish/m^2 for the Knoll and an overall density of 0.013 fish/m^2 within TNP.



Figure's 4.1 : Percentage composition of the constituent families between Plettenberg Bay (A) and TNP (B). Percent composition of total fish numbers made up by each family between Plettenberg Bay (C) and TNP (D). Percentage composition of the dominant species falling within the family Sparidae between Plettenberg Bay (E) and TNP (F).

Table 4.4 Species densities worked out per sampling area with all dives combined as fish/m^2 and fish/100m^2. Comparisons where possible are given as fish/m^2. Blank spaces indicate that no individuals of that species were seen in that location.
* = only one individual seen therefore no Stdev.

	Plettenberg Bay (13640m^2)				Tsitsikamma National Park (10362m^2)				
Species	Avg (m^2)	100m^2	Stdev	Burger	Avg (m^2)	100m^2	Stdev	Buxton	Burger
C. grandis	0.005	0.487	0.003						<0.0001
D. s. capensis	0.107	10.706	0.111		0.034	3.362	0.025		0.005
P. aeneum	0.036	3.572	0.030	0.0675	0.047	4.715	0.041		0.086
P. grande	0.008	0.835	0.005	0.0003	0.007	0.743	0.007		0.0005
O. conwayi	0.009	0.939	0.006	0.005	0.012	1.248	0.004		0.0071
R. holubi	0.016	1.629	0.017	0.0007	0.009	0.869	0.004		0.0009
P. dentata					0.003	0.318	*		
C. cristiceps				0.0002	0.004	0.424	0.002		0.0001
C. marleyi	0.007	0.656	0.004	0.0002	0.004	0.409	0.002		0.0001
B. inornata	0.137	13.720	0.115	0.114	0.254	25.372	0.137		0.068
C. capensis					0.006	0.590	0.003		
P. blochii	0.010	0.955	0.009						
G. curvidens	0.011	1.112	0.007	0.0039	0.010	1.019	0.005		0.0043
P. typus	0.004	0.443	0.002		0.003	0.318	*		
A. sebastoides	0.004	0.413	0.002	0.002	0.003	0.318	0.000		0.0027
P.olivaceum	0.112	11.243	0.126						0.0028
C. nasutus	0.007	0.743	0.005						<0.0001
H. pictus	0.003	0.318	0.000						
P. africanum	0.006	0.634	0.007	0.0005	0.003	0.318	0.000		0.0017
C. fasciatus	0.013	1.290	0.009	0.0073	0.010	1.040	0.007		0.0082
P. rupestris	0.005	0.509	0.003	0.0005	0.006	0.552	0.003	0.002	0.005
C. gibbiceps	0.009	0.915	0.007	0.0019	0.003	0.318	0.000		0.000
P. natalensis	0.079	7.949	0.115						
C. laticeps	0.028	2.790	0.013	0.0164	0.043	4.256	0.025	0.023	0.021
L. mormyrus	0.018	1.790	0.013	<0.0001	0.006	0.637	*		<0.0001
C. nufar	0.011	1.134	0.011	0.0002					<0.0001
P. saltatrix	0.005	0.507	0.003						
A. argryrzona	0.102	10.197	0.211						
S. emarginatum	0.205	20.510	0.150	0.0169	0.022	2.206	0.035		0.028
S. salpa	0.685	68.466	0.653	0.0098	0.539	53.937	0.527		0.0082
C. brachydactylus	0.035	3.520	0.020	0.0406	0.030	3.029	0.015		0.042
S. durbanensis	0.005	0.477	0.002		0.018	1.795	0.024		<0.0001
R. globiceps	0.050	5.006	0.097						<0.0001
D. hottentotus	0.028	2.813	0.021		0.013	1.259	0.007		

The three diversity indices calculated for the suprabenthic ichthyofauna within TNP and Plettenberg Bay are shown in Table 4.5. The study sites have been divided up into shallow and deep reef systems for comparison. The Margalef species richness index (which measures diversity without considering the relative proportion of each species (Krebs 1985)), showed that the greatest diversity of fish were found at the deep reef within Plettenberg Bay (higher numbers indicate greater diversity). The species richness for the other three sites were very similar indicating little difference. Both the Shannon-Weaver index (which is influenced by both the presence of species and their relative proportion of the community (Krebs 1985)), and the Pieloue evenness index indicate that the species were more evenly distributed over the deep reef within TNP followed by the shallow reef in Plett (higher numbers indicates a more even distribution). This indicates that although there was a greater diversity of species seen on the deep reef within Plett some of these species were seen infrequently and in small numbers. The shallow reef within TNP had the lowest Shannon-Weaver and Pieloue indices indicating a dominance of a few species over this reef.

Table 4.5 Species diversity indices for suprabenthic ichthyofauna at the four sites sampled.

Area	Species	Individuals	Diversity Measure		
			Margalef	Shannon	Pieloue
Shallow – Plett	27	7170	2.93	1.84	0.56
Shallow - TNP	25	4293	2.90	1.26	0.39
Deep – Plett	34	6667	3.75	1.83	0.52
Deep – TNP	25	3560	2.94	1.97	0.61

Figure 4.2.A shows the ordination performed on the transformed individual dive counts for comparative dives only. Although there is variation between dives at each

dive site, the sites can be loosely grouped. Bray-Curtis similarity clustering indicates that this grouping occurs at around a 70% similarity (Appendix IV). Cluster analysis performed on a summary of the data where individual counts were combined for each species at each sample site showed that sites within Plettenberg bay were most similar at around 75%. This group was in turn about 65% similar to the shallow dive site in TNP. The deep reef in TNP had only a 50% similarity to all other sites (Figure 4.2.B). Species dominance between the two areas is shown in Figure 4.2.C. Although strepie was the most dominant species in both areas there was considerable difference in the dominance of roman, steentjie, fransmadam and blacktail between the areas. Both fransmadam and roman were more dominant within TNP whilst steentjie was far more dominant in Plett. In both Plett and TNP blacktail were the fourth most dominant species, but in relation to roman, blacktail were more dominant within Plett.

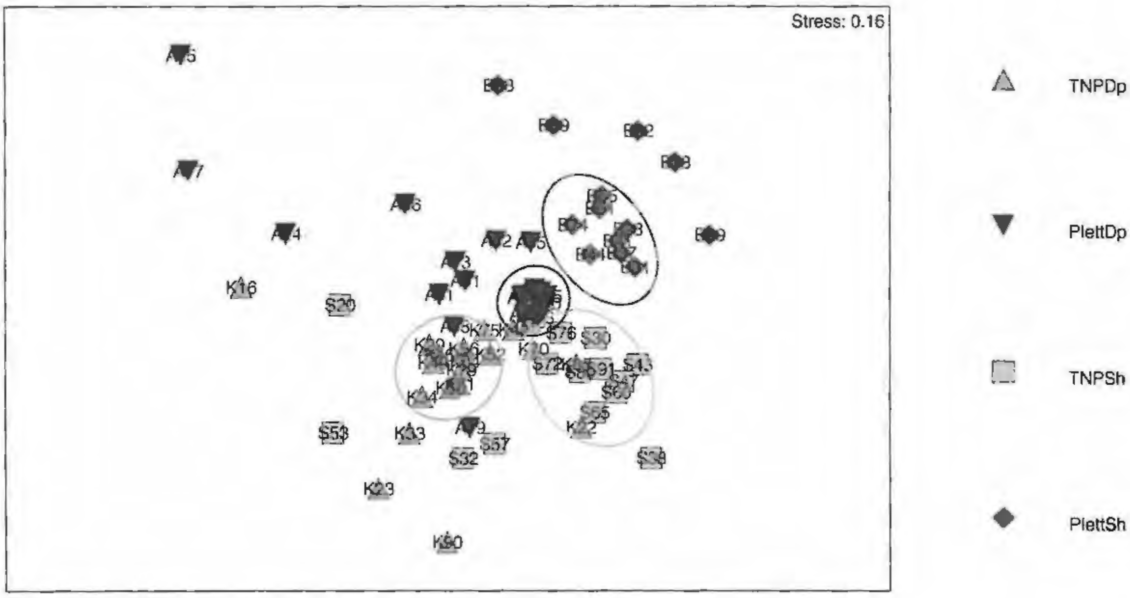


Figure 4.2 A Multi–dimensional scaling plot depicting the spatial relationship of the dive assemblages.

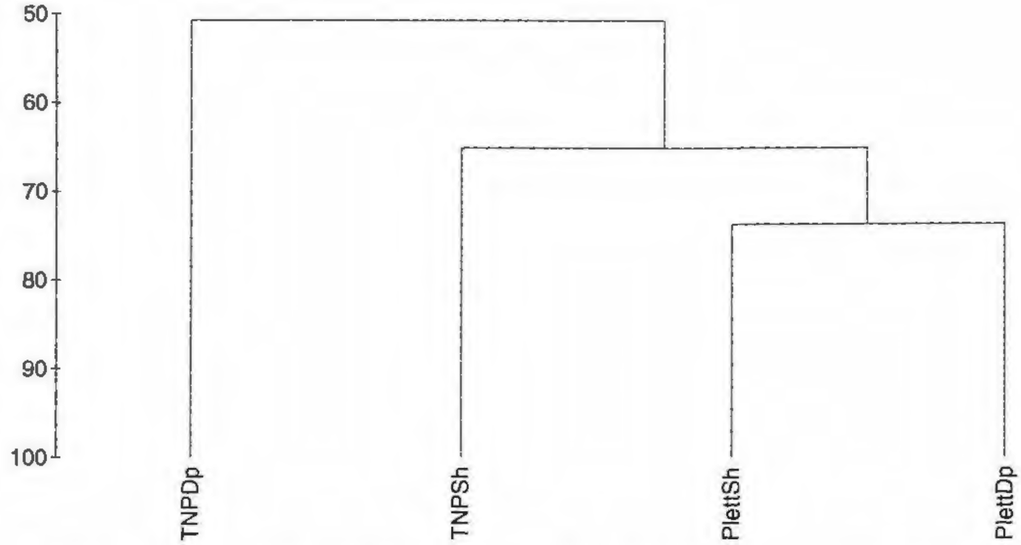


Figure 4.2.B. Bray-Curtis similarity among the reef fish assemblages of each dive sample site once the data were aggregated for each site.

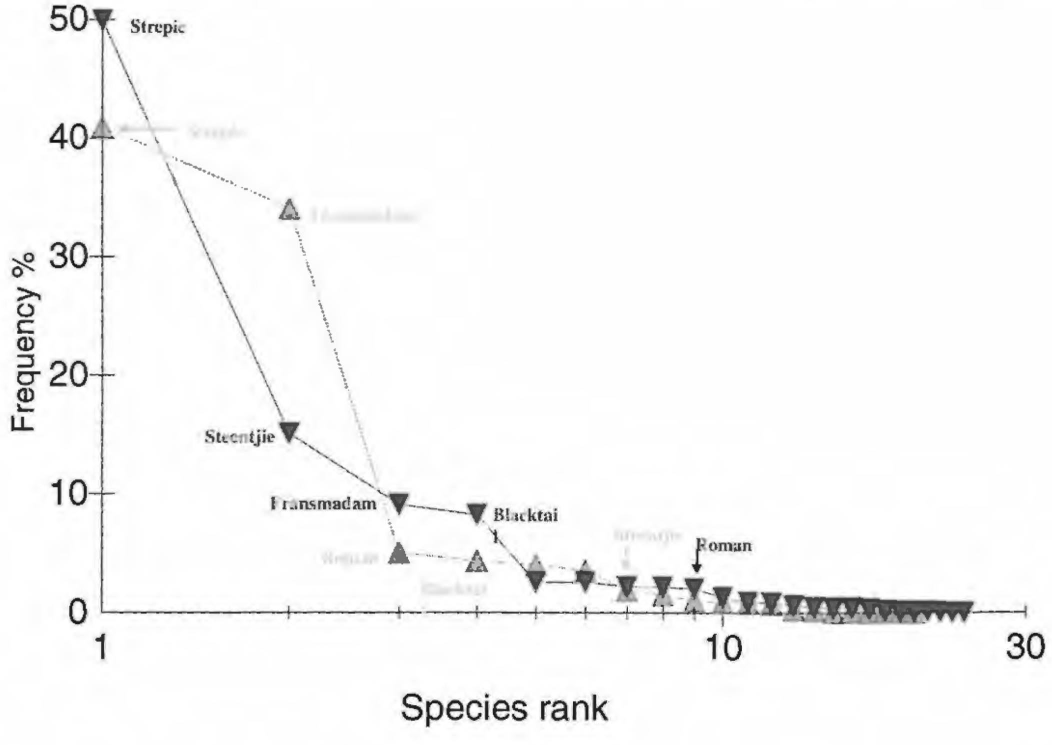


Figure 4.2C. Comparison of the species dominance plots between the two sampling areas.

Abundance modelling was carried out on nine species due to either their numerical importance and or fishery importance (e.g. *C. laticeps*). The results of the initial non-parametric data analyses are given in table 4.6. The tests were run on the entire data set comprising all dives completed during the study period and again on only the comparative dives where the different study sites were sampled on the same day. In six out of the nine species analysed the results from the comparative sub-set showed the same variables affecting species abundance as the complete data set. The area of sampling (either Plettenberg Bay or TNP) seemed to have the greatest influence with four species (blacktail, fransmadam, steentjie and zebra) showing a significant difference in abundance between the two sampling areas on comparative dives whilst roman also showed a difference with the entire data set. Rugosity had an apparent effect on blue hottentot, fransmadam and roman for both sample sets. Profile and time period had the least influence on individual species abundance.

Table 4.6. Initial results of the exploratory data analysis performed on the effect of selected categorical variables on species abundance. Values in bold indicate a significant influence.

Expolratroy Data Analysis (p-values)								
	All Dives				Comparative Dives			
	Predictor Variables				Predictor Variables			
	Mann-Whitney U test			Kruskal-Wallice	Mann-Whitney U test			Kruskal-Wallice
Species	Profile	Rugosity	Zone	Time Period	Profile	Rugosity	Zone	Time Period
D. s. capensis	0.090660	0.482057	**0.000598**	0.403400	0.121332	0.777051	**0.004058**	0.661100
P. aeneum	0.093520	**0.003596**	0.214382	0.195300	0.154241	**0.004995**	0.515009	0.278200
O. conwayi	0.435755	0.235640	0.109189	**0.021500**	0.116753	0.045306	0.704290	0.503900
B. inornata	0.883377	**0.000245**	**0.000057**	0.101600	0.954123	**0.003486**	**0.001663**	**0.326500**
C. faciatus	0.521246	0.054865	0.502416	0.336800	0.393011	0.065100	0.226898	0.592500
C. laticeps	0.131206	**0.001915**	**0.006008**	0.476500	0.133743	**0.000660**	0.080579	0.851500
S. emarginatum	0.719806	0.265681	**0.000000**	**0.016100**	0.827063	0.064705	**0.000000**	0.111400
C. brachydactylus	0.712442	0.195093	0.608800	0.460300	0.477148	0.230457	0.228521	0.365100
D. hottentotus	**0.017389**	0.267757	**0.002020**	0.583900	**0.014639**	0.976749	**0.001361**	0.396800

The scatterplot matrix graphs with abundance of each species plotted against depth, water temperature and visibility are shown in Appendix V. Although depth has been treated as a continuous variable, the dive sites only represent two depth regions being either shallow with a range of 8 to 12 meters or deep with a range of 15 to 20 meters.

Relationships in abundance can therefore only be equated to these depths and will not show trends outside this range. The relationship between depth and abundance was most noticeable for *P. aeneum, O. conwayi* and *C. laticeps* with their being an apparent increase in abundance at the deeper sampling sites. *C. fasciatus* and *D. hottentotus* appeared to have increased abundance at the shallow sites.

Temperature ranged from 10°C to 20°C with an average of 16°C. Thirty four percent of all dives were completed at this temperature with 77% of all dives having been completed within a 4° range from 14°C to 17°C. The limited sampling data outside this range may mask any true effect temperature has had on the apparent abundance of certain species (Table 4.7). Generally all species showed a decrease in abundance at temperatures below 14 °C.

Visibility ranged from 3 meters to 20 meters during the study period with an overall average of 7 meters. Although the radius of each point count only ranged from 3 to 5 meters, *P. aeneum, O. conwayi, B. inornata, C. fasciatus, C. brachydactylus* and *C. laticeps* show a general trend of an increase in abundance with an increase in visibility. For the more cryptic species (*C. fasciatus, C. brachydactylus*) this is most likely due to the increased ability to spot individual fish in cleaner water. For the other species this trend could be in part due to an over estimation on sampling area by the diver or increased attraction to the diver by these species. It was noted on the extremely clear days that in particular *P. aeneum* and *B. inornata* would converge on the diver (including descent and ascent) this seemed to bring in others that were initially beyond the visibility limits.

Table 4.7. Percentage of dives completed under various visibility conditions and water temperatures.

Visibility (m)	3	3.5	4	5	6	7	8	9	10	11	12	15	18	20
Plett	23.64	1.82	12.73	5.45	12.73	10.91	18.18	0	5.45	0	9.09	0	0	0
TNP	8.33	2.78	8.33	13.89	11.11	8.33	2.78	8.33	16.67	2.78	8.33	2.78	2.78	2.78
Temperature (°C)	10	12	13	14	15	16	17	18	19	19.5	20			
Plett	1.82	0	1.82	14.55	12.73	32.73	10.91	3.64	10.91	3.64	7.27			
TNP	0	5.56	5.56	8.33	22.22	36.11	19.44	2.78	0	0	0			

A summary of the results obtained from the Generalised Linear Modelling (GLZ) run with an all effects on the predetermined best variable subset for each species is given in Table 4.8. The influence these variables had on the abundance of different species is given in Table 4.9. Appendix VI graphically illustrates these influences.

Table 4.8. Significant variables included in the final GLZ model for the various species. Blocks with no values indicate variables that were excluded from the final model.
T = Total dives C = Comparative dives only

Generalized Liner Modeling (p - values)								
		Predictor Variables						
Species		Profile	Rugosity	Zone	Time Period	Depth	Temperature	Visibility
D. s. capensis	T	0.000000	0.009869	0.000000	0.000000	0.000000	0.000000	0.000000
	C	0.012577	0.000008	0.000000	0.000000	0.000000	0.000003	0.000000
P. aeneum	T	0.000041	0.000008		0.000000	0.000000		0.000000
	C	0.008735	0.000005		0.000448	0.000000	0.006824	0.000001
O. conwayi	T				0.021932			0.001920
	C							0.014056
B. inornata	T		0.000000	0.000000	0.000000			0.000000
	C	0.000242	0.000000	0.000000	0.000000	0.000000	0.000133	0.000000
C. fasciatus	T		0.000255					0.000940
	C					0.000139		0.025102
S. emarginatum	T	0.000000	0.004683	0.000000	0.000000	0.000000	0.000000	0.001738
	C	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	
C. brachydactylus	T			0.016106		0.003676		0.000000
	C			0.003775				
D. hottentotus	T	0.000322		0.000000		0.000003	0.001289	
	C	0.007469	0.001565	0.000000		0.000000	0.006371	0.000000
C. laticeps	T		0.001538	0.000000	0.003116	0.005013		
	C	0.039824	0.000192	0.000060	0.007608	0.003445		

The abundance of a number of species was affected by both profile and rugosity ($p < 0.05$). Abundance of *D. s. capensis*, *S. emarginatum* and *D. hottentotus* increased as profile increased whilst *P. aeneum*, *B. inornata* and *C. laticeps* were more abundant over lower profile reefs. With the exception of *S. emarginatum* abundance of these species was also highest over high rugosity reefs. Interestingly *B. inornata* and *S. emarginatum* show opposite results with more *S. emarginatum* over high profile, low rugosity reefs whilst *B. inornata* were more abundant over low profile high rugostiy reefs. With the exception of *O. conwayi*, depth influenced ($p < 0.001$) species abundance. Whilst most species were more abundant at the deeper study sites only *D. hottentotus* had a clear trend of increased numbers at the shallower depths. A greater abundance for some species was found to occur at warmer temperatures and during periods of better visibility. There was also a difference in the abundance of most species between the different sampling periods. Specifically increased numbers were encountered during the early and late sampling sessions. Of particular importance to the current study was the number of species that showed differences in abundance between the two sampling zones. *D. s. capensis*, *S. emarginatum* and *C. brachydactylus* showed increases in abundance within Plettenberg Bay, whilst *B. inornata*, *D. hottentotus* and *C. laticeps* were the opposite with greater numbers in the Tsitsikamma National Park. Multi-dimensional bubble plots depicting the spatial relationship and observed abundance of these species are shown in Appendix VII.

Table 4.9. The influence on abundance that the variables in table 4.8 had on different species. Arrows indicate the effect on abundance. Blank blocks indicate the variables had no effect. ? indicates that although the variable had a significant effect the trends could not be seen in the continuous variable scatterplots.

Species	High Profile	Low Profile	High Rugosity	Low Rugosity	Zone	Deep	Shallow	Greater Temp.	Viz	Time
D.s.capensis	↑	↓	↑	↓	**Plett**	?	?	?	?	1
P. aeneum	↓	↑	↑	↓		↑	↓	↑	↑	1
O. conwayi									↑	
B. inornata	↓	↑	↑	↓	**TNP**	↑	↓	↑	↑	1
C. fasciatus						↓	↑		↑	
S. emarginatum	↑	↓	↓	↑	**Plett**	↑	↓	↑		2+3
C. brachydactylus					**Plett**					
D. hottentotus	↑	↓	↑	↓	**TNP**	↓	↑	↑	?	
C. laticeps	↓	↑	↑	↓	**TNP**	↑	↓			

Size class frequencies were only calculated for those species that are known to be targeted by fishers and therefore could possibly show differences between the protected (TNP) and exploited (Plettenberg Bay) sampling sites. Figures 4.5 to 4.9 show the results of the comparison in size class frequencies for five species. Due to low sample sizes the size class frequencies for certain species could not be compared e.g. *C. cristiceps*, *C. gibbiceps*, *P. rupestris, and S. durbanensis*

D. s. capensis

There was a significant relationship between the area of sampling and the size frequencies of *D. s. capensis* seen (Chi-sq = 18.81082, df = 5, p = 0.00209). From the frequency histogram in figure 4.5 it can be seen that within Plettenberg Bay, in which fishing occurs, there are greater numbers of individuals within the smaller size classes whereas within TNP there were greater numbers of larger fish.

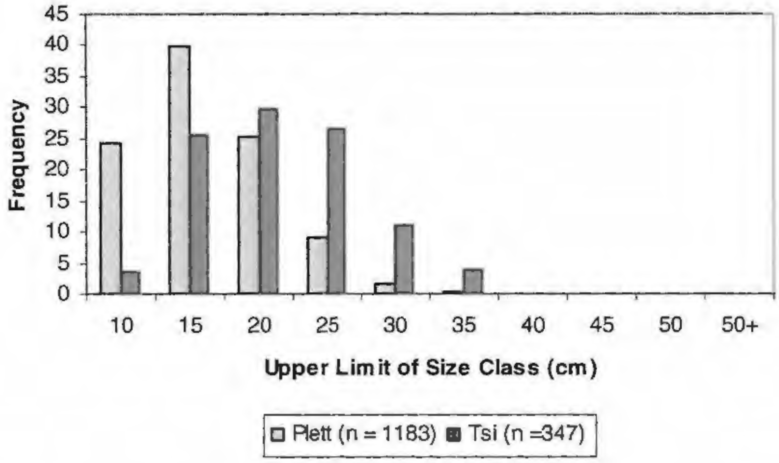


Figure 4.5. The length frequency distribution of *Diplodus sargus capensis* from exploited and protected sample sites.

D. hottentotus

Following the same trend as *D. s. capensis*, *D. hottentotus* showed a significant relationship between the area of sampling and the size frequencies of fish seen (Chi-sq = 22.11305, df = 6, p = 0.00116). Figure 4.6 is again similar to that of *D. s. capensis* with higher frequencies of smaller fish in Plettenberg Bay and larger individuals being seen in TNP.

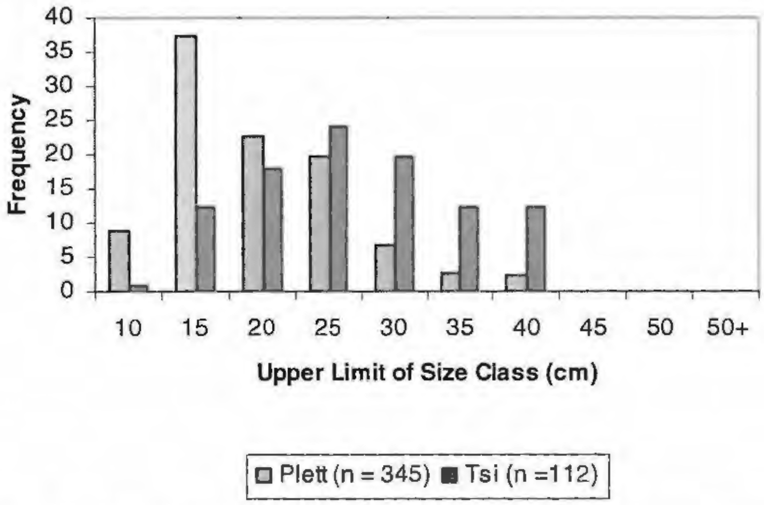


Figure 4.6 The length frequency distribution of *Diplodus cervinus hottentotus* from exploited and protected sample sites.

C.laticeps

There was a significant relationship between the area of sampling and the size frequencies of *C.laticeps* (Chi-sq = 26.10479, df = 8, p = 0.00101). From the frequency histogram in figure 4.7 it can be seen that within Plettenberg Bay there were more individuals in the smaller size classes and the largest size class of 45 to 50cm were totally absent.

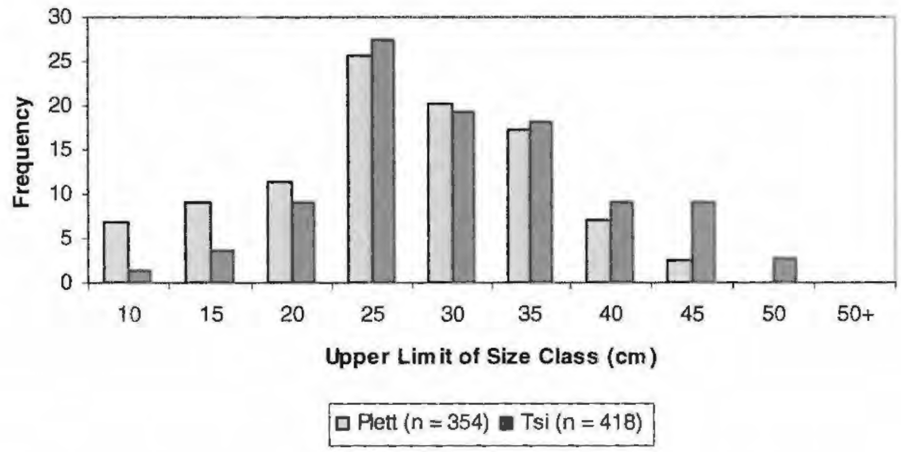


Figure 4.7 The length frequency distribution of *Chrysoblephus laticeps* from exploited and protected sample sites.

4.3.2 Fishing Stations

4.3.2.1 Similarity

Figure 4.8a and 4.8b show the results obtained from the cluster analysis and ordination performed on the transformed individual catch from comparative fishing station. The cluster analysis has been bracketed into three main groups. Group one is dominated by fishing stations within Plettenberg Bay (both shallow and deep reefs). Group 2 is more of a mix between Plett and TNP deep reefs whilst group 3 is predominantly deep and shallow stations completed within TNP. Most stations between the two sampling zones show only around 25 to 30 % similarity. Cluster analysis performed on a summary of the catch data, where individual catches were combined for each species at each sample site, showed that the sample sites within Tsitsikamma National Park were the most similar at around 60%. The catches from these sites were in turn about 50% similar to the deep fishing site within Plettenberg Bay. The shallow fishing spot in Plettenberg Bay was between 40 and 45% similar to the other sites (Figure 4.8c).

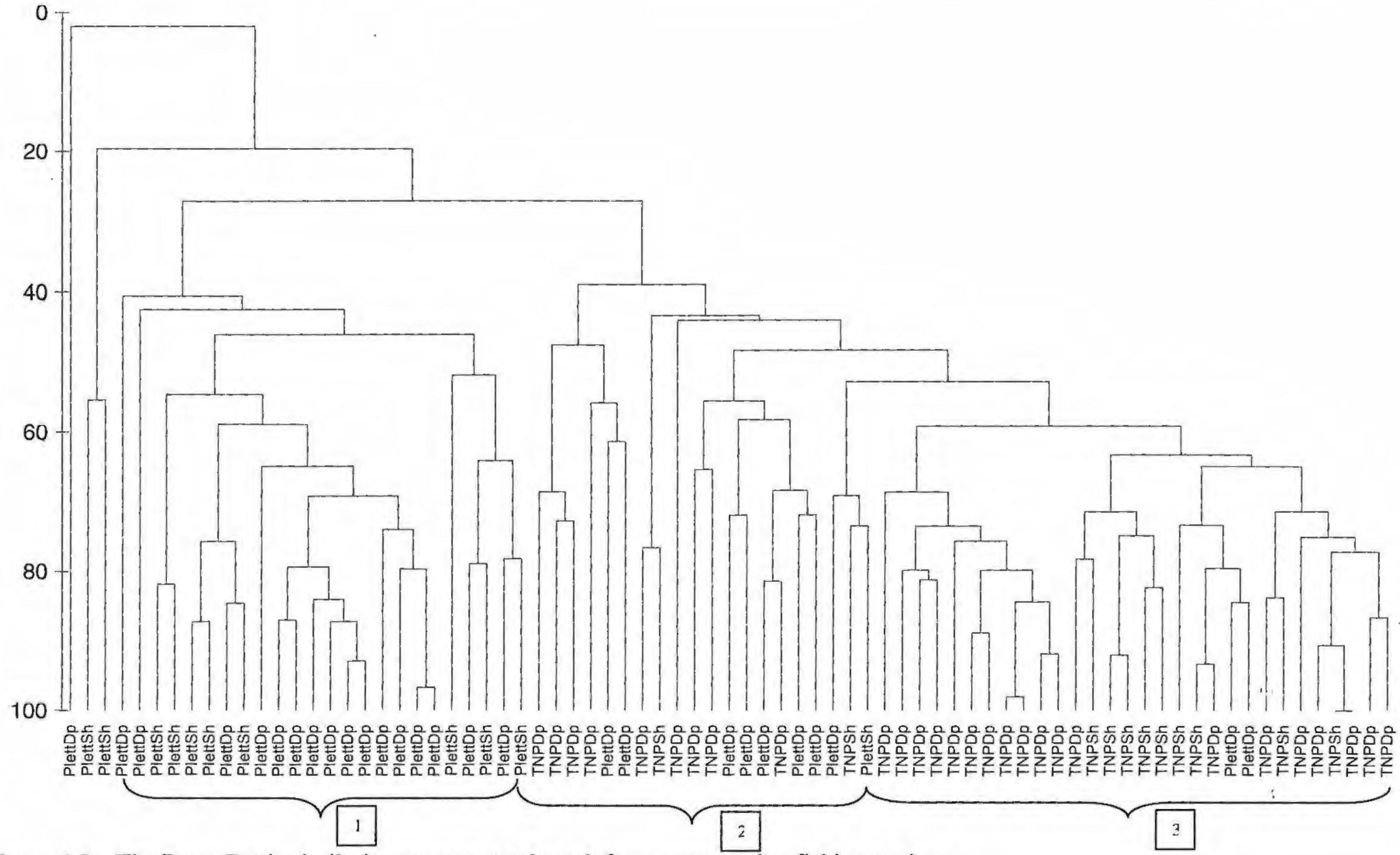


Figure 4.8a. The Bray-Curtis similarity amongst total catch from comparative fishing stations.

TNPDp= Deep Reef within TNP (16 – 20m)

TNPSh = Shallow reef within TNP (8 – 12m)

PlettSh= Shallow reef within Plettenberg Bay (8 – 12m)

PlettDp= Deep reef within Plettenberg Bay (16 – 20m)

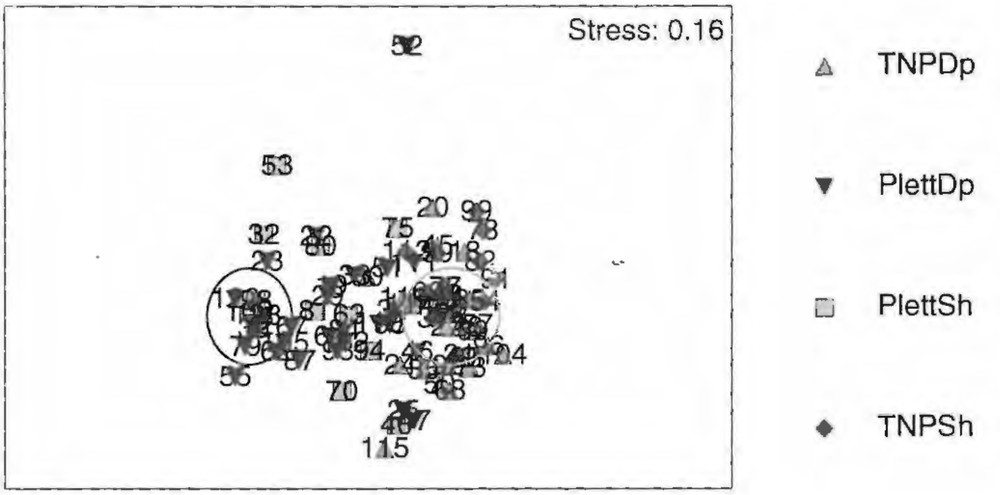


Figure 4.8b. Multi-dimensional scaling plot depicting the spatial relationship between each fishing stations catch.

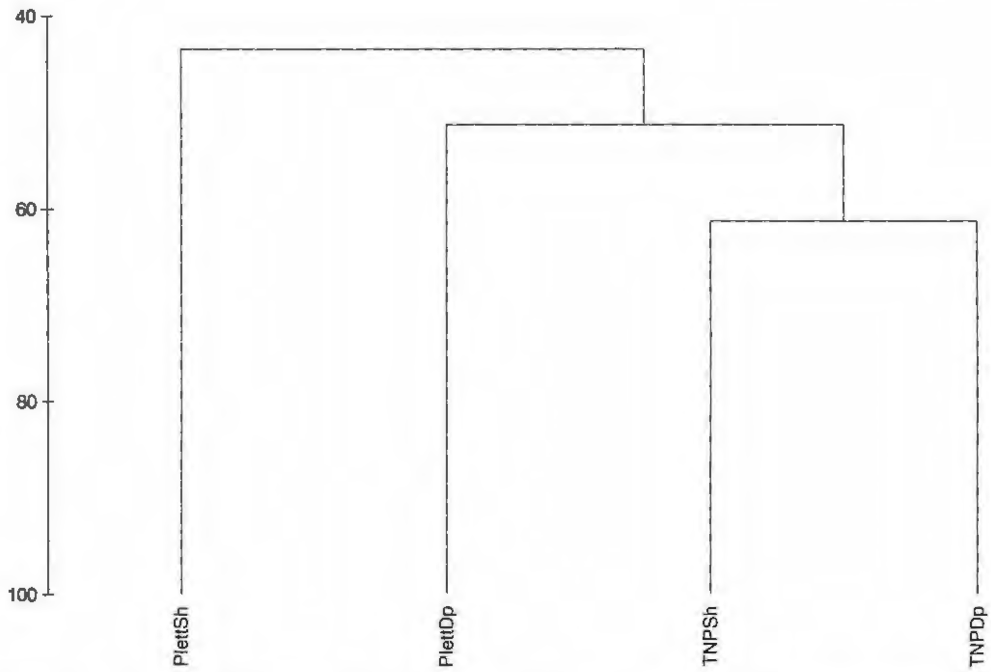


Figure 4.8c. Bray-Curtis similarity among catch composition of each fishing sample site once data were aggregated per site.

4.3.2.2 Abundance and Size Frequencies

There was little difference in the overall CPUE (both numbers and weight) between all fishing stations and the comparative stations (Table 4.9). Comparison between zones shows a slight increase in CPUE (fish.fisher^{-1}.hr^{-1}) within TNP whilst the CPUE (Kg.fisher^{-1}.hr^{-1}) was greater by a magnitude of almost three.

Table 4.9. Overall CPUE between the sampling zones and between all the fishing stations and the comparative subset.

	All Fishing Stations		Comparative Fishing Stations	
	fish.fisher^{-1}.hr^{-1}	Kg.fisher^{-1}.hr^{-1}	fish.fisher^{-1}.hr^{-1}	Kg.fisher^{-1}.hr^{-1}
Plettenberg Bay	8.45±4.27	1.81±1.16	8.10±4.25	1.66±1.08
TNP	10.14±5.04	5.08±3.08	10.08±5.19	5.10±3.11

The results of the initial nonparametric data analyses on the total abundance and weight of fish caught during the entire survey period indicated that there was no significant difference ($n = 1097$, $p > 0.05$) in the CPUE in numbers between the sampling zones (Plett and TNP), but there was a significant difference in the CPUE of weight of fish caught ($n = 1097$, $p < 0.001$). The same pattern in results was obtained when analyzing only the comparative fishing stations (Table 4.10).

Table 4.10. Initial non-parametric (Mann-Whitney U test) analysis on total numbers and weight of fish caught between the two sampling zones. Values in bold indicate significant differences.

Total Fishing Stations			Comparative Sub-set		
n	Numbers	Weight	n	Numbers	Weight
1097	P = 0.084966	**P = 0.000000**	709	p = 0.116444	**P = 0.000000**

Although there seems to be no significant difference in the overall number of fish caught on each sampling trip between the two zones, a breakdown of total catch over the sampling period begins to show the true differences. Table 4.11 provides a species checklist of the fish caught during the standardized fishing stations. Overall 1097 fish representing 24 species and 9 families were caught, 20 species from 7 families were recorded within Plettenberg Bay and 15 species from 6 families within the Tsitsikamma National Park. With 13 species the family Sparidae dominated species diversity making up 68% the species caught and 93% of total fish numbers within

Plettenberg Bay. Although only nine sparid species were caught in TNP these comprised 64% of species diversity and made up 98% of total fish numbers. Within the family Sparidae, different species dominated the catch between the study areas. *S. emarginatum* was the most dominant species making up 56% of the total fish within Plett, this same species only made up 6% of the catch in TNP. In contrast *B. inornata* made up only 8% within Plett and 40% within TNP. *C. laticeps* made up 18% in Plett but was the dominant catch making up 47% within TNP (Figure 4.9 A & B). Due to their dominance in the catches further analyses was performed on *C. laticeps*, *B. inornata*, *S. emarginatum* and *P. aeneum*. Graphs showing the predicted CPUE are given in Appendix VIII and the multi-dimensional bubble scaling plots depicting the observed differences in the CPUE are shown in Appendix IX. Size frequency differences were analysed with recorded length data rather than the calculated weights. Due to the direct relationship between length and weight, inferences on weight differences can be made from these results.

Table 4.11. Checklist of species caught during the survey period.

Family / Species	Zone Fished Plett	TNP	Total
Scyliorhinidae			
P. africanum		1	1
Ariidae			
G. feliceps	7	1	8
Serranidae			
A. sebastoides	2	5	7
Pomatomidae			
P. saltatrix	3		3
Haemulidae			
P. olivaceum	20	2	22
Sparidae			
A. argyrozona	21		21
B. inornata	47	174	221
C. nufar	8		8
C. cristiceps		14	14
C. gibbiceps	3		3
C. laticeps	110	206	316
D. s. capensis	2	5	7
L. mormyrus	10		10
P. aeneum	34	6	40
P. grande	1	1	2
P. natalensis	26	2	28
P. rupestris		2	2
R. globiceps	1		1
P. laniarius	1		1
S. salpa	2		2
S. emarginatum	338	26	364
Tetraodontidaae			
A. honckenii		1	1
Sciaenidae			
A. inodorus	8		8
Scombridae			
S.japonicus	7		7
	651	446	1097

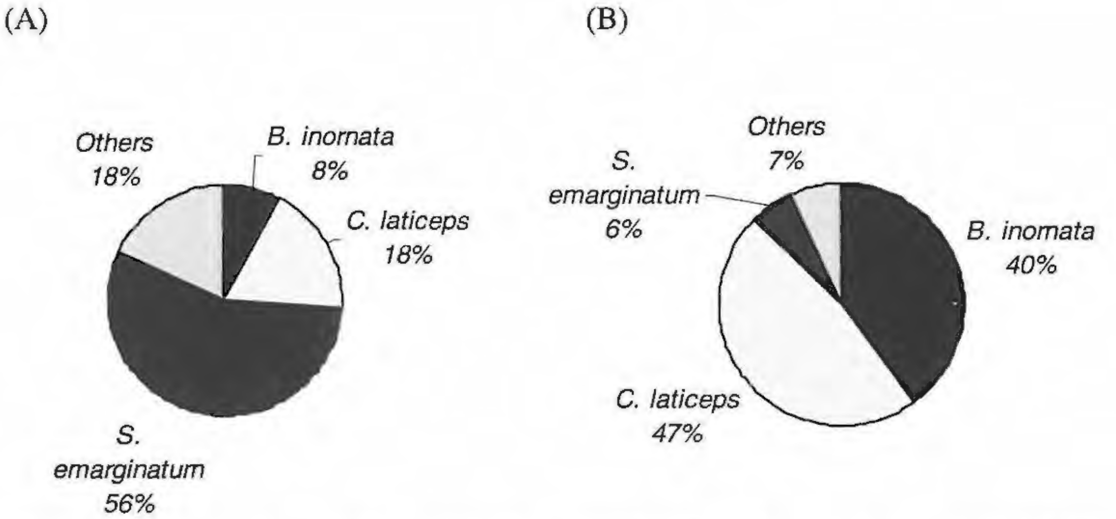


Figure 4.9. Percentage catch composition (numbers) of the dominant species falling within the family Sparidae between Plettenberg Bay (A) and TNP (B).

Spondyliosoma emarginatum

A significant difference was shown in CPUE and size class frequency ($p < 0.001$) between Plettenberg Bay and TNP with fewer larger individuals being caught in TNP (Table 4.12, Figure 4.10). However the sample size was low for TNP with only 26 fish caught during the entire study period. Results of the GLZ showed that only the zone of fishing had an effect on CPUE (Table 4.13).

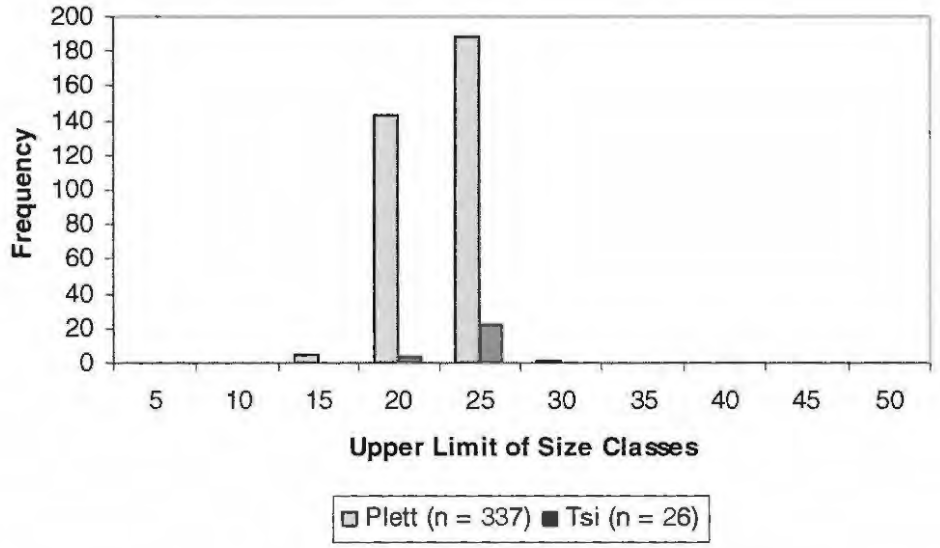


Figure 4.10. The length frequency distribution of *Spondiliosoma emarginatum* caught during angling surveys within both the exploited and protected sample sites.

Boopsoidea inornata

Although there was a significant difference in the number of Fransmadam caught per hour between the sampling zones ($p < 0.001$) with a greater CPUE in TNP, there was no significant difference in the size class distribution of *B. inornata* between the sampling areas ($p > 0.05$) (Table 4.12, Figure 4.11). Zone, time period and depth were shown to have significant effects on the CPUE of *B. inornata* when the GLZ was run with all fishing stations included. When analysing the comparative sub-set time period was not significant (Table 4.13).

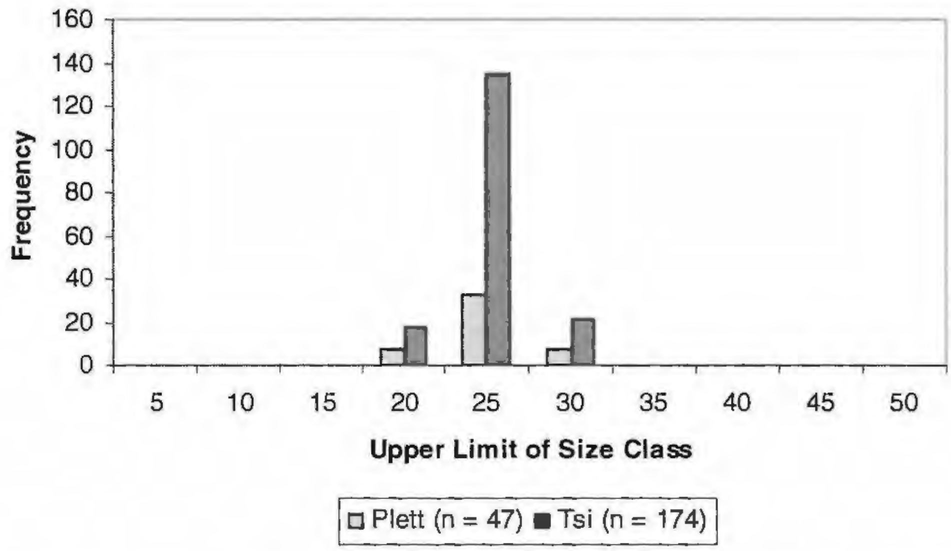


Figure 4.11. The length frequency distribution of *Boopsoidea inornata* caught during angling surveys within both the exploited and protected sample sites.

C. laticeps

The CPUE was roughly three times greater in TNP (4.60±3.64 fish.fisher^{-1}.hr^{-1}) than Plett (1.31±2.56 fish.fisher^{-1}.hr^{-1}) (Figure 4.12). Non-parametric testing confirmed that the CPUE ($p < 0.001$) and the size class frequency distribution was significantly different for *C. laticeps* ($p < 0.001$) between the sampling zones with more individuals being caught in larger size classes within TNP (Table 4.12, Figure 4.13).

In contrast to the other species, temperature and zone had an effect on CPUE of *C. laticeps* (Table 4.13).

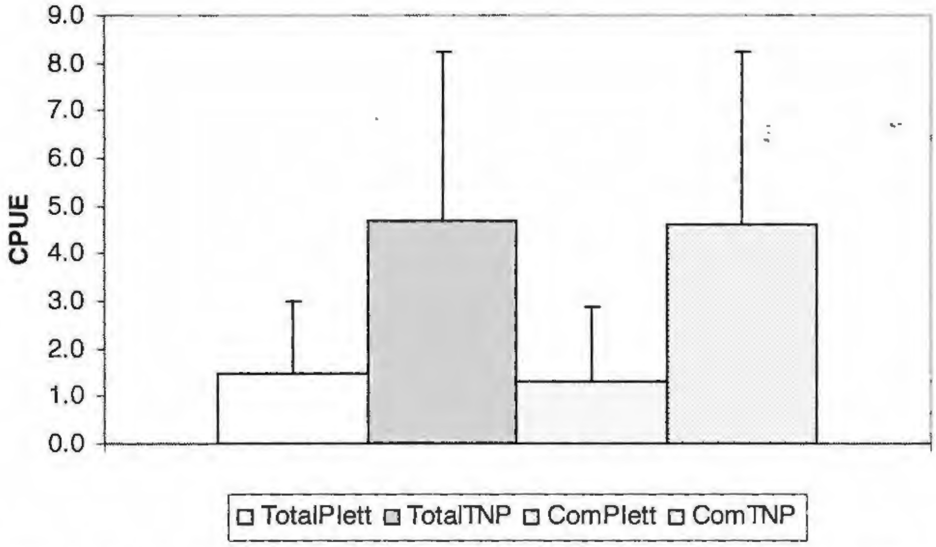


Figure 4.12. *C. laticeps* CPUE (fish.fisher^{-1}.hr^{-1}) for all sampling stations and the comparative sub-set.

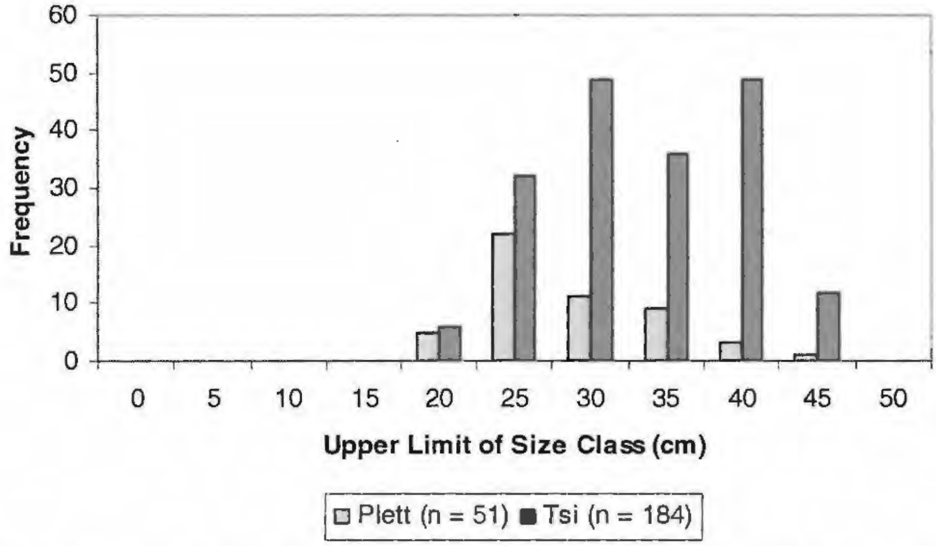


Figure 4.13. The length frequency distribution of *Chrysoblehpus laticeps* caught during angling surveys within both the exploited and protected sample sites.

Table 4.12. Initial non-parametric (Mann-Whitney U test) analysis on total numbers and length frequency of fish caught between the two sampling zones. Values in bold indicate significant differences.

All Stations				Comparative	
		Mann-Whitney U		Mann-Whitney U	
Spp	n	Abundance	Length	n	Abundance
S. emarginatum	364	**0.000002**	**0.000309**	184	**0.000075**
B. inornata	221	**0.000091**	0.452826	174	**0.004009**
C. laticeps	316	**0.000009**	**0.000001**	235	**0.000214**

Table 4.13. Variables included in the final GLZ model for the various species. Blocks with no values, indicate variables that were excluded from the final model. Values in bold indicate significance (p-values).
T = Total dives C = Comparative dives only

Genralized Linear Modelling					
		Predictor Variables			
Species		Zone	Time Period	Depth	Temperature
S. emarginatum	T	**0.000000**			
	C	**0.000000**			
B. inornata	T	**0.000000**	**0.043413**	**0.000054**	
	C	**0.000580**		**0.000027**	
C. laticeps	T	**0.000000**			**0.017088**
	C	**0.000000**			**0.037556**

4.4 DISCUSSION

Underwater visual census techniques can provide useful data on community structures in relation to presence, abundance and size distribution of species. However, the method itself introduces biases that need to be acknowledged in the final data analysis and interpretation. Willis *et al* (2000) highlight three factors that have created difficulties in demonstrating reserve effects: inadequate sampling methodology, inadequate survey design and lack of extended data time series using consistent methods. Although the aim of this project was not to demonstrate reserve effect, as previous work has already accomplished this in regard to the TNP, (Buxton 1987, Buxton & Smale 1989, Burger 1990) these same factors need to be considered when assessing the present sampling design and in the interpretation of the results. Two sampling methods were utilized in the present study: point counts (an UVC technique) and standardised fishing and are criticised below.

The first factor: inadequate sampling methodology. In this regard the sampling methodology used should be effective and unbiased (Willis *et al* 2000). Underwater visual assessments have inherent problems when dealing with fish abundance, in particular with regards to accuracy and precision. Accuracy deals with the ability to capture the true abundance of a species within a community and precision dealing with the ability to replicate the techniques (Samoilys 1991). A difficulty with point counts is possible fish behaviour alteration in the presence of divers with positive or negative approachability leading to either an over or under estimation of abundance as fish either accumulate in the sample area or may move out. For example due to their natural caution and wariness of divers Buxton & Smale (1989) point out that care must be exercised when interpreting results from underwater visual assessments on dageraad. The degree of over-estimation also varies between different species or groups depending on mobility (Samoilys 1991). To try and minimise this instantaneous point counts were conducted where each species was counted individually (thereby trying to give a series of "snap shots") with highly mobile species counted before the sedentary and cryptic species. In general the entire point count took less than five minutes. Secondly the same method was used continuously throughout the project and at each sample site. In other words the biases associated with these point counts should have been carried throughout and within each sample area. Differences in relative abundance should therefore still be comparable. From personal experience and observations, the density estimates for common species could be over-estimated. This over-estimation arises out of many of the same individuals being counted on more than one point rather than the diver being overwhelmed during a single point count. In other words fish that had followed the diver from one point to another would therefore be counted on more than one occasion, if they were in the radius of reef being sampled. Future studies should perhaps increase the distance between individual point counts. Willis *et al* (2000) advocate the use of surface-based sampling methods to counter the biases introduced in changes in fish behaviour. However fishing introduces the biases of species and size selectivity. When used in combination the overall methodology is more robust. The use of scientific angling on the current study not only helped show the difference in abundance of targeted species between the sampling zones but the results predominantly confirmed and validated those results obtained from the diving surveys. The CPUE as an indication of abundance largely agreed with the diving surveys. Furthermore the angling provided precise length measurements to show changes in size frequency.

The second factor deals with inadequate survey design. The survey design in this project needs to be criticised for both its spatial and temporal replication. First off it must be stated that by utilizing only one deep and one shallow survey area within and without the reserve, with repetitive sampling at those spots, creates the problem of possible pseudo-replication. One aspect not taken into account with this type of survey design is the natural variation and spatial patchiness of fish distribution (Willis *et al* 2000). Simply put we cannot state with certainty that the results obtained are representative of the greater treatment areas, i.e. representative of the community structure throughout TNP and Plettenberg Bay. The limitation of this sampling regime was acknowledged at the beginning of the project, however, due to the specific objectives of developing a simple set of indicators, time and monetary constraints it was not practical to have further sample sites. Furthermore an attempt was made to choose sites that were similar in terms of rugosity, profile and depth thereby minimising any "environmental noise" effecting distribution, although the exposed nature of the TNP coastline resulted in the shallow site being subjected to more wave and surge action. Further research into community structure between the treatment areas is also planned. The practicality of this type of survey design with limited sites could be validated by extending the sampling to include more sites inside and outside the reserve. The results obtained from the entire study could then be compared to the "subsection" of limited sites to gauge how representative limited sites may be.

The third factor deals with the lack of extended data time series using consistent methods. Although some previous work using transect counts had been done within TNP (Buxton 1987, Burger 1990) point counts were chosen for this study for a number of reasons including limited sampling time and available man power. It is advocated that a set method be adopted for all future work within the TNP allowing better temporal comparisons between studies.

To try and explain the differences that have been shown in both species abundance, size distribution and overall community structure one needs to not only take into account the limits associated with the sampling methods and survey design, but, there needs to be an understanding of how exploitation can effect species abundance and community structures.

Exploitation may cause changes in community structures through three main mechanisms: 1 – shifts in relative abundance, size and age of species targeted with different life histories (Russ & Alcala 1998, Polunin 2002), 2 – secondary effects involving changes in species interactions (competition, predator-prey relations) (Kaiser & Jennings 2002), and 3 – habitat modification (Russ & Alcala 1998, Kaiser & Jennings 2002). The recreational and commercial anglers utilising Plettenberg Bay are all linefishers, primarily targeting species that fall into two broad categories: coastal migrants and resident reef associated fish (See Chapter 3). It follows that any effects this fishing has on the community structure should be noticeable in relation to the resident species targeted, with possible secondary indirect effects manifesting on the overall community structure, whilst direct habitat modification should be minimal to non-existant. Many of the resident species targeted fall within the family Sparidae, which as a family generally exhibit vulnerable life-history strategies including long-life expectancy, slow growth, large size at maturity relative to max size and high residency and are thereby susceptible to overfishing. The stock status for many of these species is recognised on a national scale as having collapsed and the existing management regulations are currently under review (Griffiths 2000). By using the Tsitsikamma National Park as a control to represent a "natural" community under no fishing pressure the effect of the local exploitation could be assessed.

The decrease in abundance and size of piscivorous species has been recognised as the most readily detectable effects of fishing pressure in multispecies fisheries (Jennings & Lock 1996) with many studies showing a decrease in abundance and size structure of targeted species in areas with various levels of exploitation (Buxton & Smale 1989, Russ & Alcalca 1989, Jennings & Polunin 1997, Russ & Alcalca 1998). In a comparative study between TNP and an exploited area to the east of the park frequented by Port Elizabeth fishers, Buxton & Smale (1989) found significant differences in the abundance and size frequency distributions of red steenbras, roman and dageraad. In 1990 Burger compared the ichthyofaunal community structure between TNP and a reef structure within Plettenberg Bay, concluding that direct or indirect disruption of the reef fish community structure had occurred due to the removal of red steenbras – the top predator (Smale 1986). Within the current study the sample size for many of the sparids, including both red steenbras and dageraad, were too small to allow any statistical analyses. However, roman in particular showed a significant increased abundance along with a greater size frequency within the protected area. It is already known that roman are highly resident with little movement occurring between reefs (Buxton & Allen 1989, Wilke & Griffiths 1999) thereby increasing the susceptibility of localised populations to overfishing.

Although many studies have documented the change in abundance and size frequencies of targeted species between areas of varying exploitation the effect this has had on other species through predator-prey relationships has been mixed. Russ & Alcala (1989) found an increase in prey densities for heavily fished areas of coral reefs and Bohnsack (1982) showed an increase in the abundance of species not specifically preyed on by the top predators. In contrast, studies by Jennings & Polunin (1997) and Russ & Alcala (1998) found little evidence of secondary or indirect effects of fishing on fish diversity or biomass of prey species. Two species in the current study, fransmadam and steentjie, that are not targeted by anglers showed marked and opposite differences in abundance between the two sample areas. Fransmadam were significantly more abundant in TNP whilst steentjie were more abundant at the Plettenberg Bay sites. It is highly unlikely that the difference in abundance is a direct result of exploitation. Although both species are caught, this is primarily as by-catch and fish are either released or used as bait. Furthermore it would follow that the abundance of both species would be lower in the exploited areas. The same argument could be used against modified predator prey relations. Although red steenbras are known to feed on both these species (van der Elst 1993), greater densities of red steenbras were found within TNP indicating that should this have had an effect on the abundance of these prey species and one would expect greater numbers outside the TNP. This was not the case. The spatial difference in abundance and low targeted fishing effort points to possible alternative indirect effects. One also needs to take into account the suitability of the physical environment. However both species have similar distribution patterns, are found over reefs ranging from 5 – 30m (van der Elst 1993) and have been classified as macro-invertebrate feeders (Burger 1990). There is a dietary overlap with both species feeding on ascidians, polychaetes and small crustaceans. Fransmadam also feed on small gastropoda and micro-organsims, ingested with a variety of seaweeds, whilst steentjie feed on amphipoda and limited algal grazing (Burger 1990, van der Elst 1993). It is likely due to the distribution and feeding similarities that these species are in competition with one another. Should this competition have been modified in some way by the direct affects of fishing on other target species it may be possible that one species may start to dominate the other. For example should the density of a common prey species be decreased through increased predation by more abundant *Chrysoblephus* sp. within the TNP, the species more reliant on these prey may be negatively affected. These arguments are tenuous at best and more information on food webs, availability or abundance of food items between the zones and intraspecific competition is needed.

The increased abundance and decreased size frequencies for both zebra and blacktail within Plettenberg Bay can be attributed to the shallow sites where large numbers of juveniles were regularly seen. Juvenile fish of other species including santer, roman, two tone fingerfins and steentjie were also sampled at this site. Due to the greater protection from swell it is likely that these reefs could be utilised as temporary nursery areas. Both species are seldom caught by ski-boat fishers but blacktail is regularly caught by shore fishers (King 2005) It is also possible that the increased dominance of blacktail in Plett is a result of the decrease in roman abundance, providing the opportunity for blacktail, as a more opportunistic species, to fill this space. Again more work is needed on fish interactions and factors regulating community structure.

The results from this study indicate that there is a greater biodiversity within the exploited area. This in contrast to the findings by Burger (1990) in the same general area, other studies conducted in both temperate and tropical areas (Goets 2005, Alcala & Russ 1990, Alcala & Russ 1996), and needs to be explored in greater detail. Two options are available: 1) there is in reality a greater biodiversity within Plettenberg Bay or 2) the sampling design is restricting the ability to determine "true" trends. It could be possible that due to the limited spatial survey design, the sampling has failed to pick up the full diversity to be found within the TNP. When combining the species richness and evenness indices it can be seen that although more diversity was sampled in Plettenberg Bay, this increase in has been created by the inclusion of a few species, seen on rare occasions and in few numbers. Two good examples of this was the single sighting of a migratory species (geelbek) and a nomadic species (garrick).

With regards to the objectives of the project, a set of indicators have been identified with roman (following on from the fishery assessment in the previous chapter) proposed as an indicator species. Specific information that can be used as indicators includes density obtained from diving surveys, CPUE obtained from experimental angling and size class frequency distributions obtained from both diving and experimental angling. However due to the expense and specialized nature of sampling with SCUBA it is proposed that these indicators be evaluated every 5 years.

CHAPTER 5 – SUSTAINABILITY AND POTENTIAL INDICATORS

5.1 INTRODUCTION

The concept of sustainability or sustainable development reflected in the Rio declaration and Agenda 21 of the 1992 UNCED (United Nations Conference on Environment and Development) was incorporated into fishery management via the FAO Code of Conduct for Responsible Fisheries (Anon 1995) and includes the need to conserve the multiple resources in their environment, to satisfy social and economic needs of human beings and lastly for management to guide the required changes in institutions and technology. Consequently management is changing its focus from targeting single stock production to emphasizing the need to consider fisheries sustainability in relation to the entire ecosystem, incorporating disciplines from the natural and social sciences (see Chapter 1). It is important to recognize that sustainability does not only relate directly to the resource base but is also concerned with meeting human needs and aspirations, and that these will change on both temporal and spatial scales. In other words management needs to be adaptable and "upgradeable" as both the resource and societies requirements change. In order for management to be responsive to the dynamics of both the resource and socio-economic conditions, there firstly needs to be a greater understanding of the complex linkages involved in and between the natural and societal systems and secondly there has to be some means of continuously monitoring and assessing the success of the implemented strategy. Increasingly management systems are being based on "soft predictability" utilizing indicators and qualitative predictions as tools to measure change, results and impacts caused by activities regulated through management structures (Castro 2001, Bowen & Riley 2003, Degnbol & Jarre 2004). Dahl (2000) describes indicators as a signalling system, where indicators "signal" or point to where managers should concentrate their efforts by reflecting how far from or close a particular dimension in a fishery is to being sustainable. Sustainable fisheries indicators have been developed in relation to two different agendas. The first concerns the development of indicators that can be used to govern policies in the international domain whilst the second agenda relates to the guidance of local fisheries management (Degnbol & Jarre 2004). The important aspect being that indicators must be specific to particular uses and contexts in both scale and content (Dahl 2000).

Within the broader scope of EBM a number of conceptual models providing frameworks for the implementation of sustainable development reference systems (SDRS) are being developed to study, assess and report on the sustainability of a sector (Garcia & Staples 2000) with indicators forming an integral part of these models. Models developed include the Code of Conduct for Responsible Fisheries, the Ecologically Sustainable Development Framework (ESDF), the Pressure-State-Response (PSR) framework with its derivatives and Pajak's (2000) model depicting sustainability based on the three domains of environment, society and institutions. These models differ in the number of constituent components and structuring elements, but they deal with the same overall matrix of sustainability dimensions. A full description of these various frameworks is beyond the scope of this thesis and a review may be seen in Garcia & Staples (2000). Although various papers present conceptual models (Pajak 2000, Garcia *et al* 2000, Garcia and Staples 2000), and others propose possible indicators (Vandermeulen 1998, Ward 2000, Castro 2001, Rochet & Trenkel 2003), less has been documented on the assessment of proposed indicators (e.g. Degnbol & Jarre 2004, Adrianto *et al* 2005) and the practical implementation of the models. Bowen & Riley (2003) identified the relative paucity of indicator-based approaches to management as a result of the complex linkages involved in and between the natural and societal systems and the difficulties in isolating cause - effect relationships. Furthermore due to the lack of information, expertise, institutional infrastructure and capacity frequently experienced at local levels of governance the implementation of a "full house" SDRS is problematic.

Within a local fisheries context this project proposes a simple framework based on Pajaks (2000) ecological, institutional and social sustainability domains, along with a select set of indicators that can be utilised to assess sustainability. The model should not be interpreted as an end product, rather, as an iterative process beginning with the most urgent or critical issues identified at a local scale. This model should therefore provide the basis for a more complex, social, ecological and institutionally inclusive SDRS developed over time.

5.2 METHODS

A number of steps were involved in the selection of the indicators (Figure 5.1). Due to the lack of information regarding the local fisheries, the first step incorporated a baseline assessment or status report of the local nearshore linefisheries and a rapid assessment of the reef fish community structure (Chapter 3 & 4). The information gathered was then analysed (Chapter 3 & 4) in step 2. Key sustainability issues were identified from these results (step 3) and indicators that could be used to track these issues and meet a number of selection criteria were proposed (step 4) (Figure 5.1 block D). Although it has been highlighted in the literature (Vandermeulen 1998, Garcia & Staples 2000, Degnbol & Jarre 2004) that the selection of indicators should be directly linked to specific management objectives, the lack of local management objectives precluded our ability to do this.

The setting up of such objectives in the correct manner with stakeholder involvement was again beyond the time scope of this project. In the absence of specific local objectives the generic fishery management objectives found in the FAO Code of Conduct for Responsible Fisheries (FAO 1995) and the Marine Living Resources Act (MLRA) (Act 18 of 1998) of South Africa were used as guidelines (Figure 5.1 block B, Table 5.1). Furthermore Key Issues of the linefishery were identified in relation to these generic goals and the known impacts of fishing (Figure 5.1 block C, Table 5.2). Once the indicators had been identified they were classified (step 5) according to the Driver – Pressure – State – Impact – Response Model (Bowen & Riley 2003)(Figure 5.1 block E) and the sustainability reference direction defined (step 6). The reference direction depends on whether the indicator will increase or decrease under exploitation. Step 7 involved the setting of performance criteria for each indicator. Although a large number of indicators have been proposed within the literature, few studies take the development a step further and develop either reference points or a scoring system. This can be attributed largely to the complexities involved, including individual subjectivity and the limited available historic data available in most fisheries with which to set the reference points (Rochet & Trenkel 2003). As a result, the setting of reference values has become one of the most controversial and problematic stages in the development of an indicator system (Dahl 2000, Garcia &

Staples 2000, Dengbol & Jarre 2004). To try and alleviate some of the possible individual subjectivity, a discussion session comprising two fishery scientists and the two students involved in the projects was held to review and adapt both the indicators and their reference criteria. Details of those involved are listed in Appendix X. Furthermore due to the limited historic data relating to the local fisheries and the resource state, various indicator results were compared between previous studies (Brouwer 1997) and between Plettenberg Bay and Tsitsikamma National Park (pristine level) to gain an idea of performance criteria. Finally, methods are proposed for the data collection of the various indicators within an adopted monitoring program, however, no attempt has been made to elucidate a data collection time scale for the required monitoring program.

Once a quantitative value had been determined for each indicator and scored via the performance criteria, on a scale of 0 to 4; representing a state from very poor to good (Garcia *et al* 2000), the values were aggregated across the various sustainability domains to give indices of sustainability (Figure 1.7, block C) in a rapid assessment matrix (RAM) (Table 5.3).

Emphasis has been placed on the adoption of a few simple, well defined and easily interpretable indicators rather than a large number of less discrete or complex indicators. For example within the ecological domain the Roman (*Chrysoblephus laticeps*) is proposed as an indicator species. The popularity of roman amongst fishers, the proportion of roman caught (Chapter 3), its endemicity (Smith & Heemstra 1986) and susceptibility to overfishing due to the life history traits and territorial non-migratory behaviour (Buxton 1987, Buxton 1993, Buxton & Allen 1989) makes this species a prime candidate.

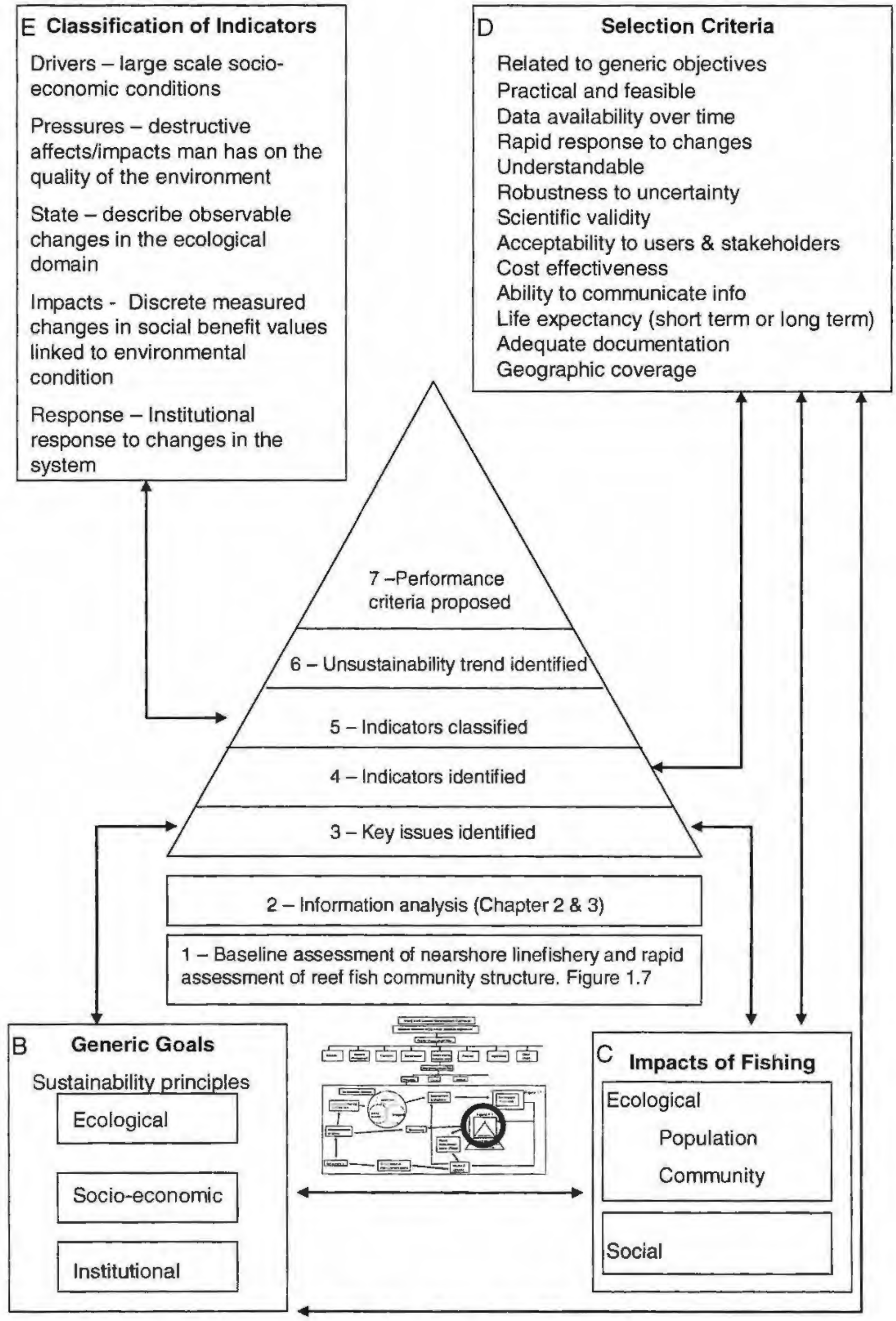


Figure 5.1. The seven steps involved in the selection of indicators. The diagram highlights how the selection of indicators is dependent on the management objectives, the known impacts of fishing and other criteria. The insert shows where this diagram fits in with Figure 1.6.

Table 5.1. Generic goals or principles of sustainable development related to the FAO Code of Conduct for Responsible Fisheries (Garcia 2000) and the South African Marine Living Resources Act (Act 18 of 1998) that were adopted for this study.

Socio-Economic Domain	
Principle S1: 'The human needs (in terms of sustainable access to high quality and safe food, employment, income and recreation), and societal / ethical values should be satisfied.'	
S1.1	Enhancing education, skills and professional qualifications of fishers
S1.2	Need to achieve to the extent practicable a broad & accountable participation in the decision making process.
Institutional	
Principle I1: 'An effective management system should be in place to orient the institutional and technological change required.'	
I1.1	Consultation and participation in laws and regulations.
I1.2	Research in all relevant disciplines and dissemination of results.
I1.3	Taking fisheries into account in multi-use of the coastal zone.
I1.4	Promoting awareness about conservation and management among fishers.
I1.5	Monitoring management performance and reviewing management strategies.
Ecological Domain	
Principle E1: 'The target resource characteristics should be maintained at levels capable of ensuring its natural renewal and continuous exploitation under ecologically acceptable conditions.'	
E1.1	The maintenance of quality, diversity and availability of resources.
E1.2	Prevention of overfishing and overcapacity.
E1.3	The need to apply the precautionary approach in respect of management and development of the marine living resources.
Principle E2: 'The environment conditions should be protected, maintained and enhanced (where appropriate) to ensure the maintenance of resource productivity.'	
E2.1	Maintenance of biodiversity, population structure and ecosystems.
E2.2	Monitoring of the coastal environment and assessment of environmental impact.

Table 5.2. Impacts of fishing on the environment. The environment has been split into an ecological domain where fishing impacts at both the population and community level and the Socio-Economic domain dealing with impacts on humans.

Impacts of fishing	
Ecological	
Populations: Removal of older and larger fish.	Communities: targeting of certain species.
Decrease in population size.	Change in overall species composition.
Change in size frequency distribution.	Change in species diversity.
Change in life history traits.	Change in trophic structuring due to the removal of fish in upper trophic levels.
Socio-Economic Impacts	
Source of recreation	
Source of food	
Source of employment and income	

5.3 PROPOSED INDICATORS

5.3.1 Domain: Socio-Economic

A - *Generic Principle:* 'The human needs (in terms of sustainable access to high quality and safe food, employment, income and recreation), and societal / ethical values should be satisfied.'

A1 - *Issue:* Poor regulatory knowledge

Indicator: Percentage of correct regulatory questionnaire answers

Type of Indicator: Driver

Sustainability reference direction: An increase in the percentage of fishers who give correct answers in relation to the regulations signifies a move towards sustainable fishing practises.

Data collection method: Access Point Surveys

Action: Educational drive

Performance Criteria:

Proportion of fishers who knew the current linefish regulations	Indicator Performance	Score
80 - 100%	Good	4
60 – 80%	Fairly good	3
40 – 60%	Moderate	2
20 – 40%	Poor	1
0 – 20%	Very poor	0

Rationale:

Knowledge of the current regulations is the first step towards compliance with those regulations. As pointed out earlier (Chapter 3) a fisher who does not know the species specific regulations inherently does not have the ability to obey the regulations. Furthermore governing authorities have the responsibility of making the information readily available but the fisher has the responsibility to educate themselves in regard to the regulations. Ignorance should not be a valid excuse and as such this issue has not been treated as an educational problem but rather an ethical problem of anglers purposefully not willing to learn and thus abide by the linefish regulations. This is highlighted by the high overall level of education amongst the fishers with 68% having a tertiary education.

A2 - *Issue:* Admitted non-compliance.

Indicator: Percentage of fishers who admit to breaking the linefish regulations.

Type of Indicator: Driver

Sustainability reference direction: A decrease in the percentage of fishers who admit to breaking the regulations signifies a move towards sustainable fishing practises.

Data collection method: Access Point Surveys

Action: Increase awareness and enforcement

Performance Criteria:

Proportion of fishers who admit to breaking the current linefish regulations	Indicator Performance	Score
0 – 20%	Good	4
20 – 40%	Fairly good	3
40 – 60%	Moderate	2
60 – 80%	Poor	1
80 – 100%	Very poor	0

Rationale:

Non-compliance of fishery regulations has been indicated as a contributing factor to the collapse of the South African linefishery. The percentage of fishers who admit to breaking the regulations are those directly contributing to the non-sustainability of the fishery. Greater compliance can be achieved through two synergistic factors: i) increasing voluntary compliance through education and stakeholder buy-in into the management strategies and ii) by increasing the possibility and level of punishment so that it exceeds the potential reward of breaking the law (see indicator B2)(Britz *et al* 2001).

A3 - *Issue:* Non-compliance

Indicator: Percentage of undersized fish kept.

Type of Indicator: Pressure

Sustainability reference direction: A decrease in the percentage of undersized fish kept signifies a move towards sustainable fishing practises.

Data collection method: Access Point Surveys

Action: Increase awareness and enforcement

Performance Criteria:

Proportion of undersized fish kept	Indicator Performance	Score
< 20%	Good	4
20 – 30%	Fairly good	3
30 – 40%	Moderate	2
40 - 50%	Poor	1
> 50%	Very poor	0

Rationale:

This indicator is linked to the one above and follows the same reasoning. Undersized fish, rather than exceeding bag limits, was used as an indicator of fisher compliance since several studies (Bennet *el al* 1994, Attwood & Bennet 1995a, Cowley *et al* 2002) have highlighted the limited impact bag limits has had on reducing total catch for most shore-angling species. The legislated bag limit for many of the species covered in these studies was seldom reached. Taking this and the current collapsed status of many of the linefishery species into account, the percent undersized fish rather than excessive bag limits were used as an indication of non-compliance.

However some caution must be exercised in the use of this indicator immediately after management regulations change.

5.3.2 Domain: Institutional

B - *Generic Principle:* 'An effective management system should be in place to orient the institutional and technological change required.'

B1 - Issue: Effective and implemented fisheries management plan.

Indicator: Existence of management plan for the local ski-boat linefishery

Type of Indicator: Response

Sustainability reference direction: The existence of a management plan is seen as contributing towards sustainable practises.

Data collection method: Local municipal policies and legislation.

Performance Criteria:

Nature of bay management plan	Indicator Performance	Score
Fully integrated at National level with full implementation and measurable indicators	Good	4
Fully integrated at National level with limited implementation	Fairly good	3
Integration at National Level	Moderate	2
Limited areas managed, but no management plan	Poor	1
No management plan in place	Very poor	0

Rationale:

A management plan is the main instrument that specifies how management is to be conducted and by whom and details the objectives for the fishery and the rules and regulations which apply to it (FAO 1997). The existence of such a plan will therefore be beneficial in achieving the objectives of the fishery and contribute to overall sustainability.

B1 - Issue: Management needs to be adaptable.

Indicator: Presence of monitoring program to gather ongoing data used to upgrade management strategies.

Type of Indicator: Response

Sustainability reference direction: The presence of such a monitoring program is seen as contributing towards sustainable practises.

Data collection method: Local municipal policies and legislation.

Performance Criteria:

Nature of monitoring program	Indicator Performance	Score
Incorporation of collected data into management plan	Good	4
Regular, long-term fishery surveys and other programs in place to collect required data	Fairly good	3
Regular surveys collecting limited information	Moderate	2
Some sporadic surveys conducted	Poor	1
No monitoring program in place	Very poor	0

Rationale:

Within an EBM approach management has to be adaptable - changing as the political, socio-economic and ecological environments change. Flexible and responsive adaptation as greater knowledge is acquired permits continual defining and redefining of management issues thereby maintaining a strategic focus (Tobey & Volk 2002). The implementation and administration of a monitoring program to track changes within the sustainability environments and gauge the success of the management plan in meeting its objectives is therefore an essential component in ensuring the overall success of the management initiative.

B2 - *Issue:* Effective enforcement of current regulations.

Indicator: Number of boats having been inspected within the last 50+ fishing trips.

Type of Indicator: Response

Sustainability reference direction: A greater enforcement presence contributes towards sustainable practises.

Data collection method: Access Point Surveys.

Action: Increase number of random boat inspections.

Performance Criteria:

Proportion of anglers who have been inspected	Indicator Performance	Score
80 - 100%	Good	4
60 – 80%	Fairly good	3
40 – 60%	Moderate	2
20 – 40%	Poor	1
0 – 20%	Very poor	0

Rationale:

The number of inspections carried out is important from two aspects. Firstly the regular presence of a fishery inspector and subsequent increased possibility of individual inspection should increase voluntary compliance. Secondly Brouwer (1997) showed a direct correlation between the number of fishery inspections and fisher regulation knowledge.

5.3.3 Domain: Ecological

The following indicators are all in connection to the indicator species - roman.

C - *Generic Principle:* 'The target resource characteristics should be maintained at levels capable of ensuring its natural renewal and continuous exploitation under ecologically acceptable conditions.'

C1 - *Issue:* Decline in CPUE.

Indicator: Targeted CPUE.

Type of Indicator: State

Sustainability reference direction: A long term increase or at least a static CPUE signifies a sustainable trend.

Data collection method: Access Point Surveys, Experimental angling

Action: Decrease bag limits, increase size limits, closed areas.

Performance Criteria:

CPUE (Fish.fisher.hr^{-1})	Indicator Performance	Score
2.81 ≤ value ≥ 6.3	Good	4
2.30 ≤ value ≥ 2.81	Fairly good	3
1.88 ≤ value ≥ 2.30	Moderate	2
1.26 ≤ value ≥ 1.88	Poor	1
≤ 1.26	Very poor	0

Rationale:

A precautionary approach to fishery management calls for the use of precautionary reference points which represent estimated values derived through an agreed scientific procedure giving information as to the state of the resource and the fishery, and which can be used as a guide for fisheries management. Furthermore, under the new Linefish Management Protocol (LMP) plans for all linefish species need to be developed with regulations being based on clearly defined objectives and quantifiable reference points that are assessed or evaluated through biologically based stock assessments and historical trends in catch and effort (Sauer *et al* 2003). Reference points have been defined as values that are derived from technical analyses (stock assessments) to signify a state of a fishery or population, and whose characteristics are thought to be useful for the management of the unit stock (Caddy & Mahon 1995). However in "data poor" situations where age dependent modeling is not possible, CPUE may be used as an alternative biomass estimator – a given value representing a specific reference point. Two reference points are used to set the outer biomass limits – the first represents a pristine biomass where the fish stock is under no fishing pressure (termed B_{max}) and the second representing a minimal biomass under which the stock should be considered collapsed (termed B_{lim}) and should be avoided, also referred to as the threshold reference point. For the current project the CPUE gained from the standardized fishing within the TNP has been taken as B_{max} and stands at 6.3 fish.angler^{-1}.hr^{-1}. The methods used in the analysis of catch and effort have been described in Chapter 4, however CPUE was worked out only for those roman caught on 5.0 hooks as most recreational fishers (86%) utilized larger hooks, 45.53% used 5.0 and 6.0 hooks. Setting of the B_{lim} reference point is more subjective, but a reference to 25% of B_{max} has been chosen corresponding to the 25% default spawner biomass-per-recruit threshold level (Griffiths *et al* 1999). With the B_{max} limit having been determined, B_{lim} = 1.26 fish.angler^{-1}.hr^{-1}. However the biomass stocks cannot be maintained at B_{max} if fishing is to be allowed, nor should it be allowed to fall to B_{lim} therefore a further reference point is needed, B_{ref}. Three reference points have been proposed in part to maintain the number of reference categories of each indicator at five. The reference points $B_{ref\ 1,\ 2\ \&\ 3}$ can be set as $B_{lim}\exp(2^*\sigma)$ where σ is a measure of uncertainty in the biomass estimate and the constant 2 reflects the approximate 95% confidence (Weyl 1999). The value of σ is usually taken as 0.2 - 0.3, a value of

0.4 has been used within this project to set the upper most reference point, ($B_{ref\ 1}$), due to the limited scale of sampling within TNP to obtain B_{max}. The $B_{ref\ 1}$ calculated in this way equals 2.81 fish.angler^{-1}.hr^{-1} or 44.5% of B_{max}. The value of σ used for the middle two reference points ($B_{ref\ 2\ \&\ 3}$) were set as 0.3 and 0.2 respectively with $B_{ref\ 2}$ = 2.30 fish.angler^{-1}.hr^{-1} or 36.44% of B_{max} and $B_{ref\ 3}$ = 1.88 fish.angler^{-1}.hr^{-1} or 29.84% of B_{max}.

C2 - *Issue:* Change in size frequency distributions

Indicator: Catch size frequencies

Type of Indicator: State

Sustainability reference direction: A decrease in the frequency of smaller size classes, corresponding increase in larger size classes and an increase in the average fish size signifies a move towards sustainability.

Data collection method: Access Point Surveys, Experimental angling, Underwater visual assessments.

Action: Decrease effort, increase size limits

Performance Criteria:

a)

Frequency of catch within 400 to 500mm (TL)	Indicator Performance	Score
20% ≤ value ≥ 25%	Good	4
15% ≤ value ≥ 20%	Fairly good	3
10% ≤ value ≥ 15%	Moderate	2
5% ≤ value ≥ 10%	Poor	1
≤ 5%	Very poor	0

b)

Frequency of catch between 200 to 300 mm (TL)	Indicator Performance	Score
35% ≤ value ≥ 30%	Good	4
40% ≤ value ≥ 35%	Fairly good	3
45% ≤ value ≥ 40%	Moderate	2
50% ≤ value ≥ 45%	Poor	1
≥ 50%	Very poor	0

Rationale:

Both a decrease in the abundance (CPUE) and a reduction in the size frequency distribution of fished species are recognised as the most readily detectable effects of fishing pressure (GESAMP 1995, Jennings & Lock 1996). Various authors (Burger 1990, Buxton 1993, Goetz 2005) have shown a reduction in the size frequency of roman under fishing pressure. However, with limited available data it becomes difficult to set reference criteria. For this reason a combination of three aspects pertaining to size class frequencies is proposed. The first is simple trends in the average catch size are used as reference criteria. The scoring would need to be modified depending on the objectives of the fishery as they change over time. For instance in the present situation, where the CPUE is below the reference limit, there should be a rebuilding strategy implemented which would suggest an increase in the average size of roman caught would be optimal. The second and third aspects look at the catch frequency falling into the 400 to 500mm (TL) and 200 to 300mm size categories respectively. Following the above argument at present one would want to see a greater frequency of larger individuals being caught representing a greater abundance of larger males in the population. All three aspects should be looked at together to get a better idea of changes occurring within size frequency distribution.

Although length data should be collected during the access point surveys thereby creating a baseline for the average size and size frequency distribution caught and kept under the new regulations and show long term trends that may be used as future indicators. The present limitations, (e.g. changing regulations), restricts the measurement of this indicator to standardised scientific fishing every 5 years where the hook size, bait and time spent fishing are strictly controlled giving accurate CPUE and length frequency data.

A summary of the details for each of the above indicators in relation to the generic management objectives and identified management issues is given in Table 5.2.

Table 5.2. Details of proposed indicators in relation to generic management objectives and specific management issues identified.
[1]: Major principles taken from the FAO Code of Conduct for Responsible Fisheries.
[2]: Sub-principles taken from the FAO Code of Conduct for Responsible Fisheries.
[3]: APS = Access Point Surveys,
[4]: A = All, R = Recreational
[5]: ↑ = Increase in the indicator value contributes towards sustainability, ↓ = A decrease in the indicator value contributes towards sustainability.

Domain	Principle[1]	Sub-Principle[2]	Issue	Indicator	DPSIR	Source[3]	Fishing Sector Involved[4]	Reference direction[5]	Possible action
Social	S1	S1.1 I1.4	Poor regulatory knowledge	% Correct regulatory answers	D	APS	A	↑	Educational Drive – signs & info
	S1	S1.1	Non compliance	% admitted non-compliance	D	APS	A	↓	Increase awareness & enforcement
	S1	S1.1		% catch undersized,	P	APS	A	↑	Increase awareness & enforcement
Institution	I1	I1.1	Effective Bay management plan	Presence & implementation of management plan	R	Municipal policies	A	Management plan developed and implemented	Development & Implementation
	I1	I1.5	Adaptable management	Monitoring programs in place	R	Municipal policies	A	Presence of monitoring programs	Development & Implementation
	I1	I1.1	Fishery inspections	No. boats inspected	D	APS	A	↑	Increase frequency of inspections
Ecological	E1	E1.1 E1.2	Decline in CPUE	Roman CPUE	S	Standardised fishing	R	↑	Decrease effort, modify bag limits, increase size limits, introduce closed areas.
	E1 & E2	E1.1 E2.1	Change in size structure	Roman Size frequency distribution	S	Standardised fishing	R	↑	

5.4 RESULTS

5.4.1 Sustainability Matrix

The performance scores of indicators within the three sustainability domains are tabled in the sustainability matrix shown in Table 5.3. Overall the recreational ski-boat fishery has been shown to be non-sustainable with an overall sustainability index of 38.8%.

The institutional domain scored the lowest with an overall index of only 8.3% highlighting the poor level of current management. The lack of a coastal management plan and an associated monitoring program meant neither of these indicators scored whilst the inspection rate only scored a one. In other words, each issue represented by these indicators needs to be addressed in order for the domain to become sustainable. The socio-economic domain on the other hand was good, scoring 10 out of a possible twelve to yield a sustainability index of 83%. Within this domain the degree of angler knowledge regarding the linefish regulations scored a two and has been highlighted as a priority management issue to be addressed. The ecological domain scored only 25% due to the very low CPUE and high frequency of smaller size classes.

Table 5.3. Sustainabiltiy matrix of the proposed indicators showing the current scores obtained by the ski-boat linefishery highlighting the present unsustainability.

	Indicator	Reference criteria					Current value	Score
		Very poor (0)	Poor (1)	Moderate (2)	Fairly good (3)	Good (4)		
Socio / Economic	*% Correct regulatory answers*	0 -20%	20 – 40%	40 – 60%	60 - 80%	80 – 100%	49 %	2
	% Admitted non-compliance	80 - 100%	60 – 80%	40 – 60%	20 – 40%	0 – 20%	13 %	4
	% Catch undersized	>50 %	40 – 50 %	30 – 40 %	20 - 30 %	< 20%	17 %	4
	Total							**10** (83%)
Institutional	*Existence of management plan*	No management plan	Limited areas managed, but no management plan	Integration at National level	Fully integrated at National level with limited implementation	Fully integrated at National level with full implementation and measurable indicators	No management plan	0
	Monitoring program in place	No monitoring program in place	Some sporadic surveys conducted	Regular surveys collecting limited information	Regular, long term fishery surveys and other programs in place to collect required data	Incorporation of collected data into management plan	No monitoring program in place	0
	Proportion of anglers who have been inspected	0 -20%	20 – 40%	40 – 60%	60 - 80%	80 – 100%	27 %	1
	Total							**1 (8.3%)**
Ecological	*CPUE (fish.angler.hr^{-1})*	≤ 1.26	1.26 < value < 1.88	1.88 < value < 2.30	2.30 < value < 2.8	2.8 < value < 6.3	0.97±0.77	0
	Size Frequency within 200 – 300 mm (TL)	≥ 50%	45%< value < 50%	40%< value < 45%	35% < value < 40%	30% < value < 35%	43.5	2
	Size Frequency within 400 – 500 mm (TL)	≤ 5%	5% < value <10%	10% < value < 15%	15% < value < 20%	20% < value < 25%	6.5	1
	Total							**3** (25%)
Overall sustainability								**38.8%**

5.5 DISCUSSION

On a global scale most fisheries are in a non-sustainable state, as indicated by the progressive decline of the world's marine resources since the 1950's (Grainger and Garcia 1996 as cited by Garcia and Staples 2000). Within a South African context the traditional linefishery has been in a state of emergency since 1998 due to the collapse of many of the species involved in this fishery. In using the proposed indicators this project has shown that the predominantly recreational ski-boat linefishery in Plettenberg Bay is currently non-sustainable and in need of greater management effort.

Although the sustainability of fishery has been scored according to indicators grouped within three domains, it must be noted that overall sustainability of the fishery system requires simultaneous achievement of all three domains. In other words, overall system sustainability would decline through a policy that continuously increases one element (e.g. socioeconomic sustainability) at the expense of excessive reductions in any other (Charles 2001). Within each domain management should be prioritized according to the individual indicator scores, thereby targeting those aspects that are contributing the least towards a sustainable system. But management efforts must also be spread over the three domains.

The high score (83%) obtained for the Socio / Economic domain is expected as the fishery is recreational in nature with the majority of anglers falling into the upper education and income brackets (see Chapter 3). It is therefore assumed that the majority of human needs (food, income and employment) are satisfied according to the generic principles proposed by the FAO Code of Conduct for Responsible fisheries (Garcia 2000). However the aim of management would be to achieve a 100% within each domain and in scoring a two out of four the regulatory knowledge of the anglers needs to be addressed. The anglers knew that there were regulations but had not made an effort to obtain or learn them. In addressing this issue an educational drive should be initiated that not only informs the anglers of the specific regulations but should increase their understanding of why the regulations are imposed and the effect they have on protecting the fish stocks. The other two indicators also deal with the ethics of the anglers but should be interpreted in combination. The admitted non-compliance relies on angler truthfulness and may be an under representation of the true non-compliance. As such the results of this indicator should be compared to that dealing with percent undersized fish caught.

Inadequate administrative and legislative frameworks have been a dominant issue in many projects aimed at achieving sustainability (Burbridge 1997, Caddy & Cochrane 2001, Sinclair *et al.* 2002, Griffiths and Lambeth 2002). The institutional domain fared especially poorly in the current assessment and requires substantial restructuring. Of particular importance is the minimal reference towards coastal management within the Plettenberg Bay IDP and the subsequent lack of any strategic management plans or monitoring programs. Although fishery management has been an exclusively national matter, the limitations of national government to carry out this responsibility has recently lead to a devolution of power and the formation of partnerships between municipalities and district councils for monitoring, compliance and educational aspects (Taylor 1999, Spencer 2005). Furthermore the territorial non-migratory habit of many of the reef associated sparids suggests that localized fishing pressures will have an effect on the local adult population abundance. The greater implication being that the problems associated with this fishery are not only a national concern but also a local concern. Importantly stakeholders need to be involved in the development and continual running of a management program (Garcia 2000, Tobey and Volk 2002) and in this regard an important question to be built into future studies would need to be related to the amount of stakeholder involvement. An ongoing monitoring program would not only evaluate the implemented management strategies but would provide much needed long term catch and effort data. The last institutional indicator deals with enforcement of resource use regulations, an important component of sustainability (Charles 2001). In order to prevent non-compliance enforcement needs to firstly be frequent so the likelihood of individual inspection is high and secondly to have adequate follow through (fines) so that non-compliance would not be financially beneficial.

From an ecological perspective, the low roman CPUE (being below the limit reference point) and the size frequency distribution with a very low percentage of large individuals is of concern and needs to be addressed. A restructuring process should be implemented in order to build up the CPUE (representing abundance) over a number of years. Various options are available to try and achieve this including the implementation of a zoning scheme for the bay with an area designated closed to fishing. One drawback of this approach is that overall fishing effort within the bay is not reduced but simply redistributed into the remaining open areas. For this reason it may be required that some sort of effort limitation (e.g. number of boats allowed to launch per day) be implemented at the start of the rebuilding process. As the monitoring progresses and the fishery stabilizes so the management measures may be revised.

If an ICM approach is to be taken by the local government a new approach to planning and decision making will be needed. The simple protocol along with the indicators proposed above provide an opportunity for the local municipality to implement a basic monitoring program that would provide information pertinent to the overall system sustainability. However the adoption of the monitoring program should be incorporated into a new coastal management strategy that is aligned with the new national and provincial policies. A model of how this new management strategy could be implemented, who the role-players should be and what part they should take is proposed in the final chapter.

CHAPTER 6 –TOWARDS A MANAGEMENT PLAN

With the promulgation of new policies and legislation within South Africa over the last ten years, management within both the fisheries and coastal sectors is becoming more holistic, integrated, co-operative and participative (see Chapter 1). Of key significance is the White Paper for Sustainable Coastal Development in South Africa (2000), which lays out a plan of action for achieving a broad set of goals and objectives for coastal management. Importantly, the White Paper called for the drafting of a National Environmental Management: Coastal Zone Bill which in turn required that each coastal province compile a Coastal Management Programme (see Figure 1.5). The ICM approach advocated in these documents should be seen as a process which co-ordinates and integrates the various coastal management sectors in deciding the strategies and actions that will be used in managing the coastal area. The White Paper (2000) and the Provincial Coastal Management Plans provide the structural framework and direction within which to implement the ICM approach. In other words, the ICM concept and general approach to resource management should be incorporated into a CMP. Although the development of local CMP is not a statutory function of coastal municipalities, as mentioned in the previous chapter, it is strongly recommended due to the importance of adapting management to suit local conditions and requirements consistent with the area of management and directly linked to the local management objectives. Furthermore municipalities need to become more involved in managing local fisheries, as they are the "closest" and most affected by the ecological and economic health and productivity of the coastal zone (Anon. 1996). In order to address local needs, it is advocated that a local BMP becomes part of the CMP (see Figure 1.6). The coastal and marine resources within the Bitou Municipalities' (Plettenberg Bay) jurisdiction must be seen as important components in the alleviation of poverty and in providing opportunities for local economic development (LED). The adoption of an ICM approach to the local coastal governance should therefore assist the local municipality to achieve the strategic objectives set out in their IDP, including: i) the need to ensure social, economic and ecological sustainability, ii) create effective, participative and transparent local governance and iii) promote local economic and social development for the People of Bitou within a safe and healthy environment (Plettenberg Bay IDP 2005). Although the White Paper (2000) and the WCCMP (2003) provide policy frameworks to guide CZM efforts, a lack of appropriate administrative structures, expertise and a defined protocol to implement these policies will hinder the development of local ICM plans or approaches.

By synthesising available literature dealing with ICM initiatives, methods and lessons learned, this chapter identifies a set of criteria and steps that should be fulfilled when implementing an ICM initiative. The objectives being to firstly outline a process to aid the development and implementation of a local ICM approach within the Bitou Municipality and secondly to identify the stakeholders along with their roles and responsibilities within this process. It is imperative that it be understood at this point that the guidelines by themselves will not achieve sustainable development but require the commitment, participation and understanding of all the stakeholders as to the need for an ICM approach to the planning and use of the coastal area.

The literature review emphasised a number of conditions or criteria that need to be addressed for ICM initiatives to be successful. Furthermore a number of steps within a structured approach to the management strategy (referred to as the policy cycle) were highlighted (Table 6.1). Details of the literature reviewed are given in Appendix XI. From the criteria and steps highlighted within Table 6.1 an implementation protocol for local ICM initiatives is proposed in Figure 6.1. Some of the criteria listed in the table cannot be defined as finite steps but are rather principles that need to be met continuously throughout an ICM process. Consequently, they were not included in the implementation protocol but should rather be achieved throughout the long-term iterative management process.

6.1 Necessary criteria for implementing an ICM initiative

The success of an ICM initiative is partly dependent on strong and effective leadership (Hewawasam 2000). Not only does the leadership need to be dedicated and consistent but needs to provide a high level of ongoing administrative and political support. In this regard, the first step in developing an ICM strategy for the management of Plettenberg Bay coastal resources is to ensure that the local municipality agree on the need for an ICM approach and accept responsibility for overseeing and implementing the proposed strategy (Figure 6.1, Section B.1) (Vallega 2001). Enhancing the managers' political will to adopt such an approach may require an awareness campaign that highlights the socio-economic value of the coastline as well as the need for an integrated approach due to the complex multi-use nature of the coastal zone (Burbridge 1997). Importantly, the management approach needs to be formally incorporated and aligned within the local Integrated Development Plan (IDP), the Local Economic Development Plan (LED) and the Spatial Development Plan (SDP) thereby providing the legal backing and "weight" behind the program.

Table 6.1. Main criteria and steps regarded as being important to achieve successful ICM. Reference codes for specific papers advocating the steps and criteria are given on the right. Literature citation are given in Appendix XII.

		Literature advocating criteria or step requirements.
Criteria that need to be addressed for successful ICM initiatives	Develop the need for ICM / Public education	1, 3, 8, 9, 11, 20, 23, 24, 30, 31, 32, 33, 34
	Appoint Leadership / Champion / Management unit	1, 9, 15, 22, 26, 28, 30, 33, 34
	Define geographical boundaries	3, 6, 21
	Stakeholder involvement / Participatory	1, 4, 7, 8, 9, 10, 13, 14, 15,17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 34
	Formation of Sub-committees	6, 15, 17, 21, 23, 27
	Phased / Iterative approach	3, 4, 8, 12, 13, 14, 17, 20, 22, 23, 24, 32, 33, 34
	Importance of research / information	1, 3, 6, 7, 8, 9, 10, 11, 13, 17, 18, 20, 22, 23, 24, 28, 33, 34
	Sharing Information / Knowledge	7, 11, 20, 26, 30, 31, 34
	Continuous training / Capacity building	7, 9, 15, 20, 23, 24, 28, 30, 32, 33, 34
	Limited no. management issues tackled	12, 13, 20, 24, 26, 32
	Establish baselines	8, 14, 33
	Objective based measurable outcomes	14, 18, 21, 22, 24, 26, 34
	Define socioeconomic & environmental goals	3, 14, 33
	Form vision	5, 15, 21
	Co-ordinated with all government levels	1, 7, 15, 20, 22, 23, 24, 32, 33, 34
	Be flexible & adaptable	7, 20, 22, 28, 32
	Schedule implementation	18, 21, 23
	Indicator system developed	2, 9, 14, 17, 18, 21
	Securing access rights	15
	Adequate enforcement	15, 31
Important steps highlighted in the ICM policy cycle	Assess current situation	3, 7, 11, 18,
	Identify Objectives	3, 4, 5, 6, 11, 18, 32
	Identify Issues	8, 11, 12, 13, 16, 19, 23, 25, 31, 32, 33
	Prioritize	16, 26
	Data Collection / Research	3, 4, 17, 19, 22, 29
	Analysis	11, 16, 17, 19, 23, 25, 29, 32, 33
	Develop options / Strategy formulation	1, 3, 4, 11, 16, 17, 31
	Program preparations / Plans formulation	6, 7, 8, 12, 13, 17, 18, 19, 25, 29, 31, 32, 33
	Agreement of actions	5, 11
	Revision of plan	1, 2, 4, 5, 6, 8, 18, 19, 33
	Formal adoption & funding	6, 7, 8, 12, 13, 15, 19, 21, 23, 25, 26, 28, 29, 31, 32, 33
	Implementation	2, 3, 5, 6, 7, 8, 11, 12, 13, 17, 18, 19, 23, 25, 29, 31, 32, 33
	Monitoring effectiveness / Evaluation	2, 3, 5, 6, 9, 11, 12, 13, 14, 15, 17, 18, 23, 25, 27, 28, 29, 31, 32, 33

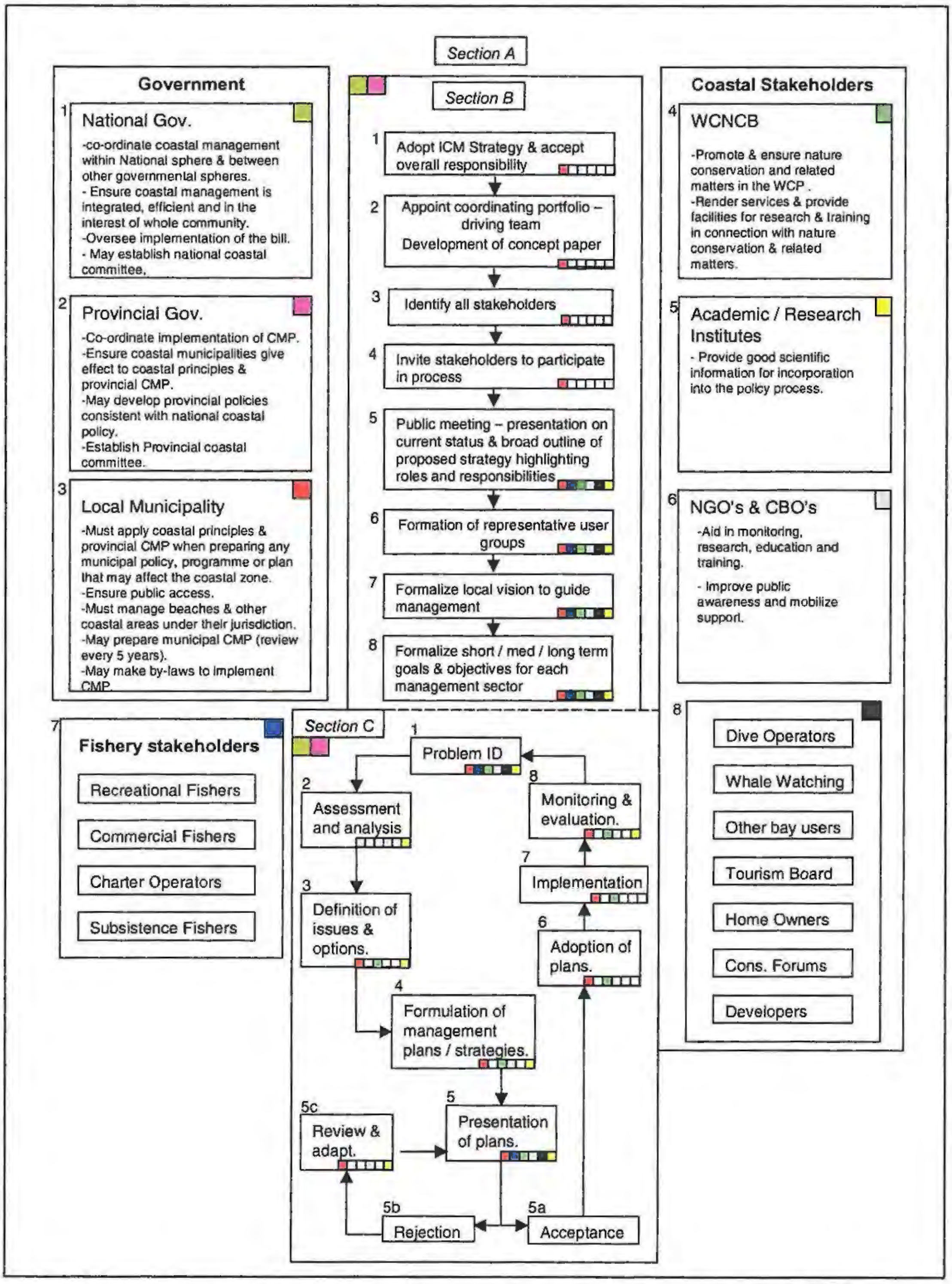


Figure 6.1. Proposed local ICM implementation protocol. The diagram is broken into three parts. Section A lists the various stakeholders involved, section B deals with specifics of initial implementation whilst section C deals with the ongoing policy cycle of how issues should be dealt with. The stakeholders involved in each step or phase are indicated by the colour-coded blocks.

Following the municipalities adoption of the principles of an ICM approach the establishment of a coastal management unit that is responsible for coordinating between government departments, NGO's, local communities and the private sector is essential (Figure 5.1, Section B.2) (ECCMP 2004). Coordination of effort and effective inter-organizational linkages among the actors involved is key to the success of the programme (Tobey and Volk 2002). Improved coordination will facilitate a clearer definition of the roles and responsibilities of the various departments that have a shared or overlapping responsibility for coastal resources and will also improve the flow of information between organizations to ultimately boost capacity for management (ECCMP 2004). A coordinating body (task team) should be constituted under the auspices of the municipality. This task team body should be multidisciplinary and include experts in coastal management, regional planning, resource economics, environmental management and ecology (Anon. 1996). The team must be responsible for developing a 'concept paper' or 'discussion document' which lays out in simple terms the need for the new programme, what it intends to accomplish, indicates how the programme will be developed and by whom. In addition, it must reveal how much time and money is required (Anon. 1996). Important information such as current legislation and resource status should also be included in this concept paper (Die 2002). The task team must identify all the stakeholders that need to be involved in the process and formally invite these stakeholders to participate in the ICM approach and assist with the development of a resource management plan (Figure 6.1, Section 3 & 4). The earlier stakeholders are involved in the process the greater their sense of ownership over the programme which in turn leads to better compliance with the management measures (Die 2002) and ensures that existing local knowledge and experience is integrated into the plan (Tobey and Volk 2002).

To ensure the success of the ICM initiative the general public have to be made fully aware of the ICM programme as well as its goals and policies (Anon. 1996). To achieve this, public meetings that are open, facilitative, inclusive, transparent and informative need to be held, that allow for detailed discussions and questions relating to the concept paper (Die 2002). This process also allows the public to express their views and contribute towards the contents of the plan (ECCMP 2004) (Figure 6.1, Section B.5). Initial investment in the consultation process will save a great deal of resources later and will help the plan to have the highest possible initial acceptance when it is implemented (Die 2002). Following the public announcement of the ICM initiative, a forum of user groups, from all sectors of the community, need to be established to provide users with a formalized means to voice their needs and views (Figure 5.1, Section B.6). An example of this is already present in Plettenberg Bay with the recent formation of the Central Beach Launch Site Forum. It currently comprises 15 sectors including National Sea Rescue, municipal representative, Rate Payers Association, New Horizons, Kwanakotula, the Ski-boat club, commercial fishing sector, charter fishing sector, inflatables and Personal Water Craft (PWC), hobie cats, charter diving, research and tourism. This forum, requested by central government as part of Plettenberg Bay's application for a launch site, is primarily a communication forum between government and the launch site users aimed at increasing public participation.

A key component in the formulation of an ICM approach is the development of a local vision to guide management (Figure 6.1, Section B.7) (Rodgers & Biggs 1999, Hauk & Sowman 2001, McMcleave *et al.* 2003). All stakeholders should be involved in this process to ensure that consensus is reached as to the long-term plans for Plettenberg Bay. The vision statement creates the foundation of the management programme by providing a reference against which all management decisions can be evaluated and informs the principles on which the objectives of the programme are based (ECCMP 2004). A range of short, medium and long-term goals and objectives for each management sector also need to be formalized by the stakeholders to guide daily and long-term management decisions (Figure 6.1, Section B.8). The developmental vision for Plettenberg Bay currently reads as follows: "To be the best together" thereby expressing the need to be united in diversity, united in action and have continual improvement on past performances. The spatial vision reads as: "Bitou, a place for all" expressing the belief that South Africa and Bitou belongs to all who live in it, a home for all and a home that ensures economic, social and ecological sustainability (IDP 2005). These visions were formulated at a strategic planning session in 2003 and spatial development framework forum meeting in 2004 respectively thereby guiding both the developmental and spatial components of the local IDP document.

Other aspects that contribute towards successful ICM initiatives include the co-ordination of all levels of government in terms of (i) legislative and policy support and (ii) in ensuring that the management objectives of the lower tiers of government are in accordance with the upper tiers. The sharing of information along with continuous training and capacity building for those involved in ICM programs is especially important since ICM should be seen as a flexible, adaptive strategy that continuously evolves as new information becomes available or as the system changes. Importantly ICM should follow a phased, iterative approach beginning on a small scale with a limited number of management issues being tackled and growing as capacity and knowledge increase and measurable objective based outcomes are met. An ICM policy cycle describing a phased approach is explained below.

6.2 Policy cycle

Experience locally and internationally demonstrates that coastal management is not a 'once off' activity, it needs to be understood as a cyclical process of continual improvement, in which the role players learn from and build upon their practical experience, thereby steadily increasing the effectiveness of the management strategy (ECCMP 2004). Consequently, several cycles of the management strategy may need to be performed before the programme is sufficiently refined to address the specific objectives of the plan. There are many variations in the policy cycle, which vary according to political structures and available resources, but the central idea of a multiple step cycle of planning-commitment-implementation-evaluation remains constant (Tobey and Volk 2002). The cycle proposed in Figure 6.1 Section C has been developed from the various papers highlighted in Table 6.1.

Stage 1: Problem issue identification

The initial cycle requires reviewing and synthesizing available information pertaining to the coastal environment to identify major issues contributing to non-sustainability. Subsequent cycles of the policy may also raise further issues through the evaluation phase.

Stage 2: Assessment and analysis

In many instances there is a lack of data pertaining to the status of the resource in question as well as the socio-economic forces acting on the resource users (Britz *et al.* 2001). Since an effective ICM programme must be based on adequate information, surveys may need to be performed to obtain this information or existing information must be collaborated (Anon. 1996).

Stage 3: Definition of issues and options

Issues identified from the analysis of information in stage two need to be defined and reduced to a manageable number (Olsen 2003, Clarke 1997). The various management options related to alleviating these issues also need to identified and defined.

Stage 4: Formulating the ICM plan

The management options identified in the previous stage need to be incorporated into a workable framework that managers can use to address the issues identified during the analysis. The formulation of a single management strategy is complex. The best approach therefore may be to generate and test several strategies through pilot-scale implementation to arrive at the most appropriate management strategy that is suited to local conditions (GESAMP 1996).

Stage 5: Presentation of plans

Once the plans have been formulated they need to be presented to all the stakeholders for acceptance (5a) before the process can continue, or alternatively be rejected (5b), in which case the plans will have to be reviewed and adapted (5c) accordingly and once again presented to the stakeholders for approval.

Stage 6: Adoption of plans

The formal adoption of the programme will require a high-level administrative decision, in this case by the municipality. It will also include consideration and agreement of a budget for each phase of the programme (Anon. 1996, GESAMP 1996).

Stage 7: Implementation

At this stage in the ICM process the management plan becomes operational and the actions aimed at implementing the plan begin (Vallega 2001). New management mechanisms are enforced. Enforcement is an essential element of programme implementation and without it the credibility of the management unit could be damaged (FAO 1997).

Stage 8: Monitoring and Evaluation

The outputs of the ICM programme must be evaluated (Vallega 2001). The monitoring process establishes what has been achieved and the evaluation procedure determines whether the completed actions have contributed to the desired outcomes and goals of sustainable development (ECCMP 2004). It is therefore important for the goals to be achieved through the ICM approach and CMP to be specified as clearly and quantitatively as possible, otherwise assessments as to how well they are being achieved are difficult (Anon. 1996). The evaluation phase, which is often omitted by a number of management initiatives, is the stage where the greatest amount of learning occurs and also provides evidence that the changes in the managed environment are attributed to the ICM programme (GESAMP 1996). Documenting the achievements attained through the new management approach is essential in demonstrating to all stakeholders the success of the ICM in achieving sustainable development and thereby ensuring continued support (GESAMP 1996, Burbridge 1997, Bower and Turner 1998, Tobey and Volk 2002).

Although the protocol outlined above follows a linear stepwise implementation, it is not always practical or feasible to stick solely to the model. It may become necessary to begin a later step before the previous is completed or even begun. Furthermore, where data is lacking and urgent management is required the precautionary approach should be followed with actions being taken to alleviate the stress before the research results are gathered. In anticipating and predicting the likely causes of environmental degradation, rather than reacting to their outcome, should result in the prevention of costs involved in rectifying the damages (Stojanovic *et al.* 2004).

6.3 Collective roles and responsibilities of all stakeholders

The various stakeholders that should be a part of the initial and ongoing process are specified in Section A (Figure 6.1). A summary of their main roles and responsibilities and the specific stages of involvement in the ICM process are described below.

National government

Marine and Coastal Management Chief-Directorate of the Department of Environmental Affairs and Tourism (DEAT) is the lead agent responsible for the management of South Africa's coastal resources (Glavovic 2000a). Responsibilities include policy formulation and implementation, coordination of management activities within and between governmental spheres, biological diversity protection, offshore resource management, research, and environmental education (WCCMP 2003). In practice, the national office plays an advisory role and has limited capacity, delegating national coastal committees with management responsibilities. Their role is also to ensure that coastal management is integrated, effective, and efficient and in the interests of the whole community (Figure 6.1, Section A.1).

Provincial government

The role of provincial government is to coordinate the implementation of the provincial coastal management plan (PCMP) and ensure that coastal municipalities give effect to coastal principles and the PCMP. Responsibilities include monitoring the state of the environment in the coastal zone and coastal management in the province to ensure that it is undertaken in an integrated, effective, and efficient manner. Other responsibilities include development and reviewing of provincial legislation and monitoring the state of the coast within the province. In addition, they establish a provincial coastal committee (PCC), which facilitates communication between the different governance spheres (Figure 6.1, Section A.2).

Although both the national and provincial government levels have not been shown to be specifically involved in any particular step, a better option is for both of these government levels to oversee the entire process ensuring that local management remains within the boundaries set by the provincial and national coastal management plans.

Local government

The primary functions of municipalities in relation to coastal management are to: i) manage beaches and other coastal areas under their jurisdiction in an integrated, effective, and efficient manner that is in accordance with the coastal management principles of the Coastal Zone Bill and ii) ensure public access to coastal public property. Furthermore local municipalities may: i) prepare and implement municipal coastal management programmes as either part of an integrated development plan or separately, ii) vary boundaries of the coastal buffer zone and iii) establish coastal set-back lines in zoning / land use schemes (WCCMP 2003). Once a CMP has been developed, the municipalities have the power to create by-laws to assist with implementing their CMP's (Figure 6.1, Section A.3). It is envisaged that the local municipality would be a lead agent to implement the ICM approach and develop the CMP and as such would be involved in all the steps given in Section B and most steps in Section C (Figure 6.1). Currently an exception would be in the research and analysis step (C.2) which would be outsourced to a research facility.

Western Cape Nature Conservation Board (WCNCB)

The objects of the WCNCB are to: i) promote and ensure nature conservation and related matters in the Western Cape Province, and ii) render services and provide facilities for research and training in connection with nature conservation and related matters (WCCMP 2003) (Figure 6.1, Section A.4). Specific involvement of the WCNCB would be in the definition of issue and options (C.3) resulting from previous assessment, the formulation of management strategies (C.4), the adoption and implementation of the strategies (C.6 & C.7) and in the monitoring and evaluation (C.8) of the strategy.

Research institutions

The role of universities and research institutions is to assist with the policy process by collecting and analysing data concerning coastal resources. One of the fundamental requirements for a successful ICM approach is that decision-making is based on scientifically sound data (Anon. 1996, Tobey and Volk 2002) (Figure 6.1, Section A.5). As such, research institution would be specifically involved in the assessment and analysis step (C.2), the definition of issues and options (C.3), the formulation of proposed management strategies (C.4) and the monitoring and evaluation of those strategies (C.8) should they be accepted.

Non-governmental and Community-based organisations

They have a valuable role to play in improving public awareness of and mobilising support for the coastal policy and its implementation and also in management activities such as monitoring, research, education and training (Glavovic 2000a) (Figure 6.1, Section A.6). NGO's and Community based organisations (CBO's) could assist or replace research institutes in the assessment and analysis of potential problems (C.2), the formulation of management strategies (C.4) and the ongoing monitoring and evaluation of those strategies (C.8) should the be accepted.

Additional stakeholders include those of the fishery sector (recreational, subsistence, commercial sectors and charter operators), and other tourism and development related role players (Figure 6.1, Section A. 7 & 8). The involvement of these stakeholders needs to go beyond simply informing and post implementation consultation to one where they have the ability to be a part of the process with adequate representation and possibility for input. However, to aid this process it is recommended that the various stakeholder groups form representative bodies that would be used as paths of communication and help in conflict resolution. It is not possible for all stakeholders to be involved in every step, rather certain steps need to be carried out by specific groups with regular feedback to all other stakeholders and provisions for their comments on the reports. As such all stakeholders should be involved from Section B.5 through to B.8 and importantly in steps C.1 &C.5 of the policy cycle. In particular, step C.5 should be seen as an opportunity for information exchange and stakeholder input.

Although the stakeholders have been identified and an implementation protocol outlined for a localised ICM approach in Plettenberg Bay, the incorporation of the program into the municipal management strategy requires departmental restructuring, which is currently under review (Windvogel 2005, pers comm.). What has been proposed is that within this restructuring there needs to be a department or leader who will be responsible for driving the process, ensuring that other relevant departments are involved in the process and communicating between all stakeholders and the different levels of government. Of equal importance to the supervision of the project is the ability of local government to fund the ICM initiative.

6.4 Funding

Once the municipality has identified the budget requirements in implementing an ICM approach, it is crucial that sufficient funding is secured. Unreliable funding can create significant obstacles and ultimately jeopardize the overall success of the management programme (Hauck and Sowman 2001). Of equal importance is the long-term availability of funds due to the iterative and expanding nature of ICM (Christie *in press*). There are too many cases where once donor funding and technical assistance are removed the initiative has failed (Hauck and Sowman 2001, Olsen 2002, Christie *in press*). Three means of obtaining financial support for the programme are outlined below.

6.4.1 Surcharge levies:

The first is through a local environmental surcharge levied on local residents through property rates and on tourists through rates imposed on accommodation facilities visited (Mollatt 2003). Through a willingness-to-pay survey, which was aimed at quantifying public's preference for the provision of public coastal management services in Plettenberg Bay, Mollatt (2003) deduced that on average residents were willing to pay approximately R175 per annum (R15 per month) toward a Bay Management Plan while domestic and foreign tourists were willing to pay a daily levy of approximately R6 and R22, respectively. Aggregated across their respective populations this yielded a passive use value (or quantitative public preference) of between R15 397 900 – R20 330 500 per annum (Mollatt 2003).

6.4.2 Public-Private-Partnerships (PPP's):

The second avenue is through the establishment of PPP's where certain activities can be outsourced from the municipality to various other organisations who would have the capacity and funding to fulfil their obligations. For example the ORCA Foundation has already funded a number of research projects to gather scientific data for input into a BMP and organised sponsorship to fund the 'ORCA' education centre and operate an education vessel. Part of the success of ORCA has been the links and partnerships that have been created between ORCA and various local businesses that have an ongoing role to play to fund the education centre and research projects.

6.4.3 National government funding:

The third avenue is through central governmental funding. Local municipalities may, upon entering into a memorandum of understanding between themselves and the governmental agency (Marine and Coastal Management), be paid a fee to carry out certain obligations that the governmental agency due to limited manpower and capacity is unable to. The money generated form the local municipal councils and the Marine Living Resources Fund (MLRF) would be placed into a trust that would then be used to fund activities set out in the memorandum of understanding (Griffiths & Lamberth 2002). From a coastal and fishery perspective this could include marine compliance inspections and monitoring along with public education and awareness programs. Although it is not a statutory function of the municipality to exercise these aspects they are important features to be incorporated into both the BMP and the CMP.

Mollatt's study (2003) highlighted the public preference for and gave an economic justification as to decentralised coastal management of Plettenberg Bay. Furthermore the local recreational fisheries have now been shown to be non-sustainable (this study and King 2005) and require increased local management effort. To achieve this, an integrated coastal management approach to the governance of the coastal resources in Plettenberg Bay has been proposed with the development of a CMP and a subsidiary BMP providing the frameworks within which the management strategies are put into operation. An implementation and ongoing management protocol that would form a core part of these plans has been developed providing the opportunity for the local municipality to implement the start of a more ecosystems approach to coastal management. Certain steps in achieving this have already been addressed (see Appendix XII).

CHAPTER 7 – CONCLUSION

In fulfilling the research objectives the current project has provided much needed baseline information, highlighted management issues and provided a set of indicators that can all be incorporated at a ground level into a more holistic coastal governance framework. Although there is a growing body of literature dealing with indicator development, few of these studies did more than identify possible indicators. The current project takes this one step further putting the indicators 'into action' and utilised them to assess the sustainability of the local linefisheries. Importantly the project has bridged the gap between research and management and between fisheries and integrated coastal management. The research performs an essential requirement for successful ICM in that management decisions need to be based upon scientifically sound information. However, good projects not only fulfil their objectives, but collect the necessary data with minimal time and financial wastage.

In this regard the comparative study on the reef fish community using both diving and fishing was successful but could be improved on. Firstly, by spreading sampling effort over the year an attempt was made to show differences in the community structure both spatially between the sampling areas and temporally with seasonal differences within the sampling areas. In the end this was not possible due to the low sampling frequencies during some of the seasons as a result of unfavourable sea conditions. Also, for a strictly comparative study on resident reef fish seasonal trends would be of minor importance. Secondly, by only having one shallow and one deep sample site being repeatedly re-surveyed the data is susceptible to the problems associated with pseudo-replication. The restricted sample sites did however allow for the sampling of similar reef structures thereby reducing the 'environmental noise' as did the comparative sampling with both sites being sampled on the same day. Further research could be conducted to gauge the effectiveness of using the restricted sites by comparing a subset of results gained from a repeatedly sampled site to a more comprehensive data set where information was collected from a number of sites.

With regards to the linefishery assessment, the methods used in the study provided the required data giving both spatial and temporal patterns in resource use. However, although the study ran over a full year, indicating seasonal trends, it still remains a snapshot reflection of the fishery and should be continuously monitored. The launch records present a simple and cost effective means of monitoring long term trends in total effort whilst access point surveys remain the most effective means of gauging total catch and cpue.

The next step for Plettenberg Bay is for the local municipality to 'buy into' the process and for a lead agent or champion to promote, encourage and support the development a local coastal management plan, thereby taking the concepts and ideas provided here and making them a reality. After all, recommendations are only as good as the actions they cause and the results they create. Importantly it is envisaged that the protocol developed in the previous chapter, along with the indicators, can be adopted by other municipalities within the warm temperate south coast bioregion specifically the area between Mossel Bay and Port Alfred. Poor institutional capacity, corruption within the local governmental bodies and adequate funding are all issues that will need to be addressed before such a protocol can be properly implemented and maintained.

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APPENDIX I

SKI-BOAT FISHING QUESTIONNAIRE

Section 1: Socio-economic indicators

Questionnaire Number:________________ Date:__________Time__________

Location:____________________ Boat Reg. #____________________

Own Boat: Y N Type: deckboat Skiboat Inflatable

Commercial A Semicommercial B Charter C Recreational D

Catch inspected: Y N if Y catch observation no.________

Skipper information

Sex: M F Race: B W M I

Age: (1) 16-20 (2) 21-25 (3) 26-30 (4) 31-35 (5) 36-40 (6) 41-45
(7)46-50 (8) 51-55 (9) 56-60 (10) 61+

Home Language: English Afrikaans Other:____________________

Place of Residence:__________________________Country ____________________

Level of Education: 1) No schooling 2) Grade 0 3) Grade 1 4) Grade 2
5) Std 1 to Std 4 6) Std 5 to Std 7 7) Std 8 to Std 9 8) Std 10
9) Higher (Degree/diploma)

Other Occupation:______________________________

Income bracket (per week): 1 R1 – R115 2 R116 – R346
3 R347 – R808 4 R809 – R6929
5 Pension

Any other sources of income:______________________

Number of dependants:____________________

Section 2: catch and effort

Crew size:_____ Estimated ages: <20 20 – 40 >40 Number of rods:______________

Crew Composition: Male ________ Female________

Where did you fish?____

(position marked on map provided)

Time started?______________________ Time ended:______________________

Type of fish targeted: [Gamefish] Species you target?____________

[Reef-fish] ____________

[Baitfish] ____________

[Bottomfish] ____________

____

Where did you launch from?____________ Bait used? [Sardine] cost?________

[Squid] ______

[Prawn] ______

Other____________

Where did you obtain your bait?____________________

Trip Catch:

Species	Number	Released	Kept

Section 3: equipment

How much did you spend on general tackle in the last year?____________

What is the estimated value of your ski-boating equipment?

Boat (plus accessories)____________ Motors____________Trailer________

Rods____________ Reels ____________ Tackle____________

Total:____________

What do you spend on insurance, licencing, storage and maintenance of your skiboat per year?____

Section 4i: If Recreational

If unemployed, Last occupation?____________________

Where do you live?______________________________________

Are you on an overnight, weekend or longer trip/holiday? YES / No

If YES
How many days will you be staying?_______ Number days spent fishing?____________
Accommodation / day:_____________________________________

Number of people in party?____________ How many will be fishing?_________________

Will you or have you done any other fishing whilst in Plett (rock and shore or estuarine)?_______

____

On a scale of 1 – 10 how important is fishing in comparison to other activities in Plett?_________

How much did you spend on this outing in respect to

Food and Drink:_____________________ Petrol:_______________

Section 4ii: Commercial fishermen

How many crew employed?____________ Salary paid per month?______________________

Do you take charters? Y N If Yes, how many in the last year?______________

On average how many per trip?________________

How much do you charge per person?___________

Section 5: Management and Fisher attitudes

Who do you think is responsible for managing the offshore living resources? Govenrment

Provincial Gov Local Council/Munic. Anglers Local People

Other:_______________

In your opinion which of the following regulations are effective management tools?

Min Size Bag limits Closed Seasons Marine Reserves

Other:____

Do you Obey these regulations:

Min Size_______Bag limits______Closed Seasons________Marine Reserves________

Has your catch ever been inspected by an inspector? Y N

If Yes how often? 1 in 5 trips 1 in 10 1 in 20 1 in 50+

Remarks as to alternative management strategies:_____________________________________

____

____

____

____

Species			
Min. Size			
Bag Limit			
Closed Season			

Section 6: General information

How many years have you been fishing?__________ In Plett_______________

How many days have you been fishing in the last week?____________Day?_________Year?__
____

Do you fish at night?___________ How often in last 12 months?_________________________
____

Do you believe fishing in Plett has deteriorated over the years?Y N Don't know

If Yes, what do you believe is the cause? Pollution Siltation Trawling

Gill-netting seine-netting overfishing (commercial) overfishing (recreational)

Other (specifiy)____

In what way has it deteriorated? Fewer fish smaller fish fewer species

____

Do you belong to a club? Y N Name?_____________________________

APPENDIX II:
Vessel data sheet

Survey #__________ Date:__________________

Time					
Loc.					
GPS					
Depth					
Substrate					
Type					
Reg. #					
Crew					
Spp targeted					
Spp caught					
Comment					

APPENDIX III

Species in the recreational and commercial ski-boat catches sampled in Plettenberg Bay between August 2003 and September 2004. Species listed alphabetically by family.

Species	Total Caught	Total Kept	Total (Kg)
CHONDRICHTHYES			
Carcharhinidae			
Carcharhinus brachyurus	115	12	
Carcharhinusobscurus	9	0	
Hexanchidae			
Cow Shark (spp unknown)	5	0	
Lamnidae			
Isurus oxyrinchus	1	1	
Odontaspididae			
Eugomphodus Taurus	3	0	
Scyliorhinidae			
Haploblepharus edwardsii	33	0	
Poroderma africanum	113	0	
Poroderma pantherinum	3	0	
Sphyrnidae			
Sphyrna zygaena	70	0	
Squalidae			
Squalus megalops	62	0	
Triakidae			
Galeorhinus galeus	29	6	
Mustelus mustelus	38	9	
Callorhinchidae			
Callorhincus capensis	1	0	
Rhinobatidae			
Rhinobatos annulatus	6	0	
OSTEICHTHYES			
Ariidae			
Galeichthysfeliceps	113	11	
Carangidae			
Lichia amia	59	45	347.93
Auxis thazard	6	6	14.88
Seriola lalandi	1	1	
Merlucciidae			
Merluccius capensis	1633	633	
Pomatomidae			
Pomatomus saltatrix	63	39	21.08
Sciaenidae			
Argyrosomus inodorus	1270	543	773.98
Atractoscion aequidens	646	368	1997.46
Scombridae			
Scomber japonicus	279	252	73.75
Sarda orientalis	12	12	36.41

Serranidae			
Acanthistius sebastoides	2	1	
Epinephilus guaza	11	1	4.41
Sparidae			
Argyrozona argyrozona	798	585	224.27
Boopsoidea inornata	187	38	15.98
Cheimerius nufar	50	45	30.59
Chrysoblephus cristiceps	40	10	9.2
Chrysoblephus gibbiceps	14	14	37.43
Chrysoblephus laticeps	862	452	435.29
Cymatoceps nasutus	2	2	
Diplodus cervinus hottentotus	1	0	
Diplodus sargus capensis	8	8	4.89
Pachymetopon aeneum	29	25	12.81
Pachymetopon grande	2	1	1.03
Petrus rupestris	8	5	11.6
Pterogymnus laniarius	59	59	32.36
Rhabdosargus globiceps	1	0	
Sarpa salpa	27	0	
Spondyliosoma emarginatum	81	18	4.39
TRIGLIDAE			
Galeichthys feliceps	13	8	

APPENDIX IV

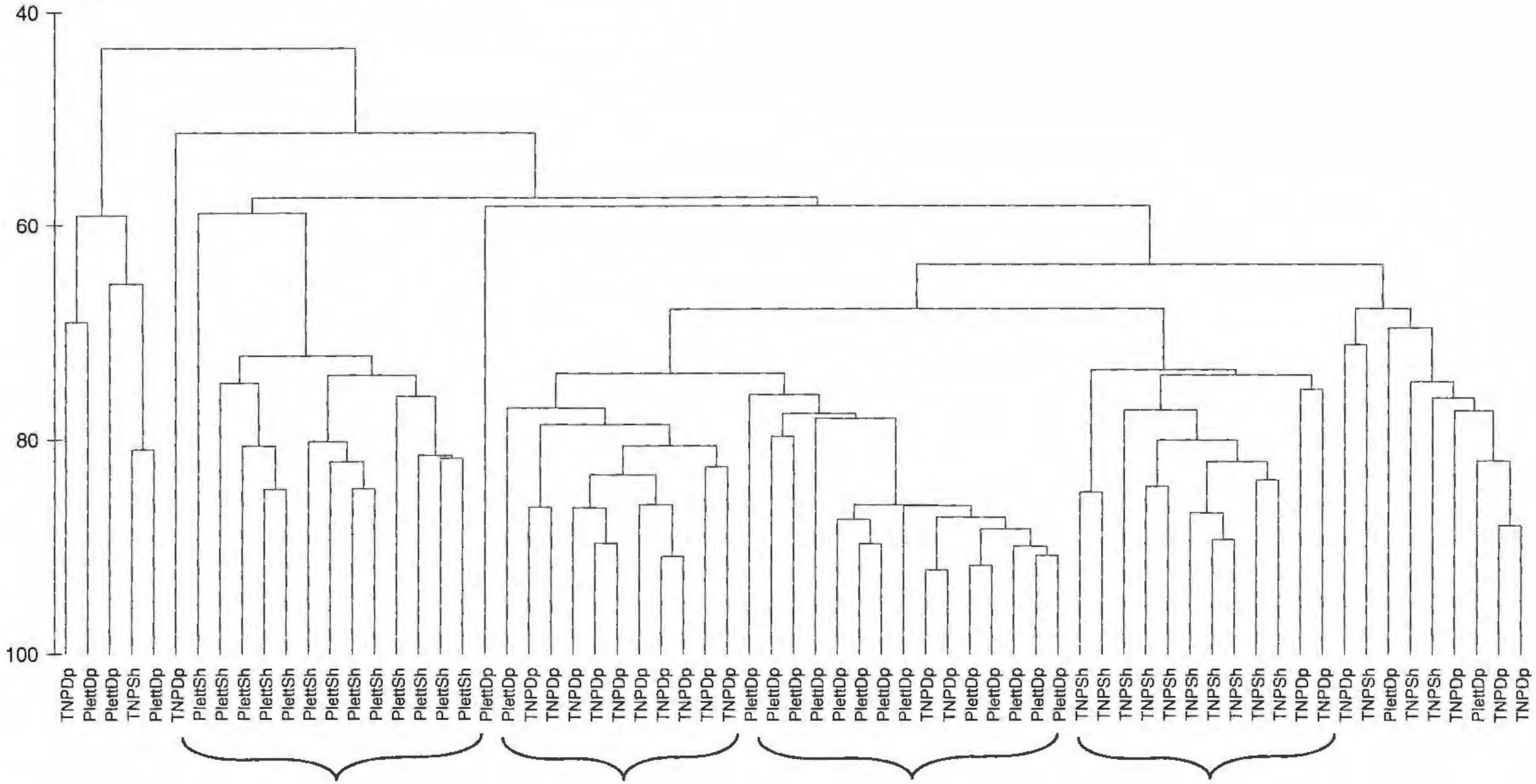
The Bray-Curtis Similarity cluster analysis on the reef fish assemblages sampled for each dive.

TNPDp= Deep Reef within TNP (16 – 20m)

TNPSh = Shallow reef within TNP (8 – 12m)

PlettSh= Shallow reef within Plettenberg Bay (8 – 12m)

PlettDp= Deep reef within Plettenberg Bay (16 – 20m)



APPENDIX V

Scatterplots illustrating the relationships between abundance of species and depth (meters), temperature (Degree Celsius) and visibility in meters.

Graphs A to C = *D. capensis*

D to F = *P. aeneum*

G to I = *O. conwayi*

J to L = *B. inornata*

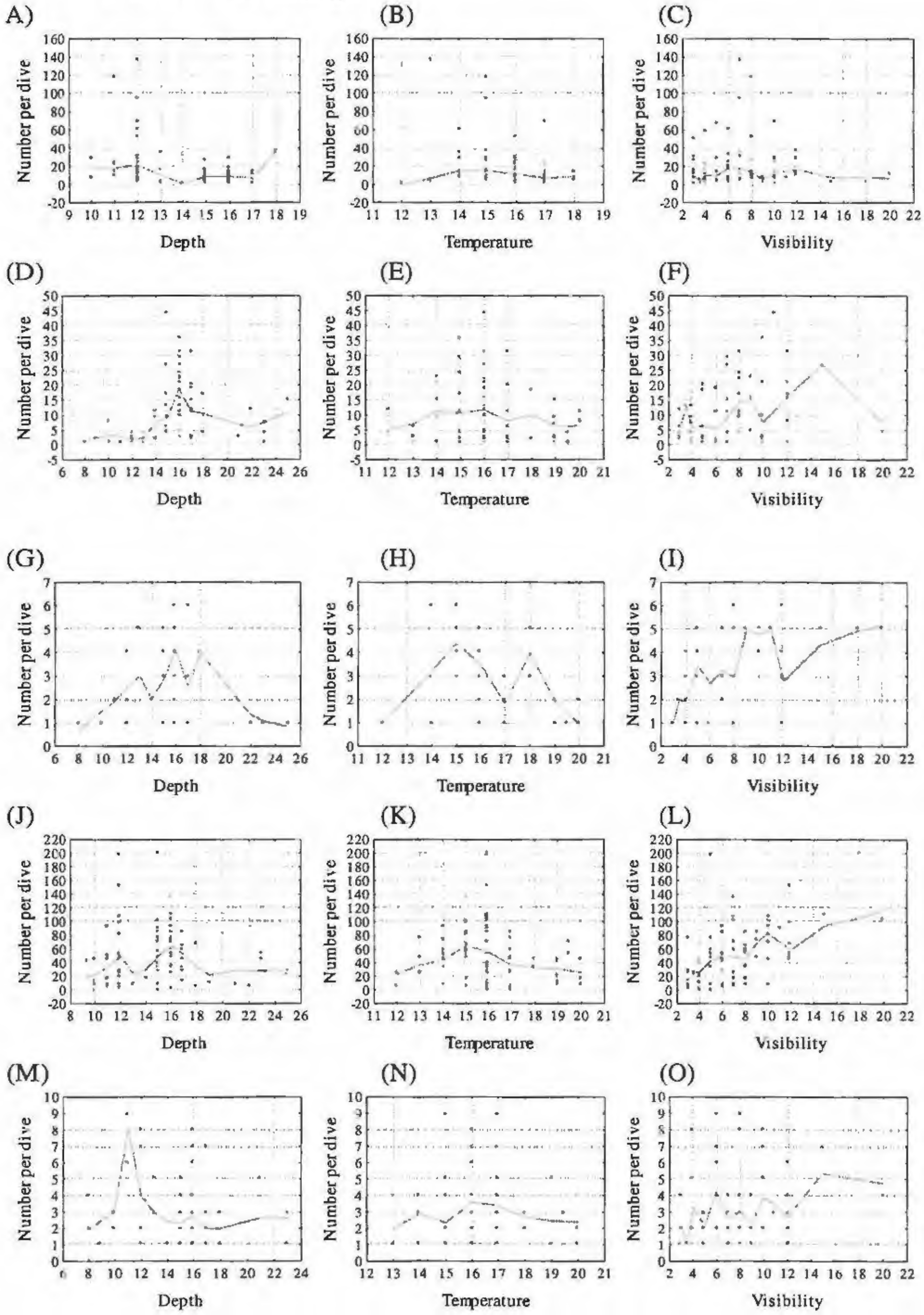
M to O = *C. fasciatus*

P to R = *S. emarginatum*

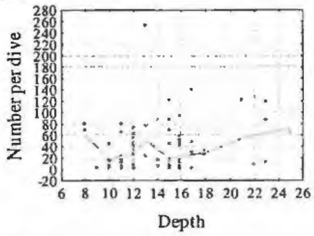
S to U = *C. bracydactylus*

V to X = *D. hottentotus*

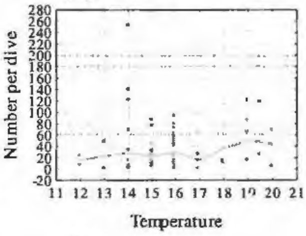
Y to Z1 = *C. laticeps*



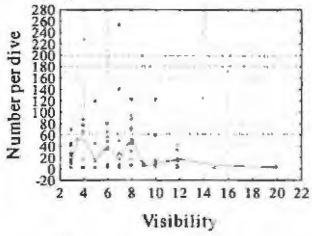
(P)



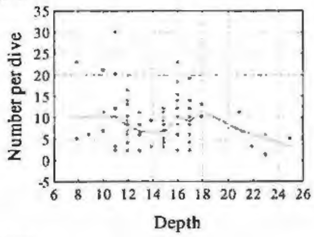
(Q)



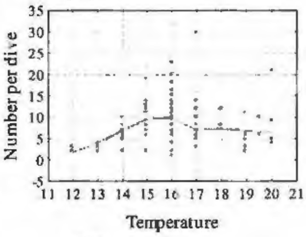
(R)



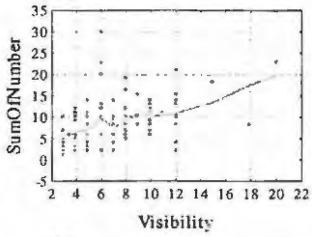
(S)



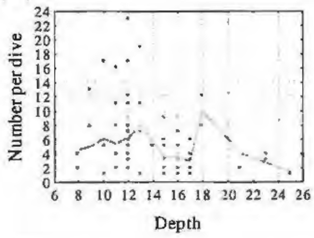
(T)



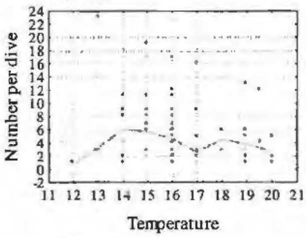
(U)



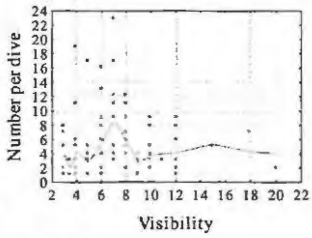
(V)



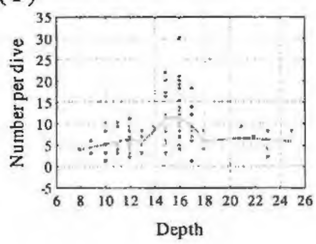
(W)



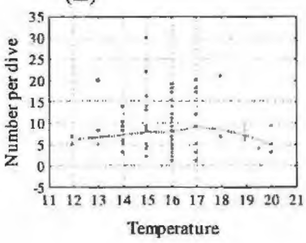
(X)



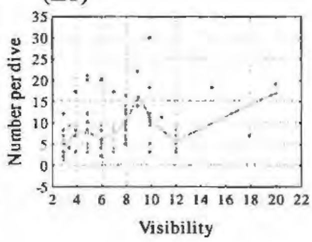
(Y)



(Z)



(Z1)



APPENDIX VI

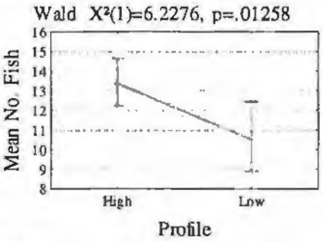
Graphs showing the results of the GLZ run for certain species. The predicted means of abundance has been plotted against the significant categorical variables. A to D = *D. capensis* E to G = *P. aeneum*

H to K = *B. inornata* L to O = *S. emarginatum*

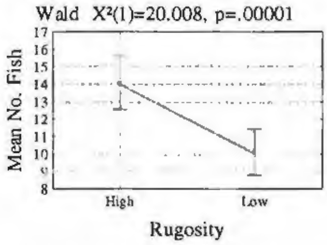
P = *C. bracydactylus* Q to S = *D. hottentotus*

T to W = *C. laticeps*

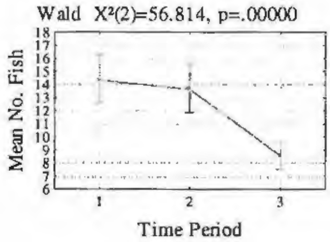
(A)



(B)



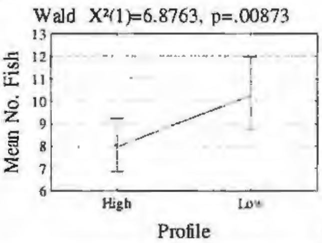
(C)



(D)

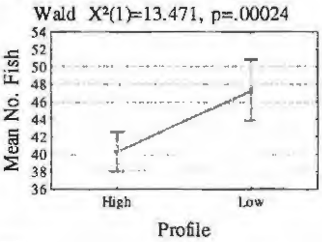
Error! Objects cannot be created from editing field codes.

(E) (F) (G)

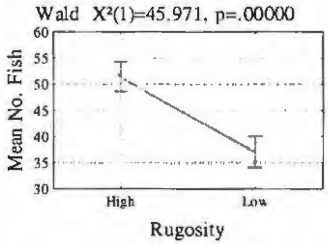


Error! Objects cannot be created from editing field codes.Error! Objects cannot be created from editing field codes.

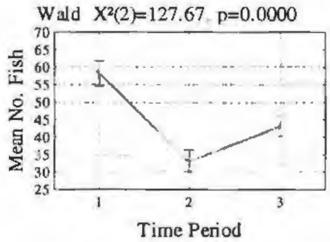
(H)



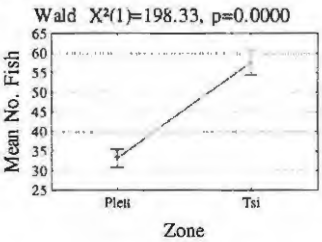
(I)



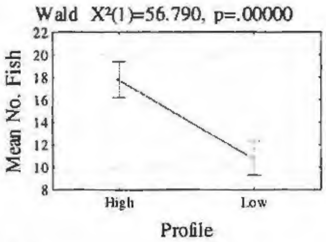
(J)

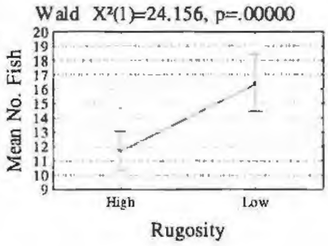


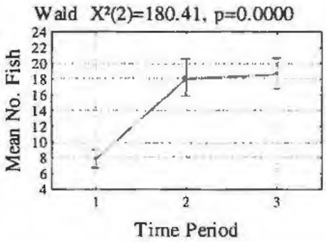
(K)



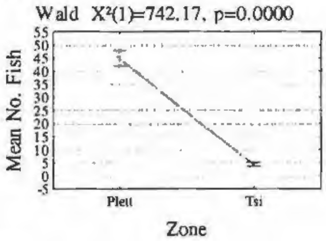
(L) (M) (N)


Wald X²(1)=56.790, p=.00000
Mean No. Fish
High
Low
Profile

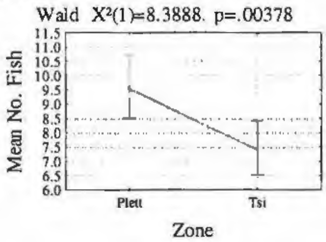

Wald X²(1)=24.156, p=.00000
Mean No. Fish
High
Low
Rugosity


Wald X²(2)=180.41, p=0.0000
Mean No. Fish
1
2
3
Time Period

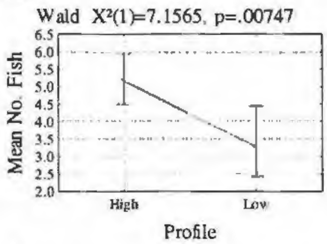
(O)


Wald X²(1)=742.17, p=0.0000
Mean No. Fish
Plett
Tsi
Zone

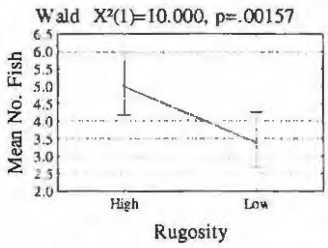
(P)


Wald X²(1)=8.3888, p=.00378
Mean No. Fish
Plett
Tsi
Zone

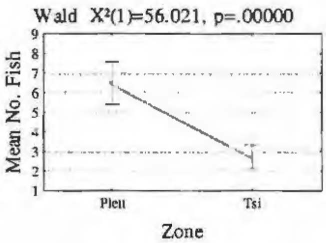
(Q)


Wald X²(1)=7.1565, p=.00747
Mean No. Fish
High
Low
Profile

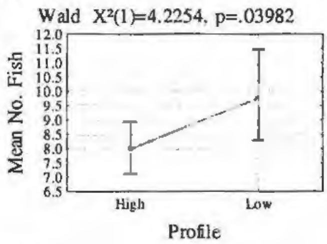
(R)


Wald X²(1)=10.000, p=.00157
Mean No. Fish
High
Low
Rugosity

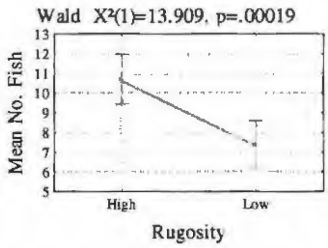
(S)


Wald X²(1)=56.021, p=.00000
Mean No. Fish
Plett
Tsi
Zone

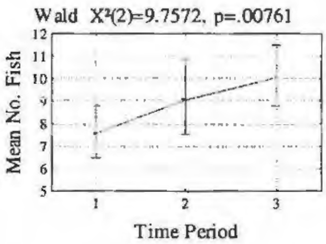
(T)


Wald X²(1)=4.2254, p=.03982
Mean No. Fish
High
Low
Profile

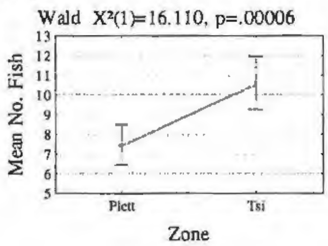
(U)


Wald X²(1)=13.909, p=.00019
Mean No. Fish
High
Low
Rugosity

(V)


Wald X²(2)=9.7572, p=.00761
Mean No. Fish
1
2
3
Time Period

(W)

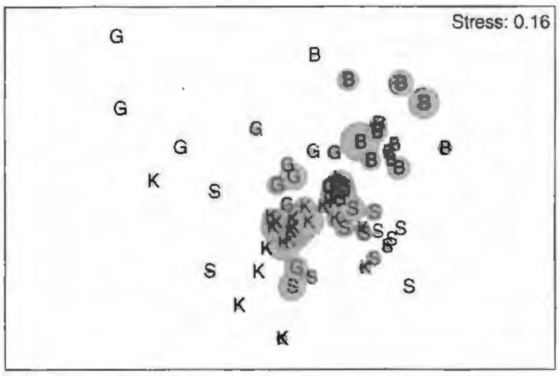

Wald X²(1)=16.110, p=.00006
Mean No. Fish
Plett
Tsi
Zone

APPENDIX VII

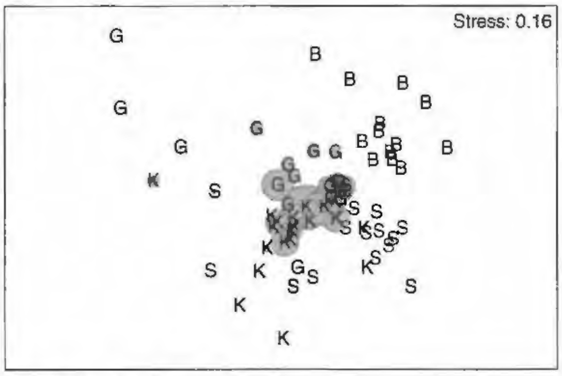
Multi-dimensional scaling bubble plots depicting the abundance of individual species and the overall spatial relationships of the dive assemblages.

B = Plett Shallow, G = Plett Deep, S = TNP Shallow, K = TNP Dee

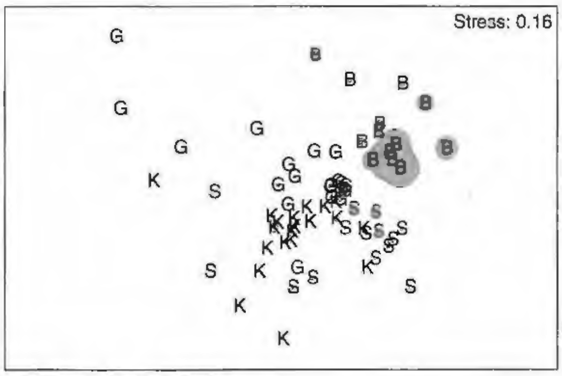
(A) Two-tone Fingerfin.



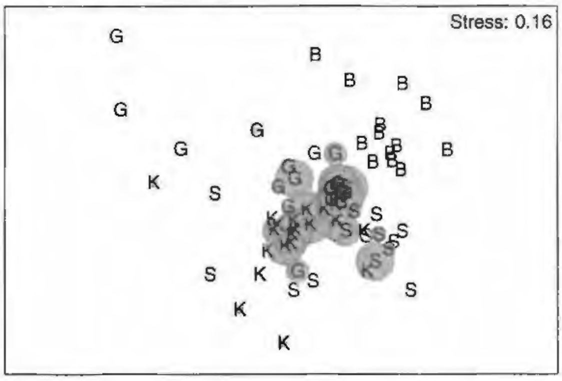
(B) Blue Hottentot



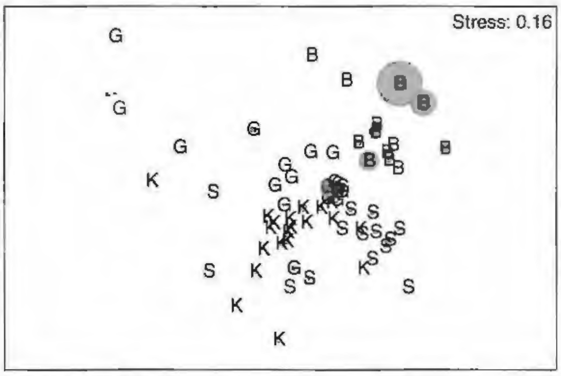
(C) Blacktail



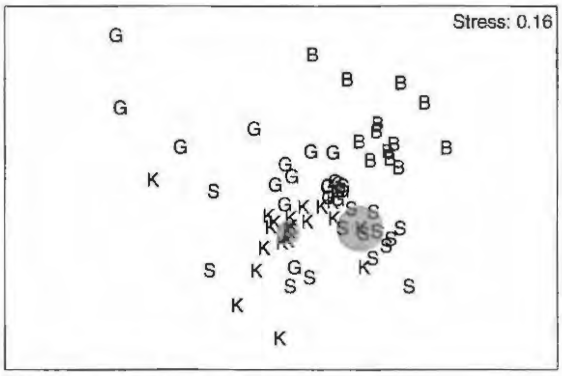
(D) Cape Knifejaw



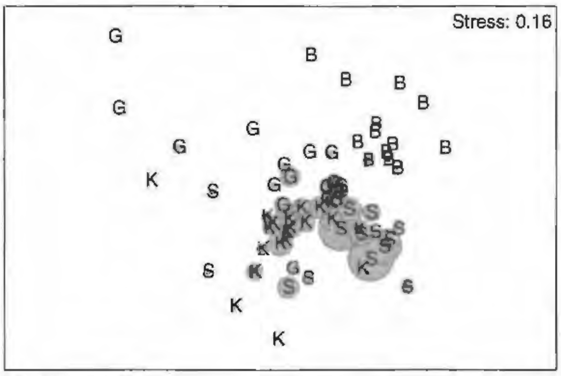
(E) Cape Stumpnose



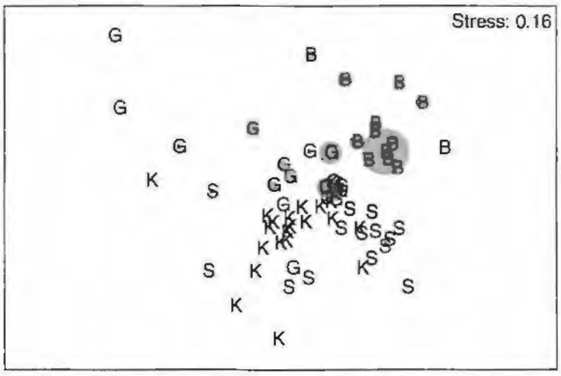
(F) Dageraad



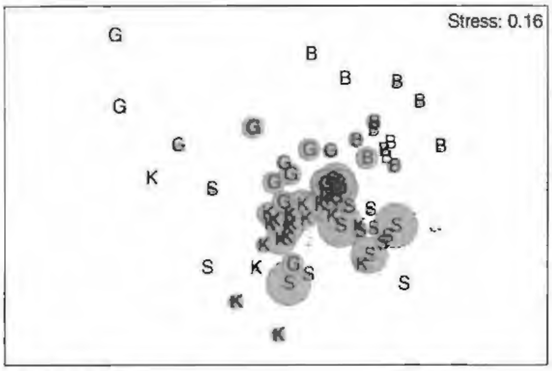
(G) Fransmadam



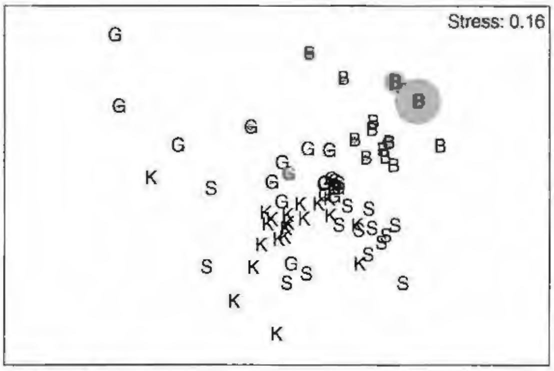
(H) Steentjie



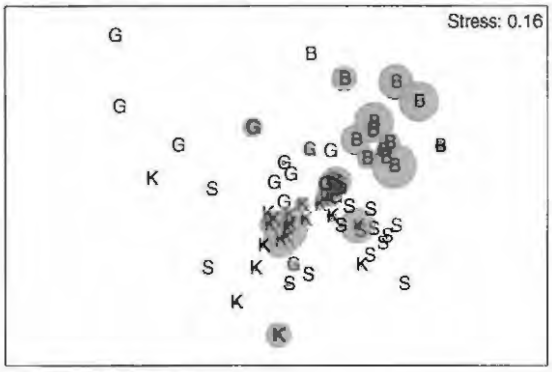
(I) Janbruin



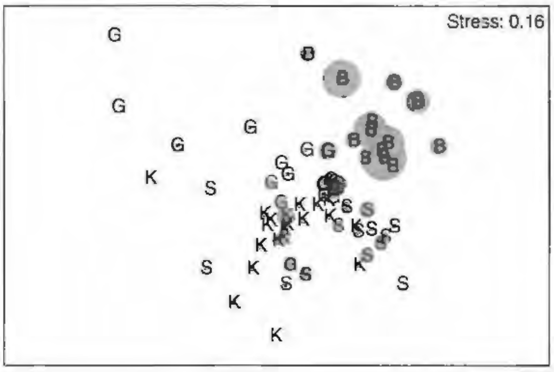
(M) Santer



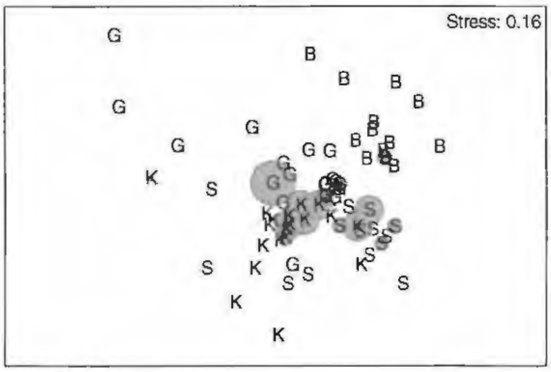
(J) Red Fingers



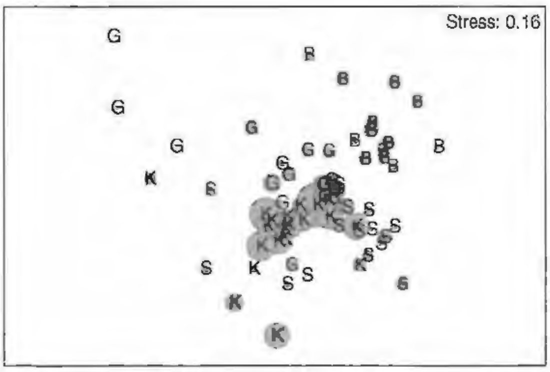
(N) Zebra



(K) Red Steenbras



(L) Roman

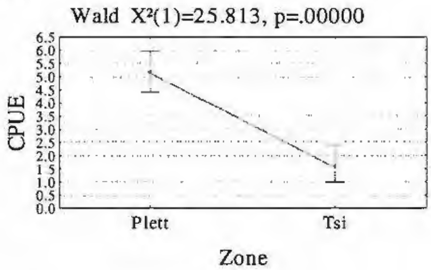


APPENDIX VIII

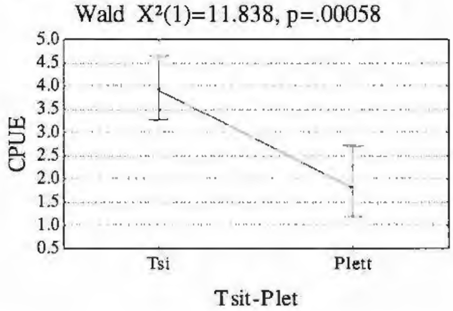
Graphed results of the GLZ run for certain species on data obtained from the fishing surveys (CPUE). The predicted means of abundance have been plotted against the zone of sampling.

A = *S. emarginatum*
B = *B. inornata*
C = *C. laticeps*

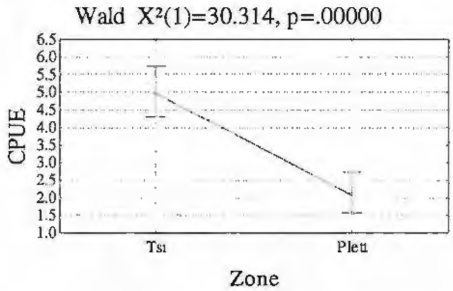
A)



B)



C)

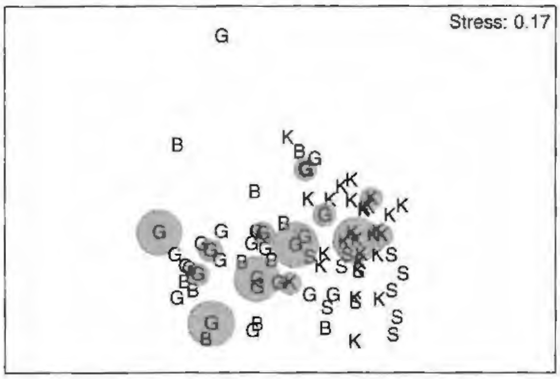


APPENDIX IX

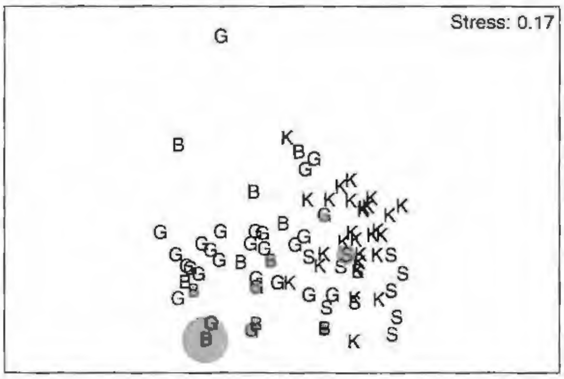
Multi-dimensional scaling bubble plots depicting the abundance of individual species and the overall spatial relationships of the fishing stations.

B = Plett Shallow, G = Plett Deep, S = TNP Shallow, K = TNP Deep

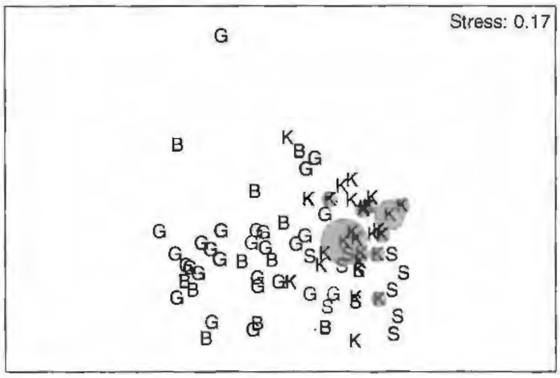
(A) Blue Hottentot



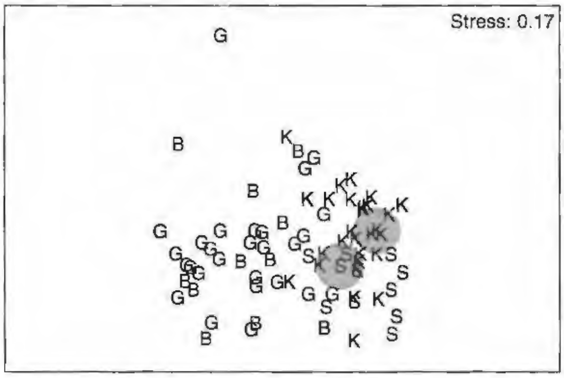
(D) Pinky



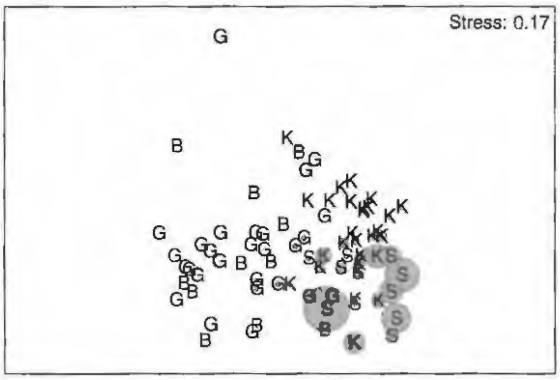
(B) Dageraad



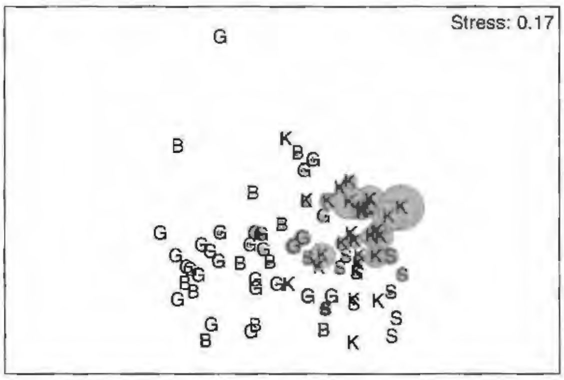
(E) Red Steenbras



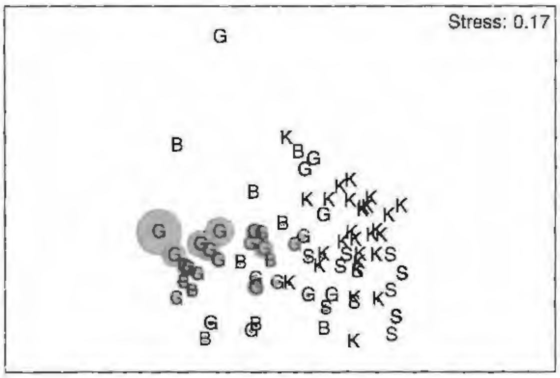
(C) Fransmadam



(F) Roman



(G) Steentjie



APPENDIX X

Details of Indicator discussion group participants. Held at Rhodes University, Grahamstown.

Name	Title	Affiliation
Cowley, Paul	Dr.	South African Institute of Aquatic Biodiversity, Grahamstown
Sauer, Warwick	Prof.	Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown
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APPENDIX XI

List of references used in the synthesis of ICM practices.
ICM = Integrated Coastal Management
SAM = Strategic Adaptive Management
FMP = Fisheries Management Plans

Paper No.	Author	Field of managament
1	Sowman, M 1993	ICM
2	Ehler, C. N. 2003	ICM
3	Stanford, J. A. & G. C. Poole 1996	EBM
4	Cochrane et al. 2004	EAF
5	Rodgers, K. & H. Biggs 1999	SAM
6	Vallega, A.2001	ICM
7	Toby, J. & R. Volk 2002	ICM
8	GESAMP 1996	ICM
9	ECCMP 2003	ICM
10	Wittmer, H. & R. Birner 2001	ICM
11	Doody, J. P. 2003	ICM
12	Treby, E. J. & M. J. Clark 2004	ICM
13	Olsen, S.B. 2003	ICM
14	Olsen. S. B. 2002	ICM
15	Belfiore, S 2003	ICM
16	Hauk, M. & M. Sowman 2001	ICM
17	Fletcher et al 2005	ICM
18	FAO guidelines 1998	ICM
19	Die, D. 2002	FMP
20	Bower, B.T & R.K.Turner 1998	ICM
21	Clark, J. R. 1997	ICM
22	McMcleave et al 2003	ICM
23	WCCMP 2003	ICM
24	Torell et al 2000	ICM
25	USAID	ICM
26	Gupta M. & S. Fletcher 2001	ICM
27	Hewawasam, I. 2000	ICM
28	Okemwa et al 1997	ICM
29	Stojanovic et al 2004	ICM
30	Thia-Eng C. 1993	ICM
31	Torell et al 2004	ICM
32	White et al in press	ICM
33	Olsen et al 1997	ICM
34	Burbridge P. R. 1997	ICM
35	Glavovic, B 2000b	ICM

APPENDIX XII

As highlighted in Table 1. below certain steps of the proposed policy cycle (Chapter 6) have already been addressed, for example local coastal stakeholders have already raised concern over the status of local coastal resources, especially fish stocks (Section C.1.) and that further degradation may have implications on the tourism potential of the bay. In response to this concern a locally based NGO initiated two research projects to study and assess the existing fisheries (Section C.2.). A number of important issues were identified from the analyses (Section C.3.), together with a suite of fisheries indicators to be used in a monitoring capacity to rapidly evaluate and assess the sustainability of the fishery in future surveys. Should the local municipality accept the protocol the next step would be to formulate specific management plans for presentation to all stakeholders (Section C. 4.). If accepted (Section C.6c.) these plans would then need to be formally adopted and implemented (Section C.8). Ongoing monitoring of the proposed indicators (Section C. 9.), would then allow the previously identified issues to be reassessed and the implemented strategies to be evaluated. Two monitoring programs have been proposed. The first, run by the local municipality would be done on a continuous basis and only collect data required for monitoring the indicators of sustainability. The second monitoring program would be run every five years and include an indepth assessment of the fishery and the local resources. This second monitoring program may be outsourced to local research or academic institutes.

Table 1: Activities and actions that have already been accomplished in the implementation of the proposed policy cycle.

Steps within the Policy Cycle	Activities or actions taken		
Step C.1. Problem identification	Initial concern expressed by local stakeholder as to state of bay resources. Specifically fish stocks.		
Step C.2. Assessment and analysis	Projects initiated		
	Fishery surveys completed		
	Analysis of results		
Step C.3. Definition of issues and options	Domain	Issue	Options
	Socio/Economic	Low angler knowledge	Awareness programs
		Poor Compliance	Increased signage and available information
	Institutional	Low inspection rate	Develop and implement a CMP and monitoring program
		Lack of municipal CMP	
		Lack of monitoring programs	Increase inpsections
	Ecological	Low CPUE	Closed areas
		Size reductions	Restrict effort
		Lack of certain species	Closed seasons
Step C.4. Formulation of management plans			
Step C.5. Presentation of plans			
Step C.6. Outcome of presentation: acceptance or rejection			
Step C.7. Adoption of plans			
Step C.8. Implementation			
Step C.9. Monitoring and evaluation	Use of indicators developed through the research projects in an ongoing monitoring program.		