Section A: Research Module

Trends of Recruitment of 5 Estuarine Fish Species for Optimum Mouth Management at the Greater Zandvlei Estuary Nature Reserve

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Photo: (Van Heerden, 2011)

Abstract

Analysing fish trek data of summer and winter fish treks between 2005 and 2010 at the Greater Zandvlei Estuary Nature Reserve (GZENR), with the target species being *A. breviceps*, *L. richardsonii*, *P. knysnaensis*, *R. globiceps* and *H. capensis*. Mouth management is controlled for recreational reasons and an analysis was done to measure the effects of mouth manipulation on fish migration. Objectives of the study were to determine if there has been an increase or decrease in fish numbers by analysing fish trek data and comparing winter and summer surveys, per species, per sampling site, determine recruitment trends for last five years by comparing size classes per species, using graphs to determine means and trend lines and assess mouth manipulation on fish migration. Methods used were correlating and analysing fish trek data from 2005 until 2010. Tables and graphs were used in order to analyse results. Majority of fish were captured during winter fish treks, with fish numbers within Zandvlei estuary reasonably stable.

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1. Introduction

Estuaries are areas where fresh water body's link to the sea. Estuaries are normally influenced by the twice-daily increasing and decreasing of the tide, therefore they tend to have wide sand or mudflats that are alternately covered or uncovered by the tides. Estuarine waters are a chemical mixture of marine and fresh water, the proportion of each changing with tidal fluctuations. Estuarine organisms are highly adapted to these varying conditions and many are found only, or largely in estuaries (Davies & Day, 1998)

In South Africa there are approximately 250 functional estuaries, making up +- 70 000ha of one of the country's most productive habitats. Estuaries are well known for their biodiversity, productive fish and invertebrate fisheries and for the essential biological functions that they perform. Estuaries provide nursery areas for marine fish, conduits for species which move between oceans and rivers, feeding and production sites for significant populations of migratory birds. Estuaries also support a large amount and variety of endemic species, many of which are completely dependent on estuaries for their survival (Turpie *et al*, 2002).

Estuaries constitute one of the most threatened habitats in the country. In the past few decades there have been numerous development projects that pressurized the biological functions of estuaries. These pressures include drastic alterations in freshwater inflow, salinities, sediment scouring and nutrient supply. As a result of this many estuaries within South Africa have become functionally degraded (Turpie *et al*, 2002).

Local fish movement can be seen as a form of habitat selection and foraging behaviour in fish species with immigration rates indicating the quality of a habitat (Lukey *et al*, 2005)

Estuarine communities are primarily dominated by juveniles of marine fish species. The life cycles of these marine species naturally comprise a juvenile phase which is mainly estuarine, and an adult phase which is generally marine. After being spawned at sea juveniles enter estuaries where they will grow rapidly, this is due to a sheltered, food rich, highly productive environment. Larvae, post larvae and juveniles enter estuaries either actively, or by drifting with incoming tides (Whitefield, 1998). Therefore correct management of an estuary mouth is crucial within intermittently open estuaries, to allow for tidal exchange between the marine and estuarine environment at the exact time of migration of larvae, post larvae and juveniles.

Van Niekerk, 2007 states that estuaries are important for fish as they provide: high productivity, low predation and refuge from unfavourable conditions within the marine environment, such as low temperature and oxygen concentrations. These factors contribute to the rapid growth and/or reduced mortality rates within the estuarine environment. As a result many South African fish species are either completely dependent or partially dependent on estuarine functionality to complete all or certain phases of their life cycles.

Many marine fish species make use of estuaries as nurseries. Extended mouth closure limits the access to estuaries by juveniles, this could have an adverse effect on the long term viability of fish populations within intermittently open estuaries. Similarly, sexually mature fish that need to return to the marine environment to spawn will be prevented from

doing so by prolonged mouth closure. In severe cases the numbers of fish will be greatly reduced due to predation by game fish and birds and by commercial and recreational angling, such that, should the mouth open eventually their numbers will be so low that they would have no significant contribution to the adult population. Alternatively, sexually mature specimens could even die within estuaries without having the opportunity to breed (Van Niekerk, 2007). It was also stated by Whitefield (1998) that "among estuarine spawning species, relatively few complete their entire life cycle within estuaries, with some of the estuarine spawners appearing to require a marine phase in their life cycles."

Estuaries differ from other inland aquatic ecosystems in that estuaries show a weak successionary trend towards a more established plant and animal community. In contrast South African estuaries are characterised by wide fluctuations in abiotic conditions with the constant restructuring of biological communities and homeostatic mechanisms with the frequent resetting of ecological succession to an earlier state. Thus fish communities of these estuaries are made up of relatively low species diversity, consisting predominantly of migratory forms with weak inter-specific connections (Whitefield, 1998). South African fish biodiversity are higher in estuaries that have a permanent connection to the sea than those that have a temporarily closed phase. This trend of declining biodiversity with an increase in seclusion from the marine environment has been reflected in the low number of fish species within coastal lakes that have lost their estuarine links with the sea, eg; Zeekovlei (Whitefield, 1998).

Fish recruitment trends are important due to the principle of fish communities or species being sensitive indicators towards the relative health of an aquatic ecosystem. Biological monitoring of estuarine health is more effective compared to chemical monitoring, as it includes anthropogenic influences where as chemical monitoring does not (Whitefield, 1998). Estuarine fish assemblages often present large year to year variations in abundance, species and size classification. Therefore long term studies are important for understanding fish population dynamics within estuaries (Cowley *et al*, 2007). Estuarine environmental values can be facilitated by monitoring of the health of fish populations using studies of their ecology (Whitefield, 1998).

Estuaries are highly valuable ecosystems as they provide a wide spectrum of opportunities and benefits, such as various sources of food, jobs and income generation, cultural activities and spiritual values. Indirect benefits are economic activities, control of floods and improvement of water quality. Due to estuaries being natural features, the opportunities that they provide are free, thus often abused. Estuary goods and services are generated through the functioning of the estuarine ecosystem (Van Niekerk, 2007).

According to Hosking *et al*, 2009 the total annual estuarine fish catch value for 2000 was estimated at R463 million and 99% of this was due to recreational fishing. Lamberth and Turpie, 2003 also state that estuaries are productive systems that provide a valuable contribution due to their goods and services ranging from fisheries to recreational opportunities. Estuaries are estimated to be worth R153 000 per ha on an annual basis. The majority of this value can be attributed to nutrient cycling (R141 000 per ha), food production (R3 500 per ha) and recreation (R2 550 per ha).

Out of the 250 estuaries within South Africa, Zandvlei is ranked 46th, in terms of conservation importance score (IMP) (74.9%), in terms of size (90%), zonal type rarity (10%), habitat importance (70%) and biodiversity importance (81.5%) (Turpie *et al*, 2002). Zandvlei is the only estuary on the False Bay that is of significance and is crucial as a fish nursery (Morant & Grindley, 1982).

According to historical maps approximately 300 years ago Zandvlei had a wide mouth and it is likely that the drainage channel moved within that in response to various factors. At that time, it most probably functioned as a true, tidally flushed estuary for most of the year, carrying out various ecological functions necessary for fish migration, with the mouth only closing in the late summer months (end of February- early March) (Morant & Grindley).

In 1866 an attempt was made to manipulate the amount of water in the Zandvlei estuary by closing off the estuary and draining it for agricultural purposes. This however was a failure and initiatives were focused on maintaining the water levels of the estuary for recreation purposes and the prevention of a flood within the area (Morant & Grindley, 1982).

The outlet channel was canalized in the 1950's and a rubble weir was constructed below the Royal Road Bridge. The purpose of the weir was to protect a sewerage pipe from scouring. It has however been used for the management of water levels in the estuary together with the artificial opening and closure of the mouth (Coastal and Environmental Consulting, 2010).

In 1983 the weir was raised from 0.7m aMSL to 0.84m aMSL and again in 1989 to 0.9m aMSL (Ninham Shand, 2000). Due to the increase in the weir to 0.9aMSL entry of marine species were restricted to extreme high spring tides and season flushing of the estuary which facilitates the emigration of marine species was minor (Ninham Shand, 2000).

In 2001 the weir was reduced to 0.7 m where it currently stands, with more importance being placed on the management of the sandbar at the mouth to regulate water levels (Coastal and Environmental Consulting, 2010).

The weir places restrictions on the system of the GZENR to fulfil estuarine functions (Ninham Shand, 2000). In rainy winter months the mouth is kept open to prevent flooding within the Marina da Gama residential development. If there is a dry spell the mouth will be closed as to restore water levels for recreational purposes. During summer months the mouth is kept closed, unless water levels exceed 1.0 m aMSL for a long duration (Coastal and Environmental Consulting, 2010). The mouth is also opened when tidal levels are high enough to allow for maximum amounts of sea water to enter the estuary, this is usually during spring highs where the mouth stays open for approximately 5 to6 days (Sheasby, 2011 pers com).

Zandvlei has been subjected to major physical alterations, along with the artificial opening and closing of the mouth, and related changes of saline and freshwater, are now determined by management system aimed primarily at maintaining water levels for recreational purposes and to prevent flooding. This has altered the natural balance of seawater entering the mouth and freshwater flow coming from the rivers which discharge into it (Coastal and Environmental Consulting, 2010). According to Lukey *et al* (2006) intermittently open estuaries are characterised by a sandbar across the mouth that acts as a temporary barrier between the marine and estuarine environment. Therefore horizontal gradients in

temperature and salinity are often absent within these systems (Lukey *et al*, 2006). Whitefield (1998) stated that temperature, salinity and water current variations within estuaries affect the breeding of resident fish species, and in turn have an effect on the population size and size classes of fish species within an estuary.

At the GZENR there has been a significant change in the biodiversity over the years as a result of physical alterations to the habitat, including changes to water levels and salinity (mouth management) of the estuary (Coastal and Environmental Consulting, 2010). Southern Waters (2000) reported a collapse of pondweed and tube worm communities in 1991 which they attributed to reduced mean ambient salinities. Recent observations suggest that both have recovered. With that mentioned, incorrect mouth management indirectly had a negative effect on fish species within the GZENR as *Potamogeton pectinatus* (Sago pondweed) plays an essential role in the lifecycle of fish. *Potamogeton pectinatus* provides the following ecological services to fish species:

- Provision of habitat, as well as food.
- Nutrient removal and water quality improvement.
- Refuge and spawning areas.
- Oxygenation of water column through the process of photosynthesis.

The list of indigenous fish species that are related to southern African estuaries accumulate to 155 species. About 50% may be regarded as having a strong association with estuaries (categories Ia, Ib, IIa, IIb, Vb) on the subcontinent. If completely dependent and partially estuarine- dependent species are included then over 100 fish species (+-67%) are related to estuaries on the subcontinent (Whitefield, 1998).

Of the 155 indigenous fish species that are related to southern African estuaries, a total of 38 species are endemic to this region (Whitefield, 1998). With endemic taxa being defined by Whitefield (1998) as “those species which have only been recorded on the African continent and/or adjacent waters south of 20˚S.” The target species that the author has analysed are known to be endemic to southern African waters.

Table 1: Table representing the five major categories and subcategories of fish that utilize southern African estuaries (Whitefield, 1998).

Category	Category Description
I.	Estuarine species which breed in southern African estuaries. Further subdivided into: Ia. Resident species which have not been recorded spawning in marine or freshwater environments. Ib. Resident species which also have marine or freshwater breeding populations.
II.	Euryhaline marine species which usually breed at sea with the juveniles showing varying degrees of dependence on southern African estuaries. Further subdivided into: IIa. Juveniles dependant on estuaries as nursery areas. IIb. Juveniles occur mainly in estuaries, but are also found at sea. IIc. Juveniles occur in estuaries but are usually more abundant at sea.
III.	Marine species which occur in estuaries in small numbers but are not dependent on these systems.
IV.	Freshwater species, whose penetration into estuaries is determined primarily by salinity tolerance. This category includes some species which may breed in both freshwater and estuarine systems.
V.	Catadromous species which use estuaries as transit routes between the marine and freshwater environments but may also occupy estuaries in certain regions. Further subdivided into: Va. Obligate catadromous species which require a freshwater phase in their development. Vb. Facultative catadromous species which do not require a freshwater phase in their development.

In 2001 Southern Waters looked at the relative proportions (%) of resident (estuarine), marine and freshwater fish that comprise the Zandvlei estuary fish community. Size composition of the more abundant species was also recorded in their study.

The methods that Southern waters used were a single sample on the 8th March 2001. They used a combination of beach seine net (30 x 2m, 10mm stretched mesh) and gill net (48, 90 and 145mm stretched mesh). Each beach seine haul covered an area of approximately 250m^2 and gill nets were set at site for 30 minutes before they were removed (Southern Waters, 2001).

The results were that; resident species made up the greatest portion of the catch (63.0%), secondly was marine migrants (35.5%), followed by freshwater species (1.5%). Resident fish comprised mostly by *Atherina breviceps* (Cape silverside) (89%) and *Gillcristela aestuarina* (Estuarine round herring) (7%), while marine migrants were made up almost entirely of *Liza richardsonii* (Southern mullet) (99%) (Southern Waters, 2001). Few juvenile specimens of species that are entirely dependent on estuaries within the juvenile stage were recorded. This presented a concern that the estuary was not functioning as a fish nursery due to the weir height and management (Coastal and Environmental Consulting, 2010).

Prior studies similar to that of Southern Waters have also been done with following results:

Table 2: Representing the percentage of marine, resident and freshwater fish recorded in earlier fish treks at the GZENR (Southern Waters, 2001).

Conducted by:	**Migrant %**	**Resident %**	**Freshwater %**
Quick & Bennet, 1989	21.2%	77.3%	1.5%
Clark *et al*, 1994	49.5%	50.1%	<0.1%
Newman, 1999	38.5%	60.7%	<0.1%

The size class size class frequency of Southern Waters data are as follows:

Table 3: Representing the number of individuals within in each size class (Southern Waters, 2001).

Species	**0-50mm**	**51-100mm**	**101-150**	**151-200mm**	**>200mm**
L. richardsonii	135	110	145	50	10
A. breviceps	220>40mm<300	110			
P. knysnaensis	6>30mm<108	13			

In 2003 during Ms Adele Pretorius Work Integrated Learning (WIL) year she did her research assignment on establishing the seasonal recruitment of fish into the Zandvlei estuary (Pretorius, 2003). The results of Ms Pretorius research are as follows:

Table 4: Representing the number of fish caught during 24hr sampling period at Zandvlei estuary (Pretorius, 2003).

Species	**18/03/2003**	**29/05/2003**	**15/07/2011**	**25/09/2011**
L. richardsonii	1890	3232	2459	1045
A. breviceps	1168	3285	1971	563
Pomatomus saltrix	54	41	0	0

R. globiceps	1224	435	41	138
P. knysnaensis	197	1138	485	464
H. capensis	10	26	39	3
Amblyrhynchotes honkenii	1	0	0	0
Caffrogobius sp.	78	29	39	3
Tilapia sparmonii	7	40	0	0
Lithognathus lithognathus	2	1	0	0
Gilchristella aesturia	3	1	0	27
Liza dumirilli	0	0	2	0
Rhabdosargus holubi	0	3	0	0
Solea bleekeri	0	5	0	2

Table 5: Representing the average sizes of fish caught during 24hr sampling period (Pretorius, 2003).

Species	**18/03/2003**	**29/05/2003**	**15/07/2011**	**25/09/2011**
L. richardsonii	128.19			
A. breviceps				
Pomatomus saltrix	54	41	0	0
R. globiceps	1224	435	41	138
P. knysnaensis	197	1138	485	464
H. capensis	10	26	39	3
Amblyrhynchotes honkenii	1	0	0	0
Caffrogobius sp.	78	29	39	3
Tilapia sparmonii	7	40	0	0
Lithognathus lithognathus	2	1	0	0
Gilchristella aesturia	3	1	0	27
Liza dumirilli	0	0	2	0
Rhabdosargus holubi	0	3	0	0
Solea bleekeri	0	5	0	2

Distribution, ecology and biology of the target species are as follows:

1.1 *Atherina breviceps*:

A. breviceps is a southern African endemic species and is often located between aquatic macrophytes within estuaries. *A. breviceps* is also common in brackish and freshwater areas that are isolated from the sea.

A. breviceps reaches sexual maturity at 40mm in the duration of approximately 8 months. Breeding takes place mainly during spring and summer with a peak in September to January. The larvae (5-8mm) of *A. breviceps* are abundant in surface waters between September and March. *A. breviceps* has been recorded in water bodies with salinities varying from 0-42%. *A. breviceps* is found in both clear and turbid estuaries, with the preference of turbid estuaries. The diet includes copepods, amphipods, isopods, gastropods, ostracods, decapods and insect larvae. Feeding is mostly nocturnal. *A. breviceps* is an important link within the food chain as it is extensively preyed upon by game fish and piscivorous birds.

1.2 *Liza richardsonii*:

L. richardsonii is endemic to southern African waters and is common in temperate estuaries, but is more abundant in nearshore marine ecosystems.

L. richardsonii matures sexually at 180mm. Juvenile recruitment within permanently open Western Cape estuaries occurs throughout the year, with a peak immigration between November and May. The Wilderness system has recorded juveniles (10-40mm) migrating during February. *L. Richardsonii* is euryhaline and has been recorded in salinities between 2-90%. It has been noted that mortalities occurred in the temporarily closed Bot Estuary when salinities remained less than 3% for a month. The diet consists of particulate organic matter, algae, pennate diatoms, macrophytic plant material and foraminiferans. Feeding is diurnal.

1.3 *Rhabdosargus globiceps*:

R. globiceps is endemic to southern African waters. Juveniles of up to 140mm are common in Western Cape estuaries and in sheltered areas of the False Bay. Adults are invariably restricted to marine environments.

Sexual maturity is reached at 3 years, with females reaching sexual maturity at 230mm and males at 270mm. In the Western Cape *R. globiceps* has been recorded breeding in inshore marine waters between August and February, with a peak spawning period in summer. Records show that recruitment of *R. globiceps* (less than 40mm) had occurred during January and February and in January-April in Palmiet and Kleinmond systems. Recruitment of less than 40mm specimens have been recorded during September-December in the Knysna and Swartvlei Estuaries, with a peak in abundance occurring in summer. Juveniles remain in estuaries for approximately 2 years and will grow between 5-10mm each month. *R.globiceps* is rarely recorded in upper sections of an estuarine system, despite upper sections of the system reaching salinities greater than10%. The recorded salinity range of *R. globiceps* is between 3-35%. Records within the temporarily closed Bot Estuary indicate a decrease in population when salinities reach 3% for prolonged periods. The diet includes macrophytic algae, molluscs, amphipods, prawns, shrimps, and isopods.

1.4 *Psammogobius knysnaensis*:

P. knysnaensis is a southern African endemic species. *P. knysnaensis* is common in the lower reaches of permanently open Western and Eastern Cape estuaries occupying shallow waters of less than 1m in depth.

P. knysnaensis reaches sexual maturity at 30mm. Breeding occurs mainly between October and March. *P. knysnaensis* has been recorded in salinity ranges of 2-35%. *P. knysnaensis* has been recorded in temporarily closed estuaries with salinity of less than 5% for long time periods. *P. knysnaensis* is a nocturnal feeder and feeds on amphipods, copepods, decapods, polychaetes and insect larvae.

1.5 *Heteromycteris capensis:*

H. capensis is a southern African endemic species which is mostly found in shallow, sandy habitats. *H. capensis* prefers waters between 1-25m in depth and is a common resident in shallow sections of permanently open estuaries.

H. capensis reaches sexual maturity at approximately 80mm. Spawning occurs inshore throughout the year and peaks between October and February. Larvae have been recorded in the False Bay throughout the year. Between October and

March larvae and post larvae, at a length of 5-15mm, will recruit into warm temperate estuaries. The salinity range is recorded to be between 5-35%, but is usually located at the lower reaches of permanently open estuaries where salinities rarely drop below 30%, indicating a higher salinity preference. The diet of *H. capensis* within estuaries consists of small benthic invertebrates.

Table 6: Comparing target species with regards to juvenile size, breeding period, larvae recruitment and salinity preference (Whitefield, 1998).

Species	Size of juvenile	Breeding	Larvae recruitment	Salinity preference
Atherina breviceps	1-39mm	September - January	September - March	0-42%
Liza richardsonii	1-179mm	All year	November – May, with a peak in February.	2-90%
Rhabdosargus globiceps	Female < 230mm Male < 270mm	August - February	January - April	3-35%
Psammogobius knysnaensis	1-29mm	October - March	During ebb tide.	2-35%
Heteromycteris capensis	1-79mm	October - February	October - March	5-35%

Majority of estuarine fish studies have tended to be less than three years in duration. These short term studies have indicated that most estuarine fish assemblages undergo significant changes in community structure, often related to a change within the estuarine mouth phase, flood events, seasons etc. Long term studies, greater than five years, have shown that although interannual variations may be observed, due to random climatic events such as droughts, storms, cold winters etc climatic changes can result in restructure of fish assemblages (Cowley *et al*, 2007).

Ninham Shand (2000) stated that in order to establish the effectiveness of Zandvlei as a nursery and feeding ground for fish, surveys should be undertaken at least twice per year in summer and winter. It was further stated that these surveys would give an indication of which species are entering the estuary and their population sizes. These patterns could then be evaluated to historic patterns to measure improvement (Ninham Shand, 2000).

The author focused on the 5 estuarine fish species at GZENR for his research assignment, 2 of the 5 species are benthic species, while the other three are pelagic species. These species were selected to show numbers of sediment dwelling fish as well as water column dwelling fish. The target species that were analysed were *Liza richardsonii* (Southern mullet), *Rhabdosargus globiceps* (White stumpnose), *Atherina breviceps* (Cape silverside), *Psammogobius knysnaensis* (Knysna sand goby) and *Heteromycteris capensis* (Cape sole).

Since 2000, Oceans and Coasts (Provincial Government) have undertaken quarterly fish surveys in Zandvlei in partnership with City of Cape Town Environmental Resource Management Department. The data has not yet been analysed in any detail (Coastal and Environmental Consulting, 2010). The aim of this research is to analyse the last five

years data, focusing on fish recruitment trends and comparing them to historical fish data with the aim of management recommendations to be implemented.

2. Research Objectives

- Determine if there has been an increase or decrease in fish numbers by analysing fish trek data and comparing winter and summer surveys, per species, per sampling site.
- Determine recruitment trends for last five years by comparing size classes per species, using graphs to determine means and trend lines.
- Collate best management guideline for mouth opening/closing for optimum fish migration.

3. Study Area

Zandvlei (34°05'S, 18°28'E) is a temporarily closed estuary situated in the north-western corner of the False Bay (Clark *et al*, 1994). The co-ordinates of the mouth are 34°06'24"S, 18°28'42"E (Morant & Grindley, 1982). The Zandvlei system is made up of three components, the main vlei basin (56ha), the Marina development (31ha) located on the eastern shore and an outlet channel of 9ha. Additionally, wetland areas border the vlei to the north and north-western areas (Ninham Shand, 2000). The main vlei is approximately 2.5km long and 0.5km wide with a maximum depth of 1.5m (Clark *et al*, 1994). The catchment area of the estuary is approximately 85km^2 and is drained by the Sand River, Keysers River and the Westlake Stream (Clark *et al*, 1994).

The Zandvlei catchment falls into the Southern Management Area of Cape Town which has a mean annual precipitation of 711 mm. This area is estimated to have a mean annual runoff of 73 million m^3. Zandvlei lies in a Mediterranean climatic area with majority of the rainfall occurring in winter, with warm dry summers (Clark *et al*, 1994). The main axis of the system lies almost exactly north-south more or less parallel with the summer southerly and winter northerly winds, thus allowing good wind induced mixing of the water Morant & Grindley, 1982).

The water temperature within the estuary seems to be consistent with no major temperature fluctuations or significant changes over time. Generally temperatures vary from 24˚C (maximum) to a minimum of between 9-12˚C (Coastal and Environmental Consulting, 2010). Morant & Grindley (1982) stated that Zandvlei displays a high degree of homogeneity with regards to the water temperature. This referred to the depth as well as the head to mouth areas. There is however a significant difference in surface temperatures and bottom temperatures during calm conditions (May-June) (Morant & Grindley, 1982).

Table 7: Indicates the mean minimum and maximum temperatures (surface and bottom waters) and the mean salinity% of Zandvlei estuary for the period 1973-1978 (Morant & Grindley, 1982)

	Zandvlei North		Zandvlei Centre		Zandvlei South		Zandvlei Mouth		Tiller Arm Beat		Burgee Cove	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Temperature (surface)	11.7	24.2	11	24.3	11.5	24	11	23.5	13.5	24.1	11.8	24.2
Temperatures (bottom)	13.5	24.2	12.2	23.1	12	23.7	15.8	23.5	15	23.2	12	23.7
Salinity%	5.62	19.52	2.23	19.34	0.89	21.33	4.54	21.69	6.85	26.20	4.78	25.30

The data that was collected between 1973-1978 shows a relatively uniform salinity reading across the system (Morant & Grindley, 1982). In the 1980's when the weir was raise to 0.9m aMSL the salinity within the vlei had dropped significantly. Between 1985-1989 the mean salinity within the central region of the estuary was at a mean of 7ppt (Ninham Shand, 2000). This major drop in salinity then caused a crash in the *Potamogeton pectinatus* (Sago pondweed) and tube worm populations in 1991 (Ninham Shand, 2000).

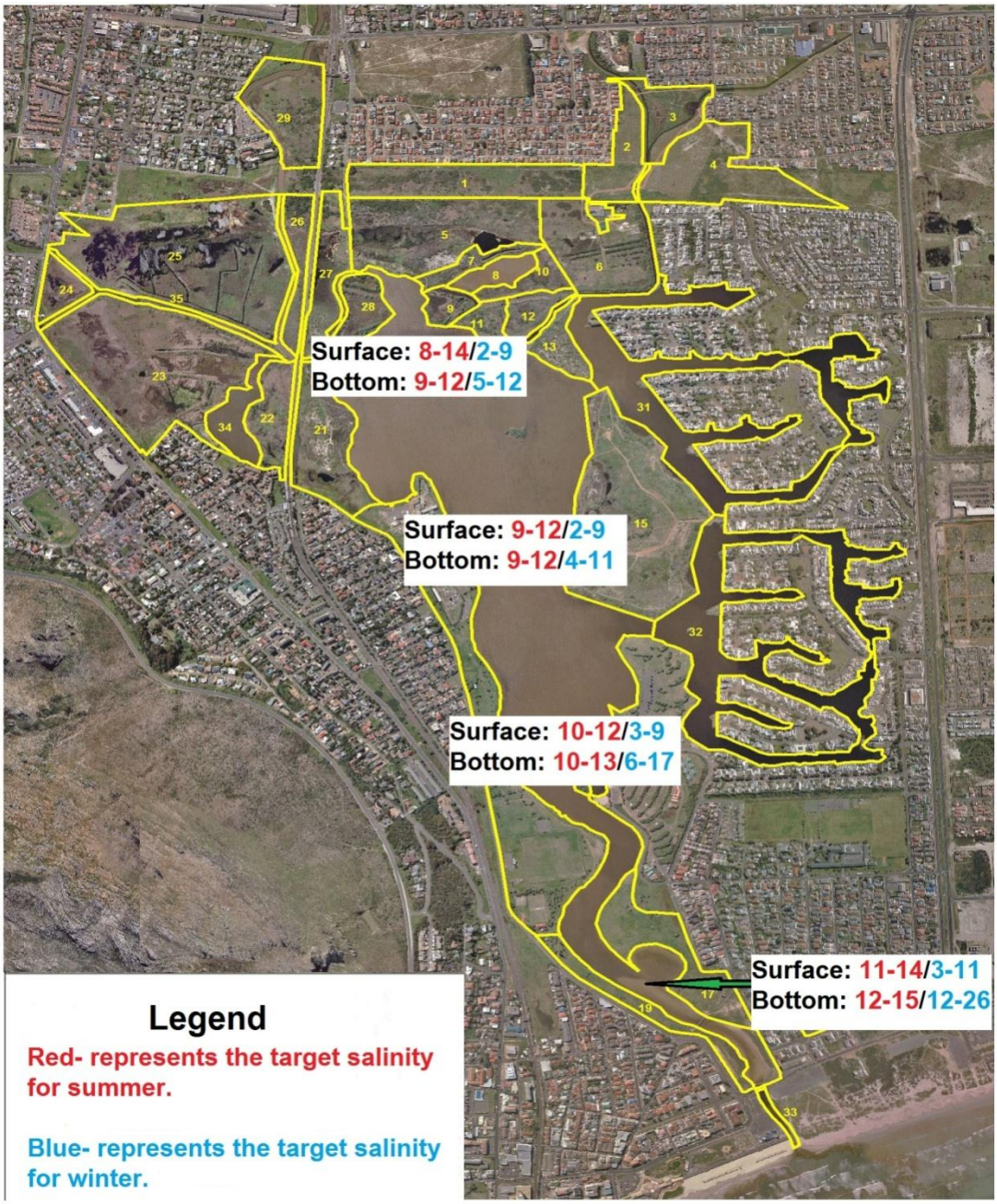
Table 8: Indicating the ambient salinity (ppt) of Zandvlei estuary from 1980 to 1998 (Ninham Shand, 2000)

Year	Ambient Salinity (ppt)
1980	10
1981	9.8
1982	9.9
1983	10
1984	7
1985	7
1986	7.4
1987	7.7
1988	9
1989	6
1990	4.8
1991	6
1992	4.8
1993	8
1994	11
1995	9.9
1996	7
1997	5.7
1998	5.2

Table 9: The minimum, maximum and average salinity (%) at Zandvlei estuary for the period of 2002-2010 (Coastal and Environmental Consulting, 2010).

Salinity o/oo	Mouth/channel	Vlei South	Vlei Centre	Vlei North	West lake	Marina da Gama
Min	1	1	0	0	0	0
Max	35	25	23	25	15	23
Average	12	11	10	9	3	10.6

Figure 1: Represents the target salinity range for summer and winter with regards to surface and bottom waters.



4. Methodology

The author has two sections for methodology for his research report. The first is the methodology on the actual fish trek which takes place quarterly. The author was not involved in any of the fish treks done from 2005 until 2010, but has organised and took part in all treks in 2011. The second section of the author's methodology is what the author was involved with. This was the compilation and correlation of the raw data which was collected in 2005 until 2010.

The materials that were required for the gathering of the fish trek data were: 30 x 1.5m seine net (8mm mesh size), measuring boards, a row boat, buckets and pen and paper.

The procedures of the fish treks were as follows; on arrival to the sample site Mr Corne Erasmus from Oceans and Coasts would then record the temperature, salinity and turbidity of the sample site. He would then go out with the row boat to the sample site and offload the seine net. The net will then be given time to sink to the bottom of the estuary. Approximately 5-7 people would then pull the net in from the sample site towards the shore, it is important not to pull the net too fast as the sinkers lift off the ground allowing fish to escape. Once the net is out, buckets are filled with water and the fish are then placed in the buckets. The fish are then sorted by species and are then recorded and measured. The fish are then released back into the estuary.

Figure 2: Representing the sample areas for the fish treks.

The compilation and analytical process was done as follows; fish trek data from 2005-2010 was used statistically in order to determine trend lines. Microsoft Excel was used in order to organise size classes of the target species for each year and to draw up graphs to show comparison of recruitment sizes for the specific years for each target species. Dr. Stephen Lamberth from Oceans and Coasts was also consulted for guidance on statistical analysis and interpretation.

5. Results

The author created approximately 30 graphs with the results of the authors research, however the results below are summaries of the overall results.

Table 10: Indicating the number of *A.breviceps* recorded in the GZENR during summer and winter fish treks at each sample sites.

	2005		2006		2007		2008		2009		2010	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Perdeskoen	9	1	32	339	16	117	203	0	No sample	No sample	721	106
Camp site	16	5	344	167	392	515	279	159	91	0	86	0
Picnic site	24	205	0	116	114	91	108	309	99	11	638	1459
Yacht club	0	770	683	478	87	267	35	1614	200	111	0	149
Mouth	0	0	0	0	0	291	2	0	0	2	0	0
Total	1030		2159		1890		2657		514		3159	

Figure 3: Average size (mm) of *A. breviceps* during summer and winter fish treks at GZENR between 2005 and 2010.

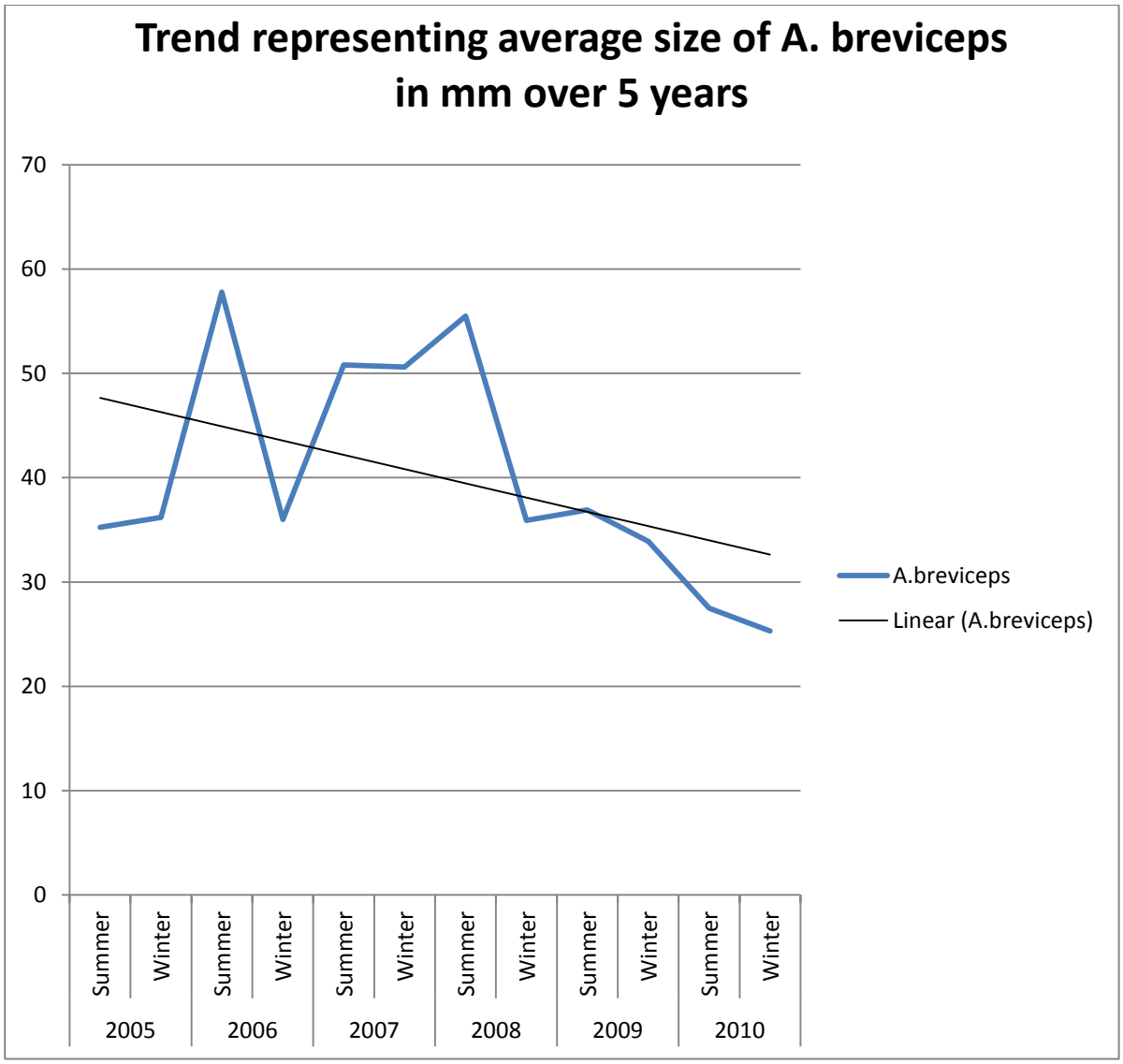


Table 11: Indicating the number of *P.kysnaensis* recorded in the GZENR during summer and winter fish treks at each sample sites.

	2005		2006		2007		2008		2009		2010	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Perdeskoen	5	15	4	97	27	54	119	111	No sample	No sample	0	6
Camp site	0	11	2	30	8	0	4	9	0	0	0	0
Picnic site	8	19	0	216	25	77	22	37	5	8	4	40
Yacht club	0	25	53	36	2	4	29	99	22	0	13	34
Mouth	0	0	0	17	16	1	5	0	0	3	1	51
Total	83		465		214		435		38		149	

Figure 4: Average size (mm) of *P. knysnaensis* during summer and winter fish treks at GZENR between 2005 and 2010.

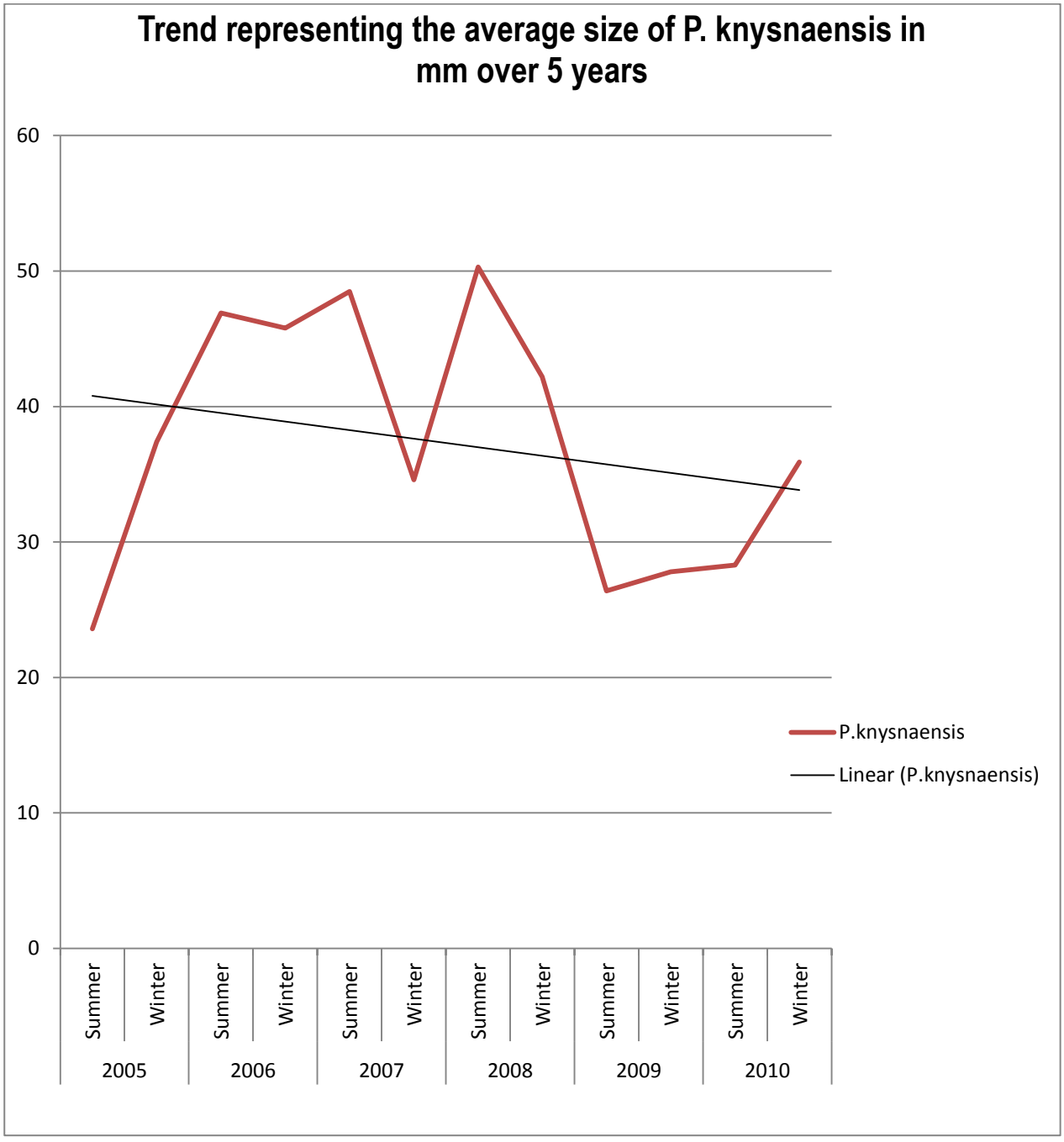


Table 12: Indicating the number of *L.richardsonii* recorded in the GZENR during summer and winter fish treks at each sample sites.

	2005		2006		2007		2008		2009		2010	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Perdeskoen	0	2	732	16	3585	112	179	4	No sample	No sample	110	0
Camp site	1	6	235	18	137	301	149	79	3	2	9	0
Picnic site	0	2	0	6	580	1	1182	7	913	0	454	30
Yacht club	0	39	23	1	106	0	127	508	2091	362	143	132
Mouth	0	0	0	1578	659	374	14	0	109	110	96	3
Total	50		2609		5855		2249		3590		977	

Figure 5: Average size (mm) of *L. richardsonii* during summer and winter fish treks at GZENR between 2005 and 2010.

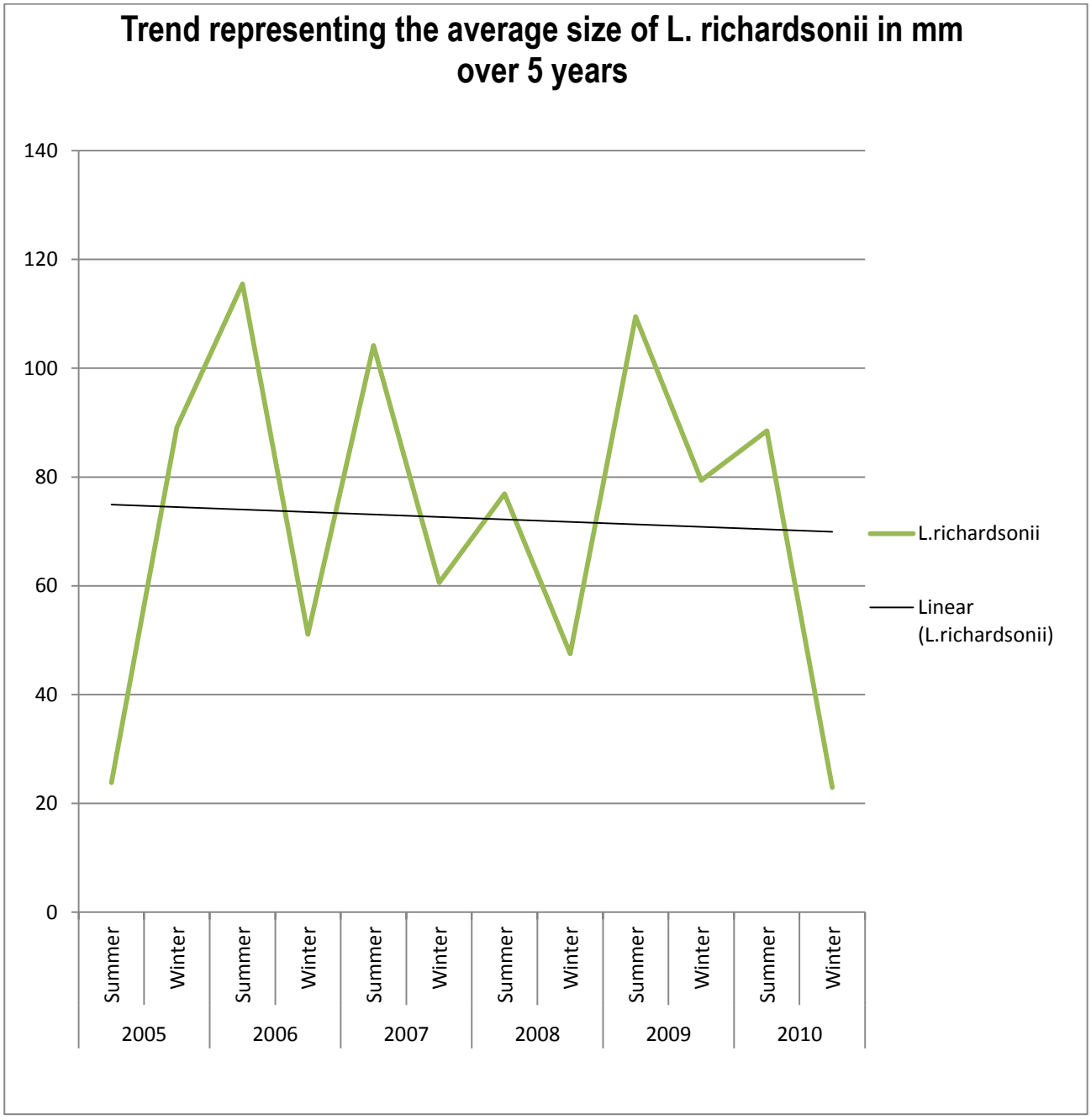


Table 13: Indicating the number of *R. globiceps* recorded in the GZENR during summer and winter fish treks at each sample sites.

	2005		2006		2007		2008		2009		2010	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Perdeskoen	0	0	0	0	0	0	0	0	No sample	No sample	10	0
Camp site	0	0	0	0	0	0	0	0	1	0	0	0
Picnic site	5	0	0	0	4	0	0	0	0	0	0	0
Yacht club	0	0	0	0	0	0	0	0	0	0	0	0
Mouth	0	0	0	16	1	0	1	0	0	0	40	0
Total	5		16		5		1		1		50	

Figure 6: Average size (mm) of *R. globiceps* during summer and winter fish treks at GZENR between 2005 and 2010.

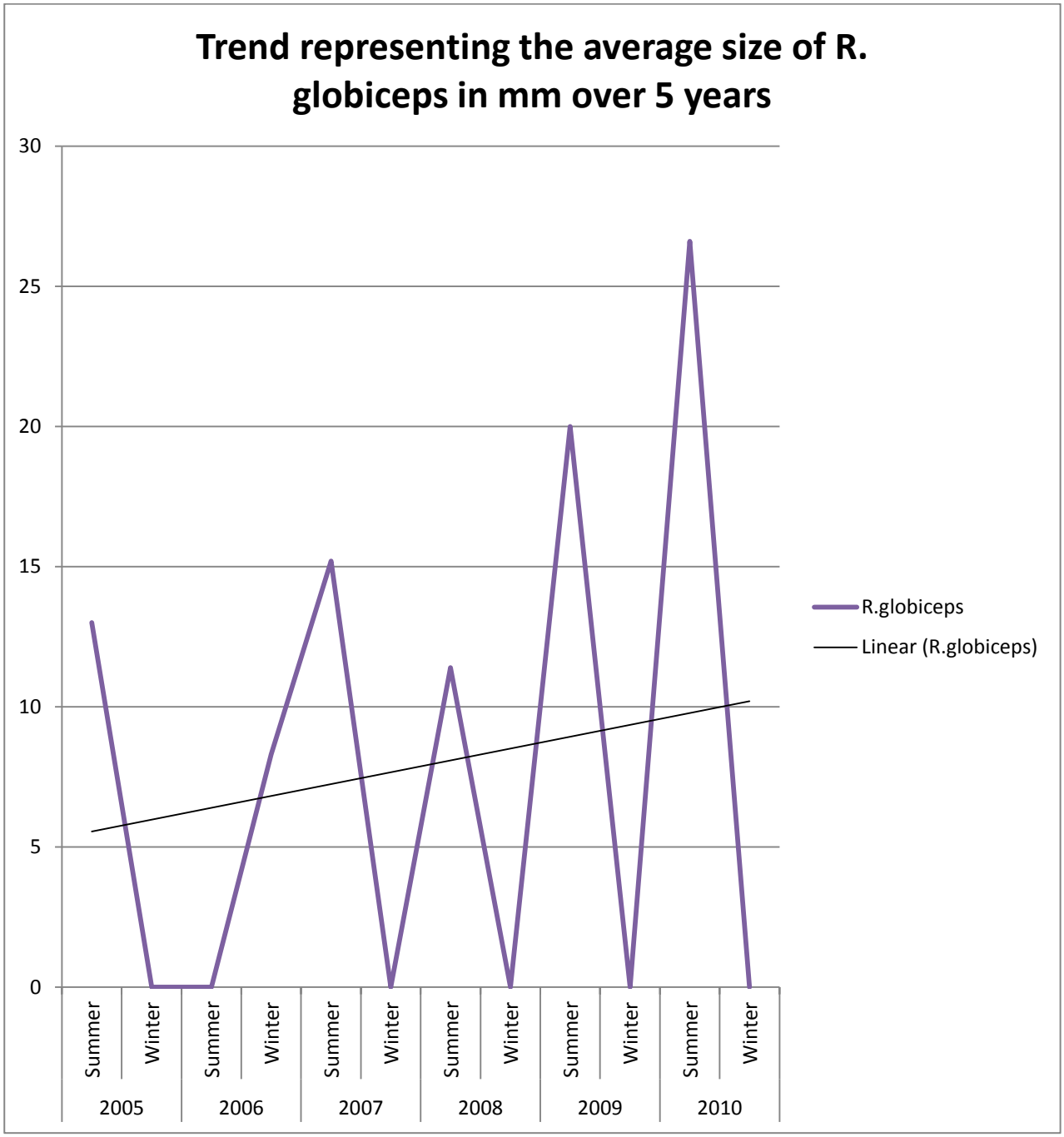
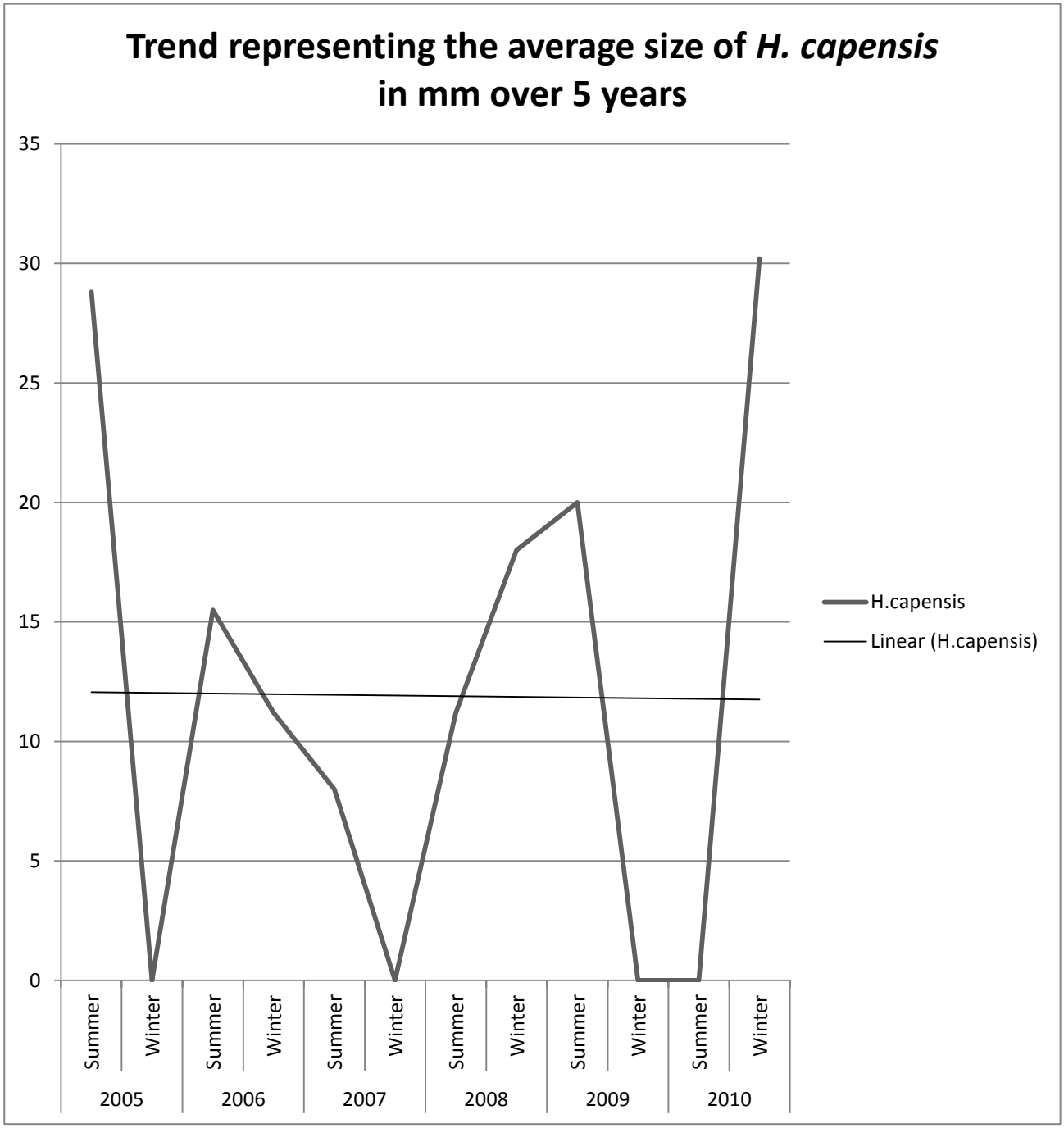


Table 14: Indicating the number of *H. capensis* recorded in the GZENR during summer and winter fish treks at each sample sites.

	2005		2006		2007		2008		2009		2010	
	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter	summer	winter
Perdeskoen	1	0	0	0	0	0	0	0	No sample	No sample	0	0
Camp site	0	0	0	0	0	0	0	0	0	0	0	0
Picnic site	31	0	0	2	0	0	0	1	1	0	0	2
Yacht club	0	0	9	0	0	0	0	0	0	0	0	0
Mouth	12	0	0	0	17	0	1	0	0	0	0	1
Total	44		11		17		2		1		3	

Figure 7: Average size (mm) of *H. capensis* during summer and winter fish treks at GZENR between 2005 and 2010.



6. Discussion

Atherina breviceps:

A. breviceps are known to be estuarine residents, with specimens even found in fresh water bodies that are isolated from the sea, however Whitefield (1998) stated that large populations occur in inshore marine environments. He further stated that among estuarine spawning residents, few complete their entire life cycle within estuaries, with some of the estuarine spawners requiring a marine phase in their life cycles (Whitefield, 1998).

Atherina breviceps spawn from September to January with a peak in spawning during mid summer months (Whitefield, 1998). The results of the author's research indicate that in summer fish treks majority of the specimens that were recorded were adults, with the overall average size class in summer fish treks at 52.7mm. Whereas in winter fish treks the overall average over the five year period was 47.5mm. This indicates that over the five year period the majority of the *A. breviceps* that were recorded in Zandvlei Estuary were adult specimens. Therefore the results mentioned prove that the spawning time of the *A. breviceps* within Zandvlei Estuary are standard.

The overall number of specimens caught over the five year period during both seasons was at 11215. The overall number of specimens caught within the different seasons contradicts the spawning time theory of the *A. breviceps* within Zandvlei Estuary. The overall number of specimens that were recorded over the five year period for summer was at 4188 (37.34%) specimens whereas the number of specimens recorded in winter was 7027 (62.66%) specimens. This indicates that majority of the *A. breviceps* were recorded in winter whereas the spawning period is in summer. This change in species migration could be due to the mouth being open during winter months and closed during the summer months with the open and closing depending on the tide level of the marine environment and the water level within Marina Da Gama. Mouth manipulation as a factor in the change in numbers during summer and winter can also be emphasised by comparing the numbers caught in each season in 2005, as Mr Corne Erasmus (2005) stated that the mouth was open during the winter fish trek in 2005 and closed during the summer fish trek in 2005.

Table 15: Average annual size class (mm) for *A. breviceps* between 2005 and 2010 during summer and winter fish treks.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Summer	59.46939	57.88209607	63.04248	51.0101	48.903448	44.2274
Winter	51.94466	44.97143	50.70109	47.8293413	49.58871	41.76087

With reference to table 10, indication of the preferred areas of *A. breviceps* within the GZENR are: in first place the yacht club with overall numbers caught at that site during the five year period for both seasons at 4394, (39.2%) of the overall total caught for both seasons during the five year period. This site could also be the preferred breeding site due to the site accumulating the most numbers within the summer months, 1005 specimens were caught during the five year period during summer for this site, (22.9%) of the overall caught within the five year period during both seasons at the yacht club.

The second preferred site was the picnic site with the overall amount caught at this site at 3174 (28.3%) specimens during the five year period for both seasons. The other three sites then made up (32.5%) of the total amount of *A.breviceps* caught over the five year period during both seasons.

Psammogobius Knysnaensis:

The overall number of *P. knysnaensis* that were caught over the five year period in both summer and winter fish treks was 1374 specimens. Of the total 374 (27.2%) of the specimens were caught during summer fish treks and 1000 (72.8%) of the specimens were caught during winter fish treks.

Of the 374 specimens of *P. knysnaensis* that were caught in summer over the five year period 2.1% where juveniles and of the 1000 specimens that were caught in winter over the five year period 2.8% where juveniles. This indicates that majority of the adults of *P. knysnaensis* occurs during winter fish treks, which indicates that recruitment is higher during winter fish treks and could further indicate that adult specimen are exiting the estuary due to the release of larvae into inshore marine environment.

Whitefield (1998) stated that *P. knysnaensis* are common in the lower reaches of Western Cape estuaries that are permanently open. *P. knysnaensis* are known to be indicator species, indicating the health of an area (according to their numbers) in which they are located (Sheasby, 2011). The average size of *P. knysnaensis* between 2005 and 2010 during both fish treks show a decline in size class, however the number of *P. knysnaensis* within the Zandvlei estuary are stable.

Liza richardsonii:

The overall number of *L. richardsonii* caught between 2005 and 2010 were 15313. Of the total 11547 (75.4%) were caught during summer fish treks and 3766 (24.6%) were caught during winter fish treks.

In 2005 a total of 51 specimens were caught with 1 specimen caught during summer and 50 specimens caught during winter. Of the 51 specimens caught in 2005 only 7 (13.7%) were sexually mature with 44 (86.3%) being juveniles. In 2006 2602 specimens were caught with 982 (37.7%) specimens being caught in summer and 1620 (62.3%) specimens caught during winter. Of the 982 specimens that were caught in summer, 36 (3.7%) of the specimens were adults with 946 (96.3%) of the specimens being juveniles, all winter specimens in 2006 were juveniles. In 2007 a total of 5857 specimens were caught with 5068 (86.5%) specimens being caught in summer and 789 (13.5%) specimens caught during winter. Of the 5068 specimens that were caught in summer, 6 (0.12%) of the specimens were adults with 5062 (99.8%) of the specimens being juveniles, all specimens caught in winter were juveniles. In 2008 2239 specimens were caught with 1571 (70.2%) of the specimens being caught in summer and 668 (29.8%) of the specimens caught during winter. Of the 1571 specimens that were caught in summer, 1 (0.06%) of the specimens were adults with 1570 (99.94%) of the specimens being juveniles, all winter specimens in 2008 were juveniles. In 2009 3587 specimens were caught with 3113 (86.8%) specimens being caught in summer and 474 (13.2%) specimens caught during winter. In summer all specimens that were caught were juveniles, 2 (0.4%) of the specimens that were caught in winter were adults and 472 (99.6%) of the specimens were juveniles. In 2010 977 specimens were caught with 812 (83.1%) specimens being caught

in summer and 165 (16.9%) specimens caught during winter. Of the 812 specimens that were caught in summer, 1 (0.1%) of the specimens were adults with 811 (99.9%) of the specimens being juveniles, all winter specimens were juveniles.

Table 10: Average annual size class (mm) for *L. richardsonii* between 2005 and 2010 during summer and winter fish treks.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Summer	119	125.7672414	102.3367	78.42251	98.830671	82.90192
Winter	142.66	71.29167	70.55202	51.64102564	35.790179	42.47879

The above table indicates that recruitment of *L. richardsonii* was preferred during summer within Zandvlei estuary. Capture of adults was more common during summer fish treks, where as capture of smaller juveniles are more common during winter fish treks. Larvae recruitment also takes place between September and March with a peak in February (Sheasby, 2011 per comm).

Rhabdosargus globiceps:

Bennet *et al* (1994) stated that R. globiceps are found within estuaries, but are more common in inshore marine environments. *R. globiceps* recruit into estuaries during their larvae and juveniles stages where they make use of estuaries as nursery areas for optimum growth. Juvenile *R. globiceps* recruit into estuaries between September and March with a peak in October and November (Whitefield, 1998).

According to Ms Pretorius (2003) 1313 *R. globiceps* specimens were recorded in her 24hr fish treks, which were conducted every 4hrs in 2003. All samples were at the mouth and fish treks took place in March, May, July and September. Of the specimens that were recorded 144 (11%) were captured during winter fish treks and 1169 (89%) were caught during summer fish treks.

The authors research indicates that the total amount of *R. globiceps* that were caught during the five year period between 2005 and 2010 were 77 specimens. Of the total amount 61 (79.2%) were caught during summer fish treks and 16 (20.8%) were caught during winter fish treks. The site that accumulated the most amount of *R. globiceps* over the five year period for both seasons was the mouth with 57 (74%) of the specimens caught at the mouth.

Comparing the author's research with Ms Pretorius's research the amount of *R. globiceps* that were located in Zandvlei estuary has dropped significantly. This indicates that less *R. globiceps* are utilising the estuary, however the author's research indicates that more *R. globiceps* are utilising the estuary during winter than in Ms Pretorius's research. This could be due to the estuary being open more often during winter months than summer months when peak migration of juvenile *R. globiceps* occurs.

Heteromycteris capensis:

In the author's research the total number of *H. capensis* that were caught between 2005 and 2010 during winter and summer fish treks were 78 specimens, with 72 (92.3%) of the specimens being caught in summer fish treks and 6 (7.7%)

of the specimens being caught within winter fish treks. Of the total amount of *H. capensis* specimens that were caught between 2005 and 2010 in summer and winter fish treks, 3 (3.8%) of the specimens were juveniles and 75 (96.2%) of the specimens were adults.

According to Whitefield (1998) *H. capensis* are common at lower reaches of open estuaries, however the author's research indicates that 37 (47.4%) of the specimens recorded between 2005 and 2010 for summer and winter fish treks were located at the picnic site (middle-upper reaches) of Zandvlei estuary. The average salinity of this site between 2005 and 2010 was at 7.4ppt (parts per thousand), which also indicates that the *H. capensis* within Zandvlei estuary prefer lower salinity waters.

7. Conclusion and Recommendations

In conclusion the author's research indicates that the numbers of fish caught within the GZENR of the past five years have been fairly stable. The research of the author with regards to the size classes of each species shows a general decline in the size classes between 2005 and 2010 of the target species located at the GZENR, however the size classes of *R. globiceps* show an increase between 2005 and 2010.

With the authors' research being compared to that of Ms Pretorius's results in 2003, the numbers of fish have decreased significantly; this could be as a result of poor mouth management as majority of the fish that were recorded in the author's research were recorded in winter fish treks when the mouth is mainly open. This could also indicate that fish were forced to move into the estuary during winter periods when the estuary is frequently open. Therefore due to spring and summer being active periods for fish breeding and migration in other estuaries within the Western Cape the author recommends that the Zandvlei estuary be opened as often as possible between spring and summer. Monitoring during this period should also be conducted in minor fish treks situated close to the mouth area as to analyse the results of open at favoured periods for fish species.

The author's research could be improved by recommending that mouth management as a factor effecting fish migration and Zandvlei estuary as a fish nursery can be effectively analysed if opening and closing of the mouth is recorded simultaneously with fish treks within the GZENR. Results could also be improved if specimens that are dependent on estuaries as nursery areas such as *Lichia amia* and *Lithognathus lithognathus* undergo a tagging project for at least five years.

8. Acknowledgements

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treks and for providing the author with all the fish treks that were required, Dr Stephen Lamberth of Oceans and Coast for his expertise and literature and Ms Candice Haskins of City of Cape Town for providing salinity recordings of the GZENR.

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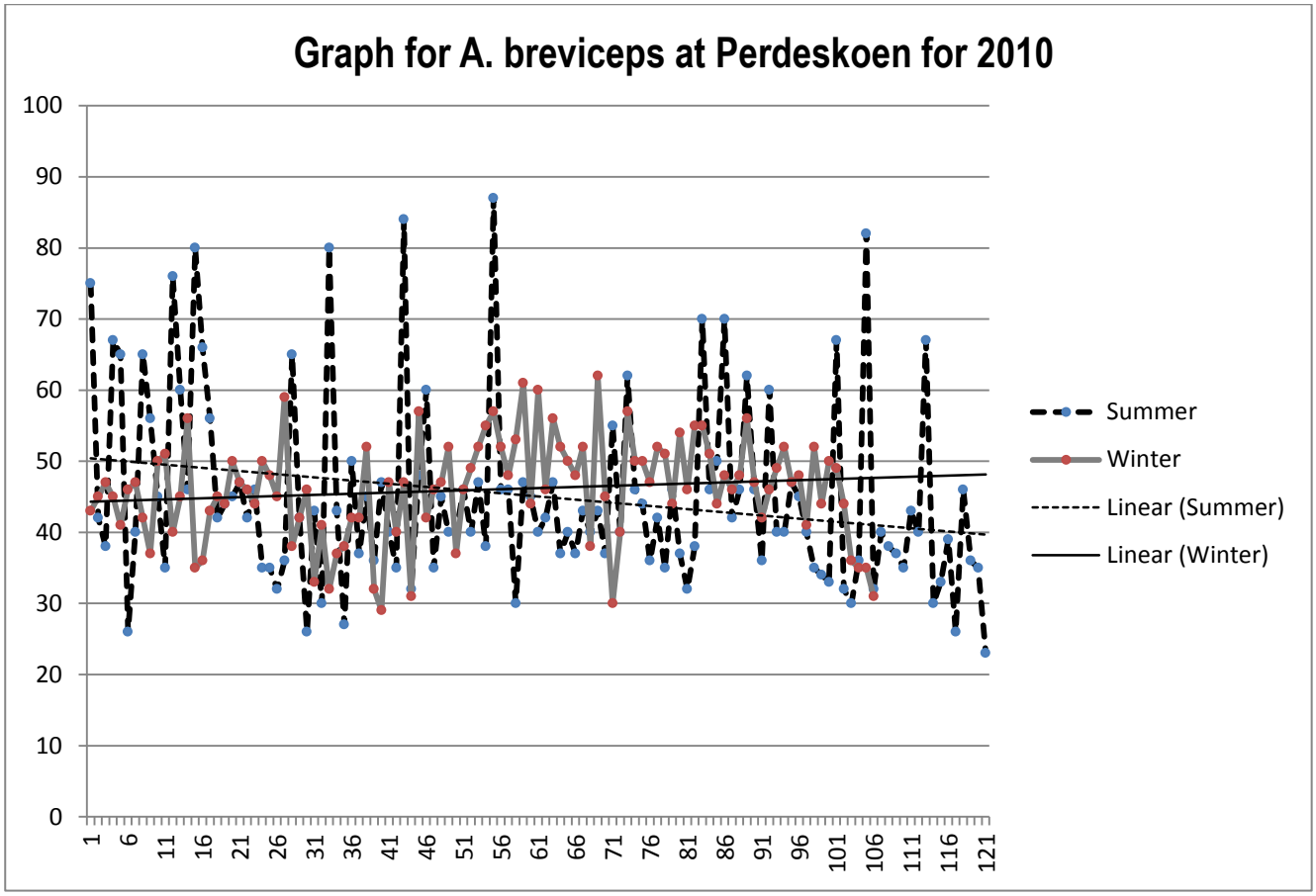
Appendix 1:

Example of the many graphs that the author created, graphs were made per sample site, per year with a comparison of winter and summer fish treks.



Appendix 2: Research Proposal

Trends of recruitment of 5 estuarine fish species at Zandvlei Estuary Nature Reserve over five years.

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Mentor: Cassandra Sheasby

Date of proposal: 12 May 2011

Envisaged completion date: 30 October 2011

Photo: (Van Heerden, 2010)

Introduction:

The Greater Zandvlei Estuary Nature Reserve (GZENR) is located between Muizenberg, Marina da Gama and Retreat (Sheasby, 2009). The co-ordinates of ZENR are 34° 05'S, 18° 28'E, and GZENR is an exceptionally low lying reserve with the highest point being 9 meters above sea level, while the lowest point is at sea level (Pretorius, 2003).

Fish recruitment trends within GZENR are unknown. Fish treks take place quarterly, however the data is kept predominantly by Oceans and Coasts (Provincial Government) and has not been analysed. Estuaries in general are high productive ecosystems (Coastal and Environmental Consulting, 2010). South Africa has approximately 260 estuaries and of those, 62 are situated within the Cape Floristic Region (Coastal and Environmental Consulting, 2010). Zandvlei is the only functioning estuary on the entire coast of False Bay (Pretorius, 2003), which makes Zandvlei a highly valuable estuary, due to it acting as a nursery and home for estuarine fish species. In order to correctly manage the factors influencing fish species at Zandvlei, such as mouth management, pollution events, and harvesting a review of the fish trek data from 2005-2010 is necessary.

The author will focus on the 5 most common estuarine fish species for his research assignment, 2 of the 5 species are benthic species, while the other three are pelagic species. The target species to be analysed are *Liza richardsonii* (Southern mullet), *Rhabdosargus globiceps* (White stumpnose), *Atherina breviceps* (Cape silverside), *Psammogobius knysnaensis* (Knysna sand goby) and *Heteromycteris capensis* (Cape sole).

"Water levels in Zandvlei have, for many years, been managed primarily to provide water of sufficient depth for yachting, and to prevent flooding and/or the destabilisation of the revetments in Marina da Gama which were designed for an operating water level of 0.7 m aMSL." (Coastal and Environmental Consulting, 2010). As stated in the quotation it is evident that the mouth is managed for a recreational purpose and not from a biodiversity perspective. Therefore this research is necessary to ensure sustainability of the estuary as a fish nursery through management recommendations based on the analysis.

Literature Review:

There are 2 main factors that affect the future health of South African estuaries; these factors are their direct management and the quantity and quality of freshwater inputs (Adams et al, 2002).

Estuaries provide environmental services to their surrounding environments, mainly the marine environment. These services are exporting of nutrients, detritus and sediments to the coastal zone. Nursery function for various marine organisms and act as a movement corridor for migratory species (Adams et al, 2002).

"Local fish movement can be seen as a measure of habitat selection and foraging behavior in fish species with immigration rates as indicator of habitat quality. At present very little is known about fish population sizes and movement within southern African intermittently open estuaries." (Booth *et al*, 2005)

***Liza richardsonii* (Southern mullet): biological facts**

This species is identified by being elongate and silvery with a dark dorsal surface and a sharp snout. The maximum size limit is approximately 400mm. *L.richardsonii* will feed on phytoplankton and benthic diatoms, this species spawns during spring and summer (Beckley, *et al*, 2002). *L.richardsonii* is endemic to South African coasts and the juveniles utilize estuaries as nurseries, but mainly occur at sea (Jacobs, 2004). Females are known to reach sexual maturity at 250mm whereas male are unknown. The habitat requirements are diverse, with *L.richardsonii* occurring in fresh, brackish, and marine waters (Smith and Smith, 1986).

***Rhabdosargus globiceps* (White stumpnose): biological facts**

This species is identified by being silvery with 6-7 dark vertical crossbars and has a blunt shaped head. The maximum size limit for this species is approximately 500mm and can reach 3kg (Beckley *et al*, 2002). This species feeds on worms, crustaceans and molluscs. It spawns during spring and summer, and moves closer onshore during spawning time. The species reaches sexual maturity at 220-240mm, therefore anything under would be considered juvenile (Bauchot and Hureau, 1990). Juveniles are known to occur mainly at sea, but will make use estuaries as a nursery. This species is endemic to South African coasts (Jacobs, 2004).

***Atherina breviceps* (Cape silverside): biological facts**

This species has a distinct silver stripe along its sides, it has small black dots on the dorsal area. The maximum size limit is approximately 110mm (Beckley *et al*, 2002). This species is known to reach sexual maturity at approximately 40mm, specimens under 40mm are assumed to be juveniles. *A.breviceps* feed on small organisms such as phytoplankton and rotifers, and as they reach sexual maturity they include amphipods in their diet. *A.breviceps* is able to withstand fresh, brackish and marine waters (Skelton, 1993). It is endemic to South African coasts and is mainly found in estuaries, but also occurs at sea (Jacobs, 2004).

***Psammogobius knysnaensis* (Knysna sand goby): biological facts**

P.knysnaensis is a small grey-brown fish with brown spots on the dorsal surface and flanks, it has pale undersides and a broad head. The pelvic fins are disc-shaped and males have a black spot on the rear of the first dorsal fin. The maximum size of *P.knysnaensis* is 70mm. This species is endemic to South African coasts and is usually found on sandy banks in estuaries where it partially buries itself. *P.knysnaensis* breeds all year round and feeds on small benthic invertebrates (Beckley *et al*, 2002). *P.knysnaensis* reaches sexual maturity at 30mm (Maugé, 1986).

***Heteromycteris capensis* (Cape sole): biological facts**

H.capensis has pale and dark spots on the body and fins, with the eyes situated on the right side of its head. This species has no pectoral fins and has a hooked snout. The maximum size is 150mm. *H.capensis* is endemic to South African coasts residing in shallow sandy areas in estuaries. Spawning will increase in summer, and juveniles recruit to estuaries after reaching 10mm (Beckley *et al*, 2002)

Research Objectives:

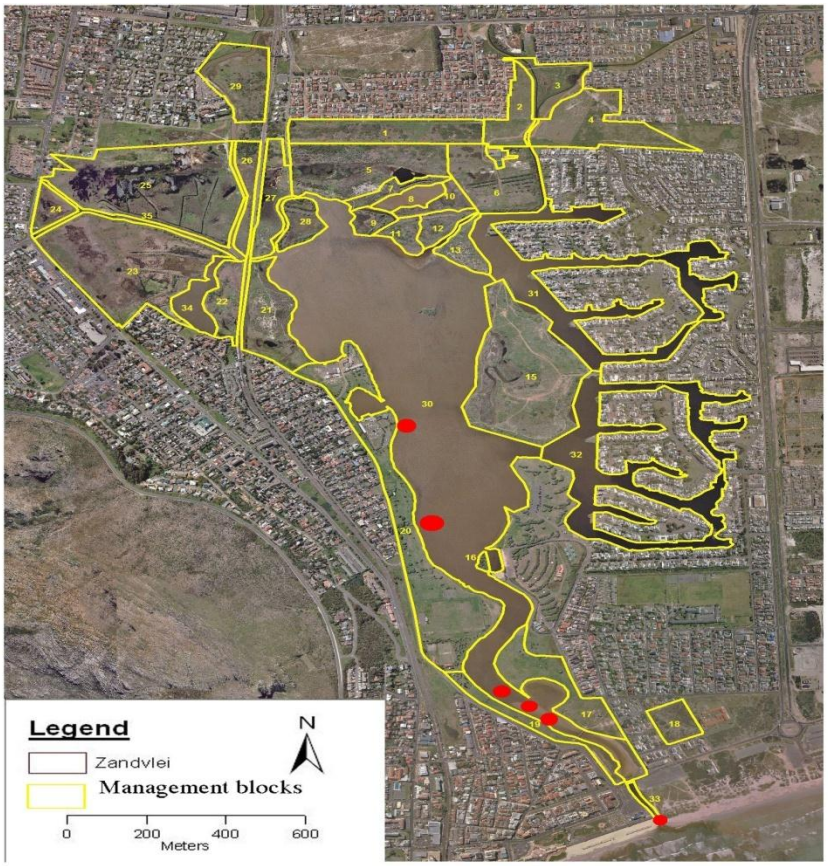
1. Determine if there has been an increase or decrease in fish numbers by analysing fish trek data and comparing winter and summer surveys, per species, per sampling site.
2. Determine recruitment trends for last five years by comparing size classes per species, using graphs to determine means and trend lines.
3. Collate best management guideline for mouth opening/closing for optimum fish migration.

Research Methodology:

Collating and analysing previous fish trek data from 2005-2010 by use of statistical methods to determine trend lines. Microsoft Excel will be used in order to organise size classes of the target species for each year and to draw up graphs to show comparison of recruitment sizes for the specific years for each target species. Dr. Stephen Lamberth from Oceans and Coasts will also be consulted for guidance on statistical analysis and interpretation.

The fish treks took place at the following sites (marked red).

Figure 1: Zandvlei Management Blocks



Contribution of the Research:

1. The end results of the research will indicate recruitment trends of the target species with regards to juveniles oppose to adults.
2. The end results will also give an indication of the general health of the estuary.
3. Collate best management guideline for mouth opening/closing for optimum fish migration.
4. The end results will also provide a platform for other projects.

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