THE DIET AND FEEDING OF THE COMPASS JELLYFISH CHRYSAORA HYSOSCELLA IN THE WALVIS BAY HARBOUR.

UNIVERSITY OF NAMIBIA

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A REPORT IN THE DEPARTMENT OF FISHERIES AND AQUATIC SCIENCES   FACULTY OF AGRICULTURE AND NATURAL RESOURCES.

SUBMITTED TO THE DEPARMENT OF FISHERIES AND AQUATIC SCIENCE, FACULTY OF AGRICULTURE AND NATURAL RESOURCES, UNIVERSITY OF NAMIBIA, IN PARITIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN FISHERIES AND AQUATIC SCIENCCE OF UNIVERISTY OF NAMIBIA.

NOVERMBER 2010

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DECLARATION

I hereby declare that this work is the product of my own research effort, undertaken under the supervision of Mr Kauve, Mr Mwafila, Mr Gibbons and has not been presented elsewhere for the award of a degree. All other sources of information used in compiling this paper have been appropriately acknowledged.

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Date:

CERTIFICATION

This is to certify that this report has been examined and approved for the award of a Bachelors Degree in Fisheries and Aquatic Science offered at the University of Namibia.

Supervisor:

External Examiner:

Head of Department:

ACKNOWLEDEMENTS

Firstly I would like to thank God the Almighty for the strength and wisdom he has given me throughout the research.

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Thank the department of Fisheries and Aquatic Science of the University of Namibia for their support.

Thank the National Marine Information and Research Centre (NatMIRC) for their assistance with sampling equipment and most importantly for the knowledge they have given me.

DEDICATION

This research is dedicated to my grandmother (Rachel Abraham), and my aunt Anneli Neema who have always motivated and pushed me to work hard and achieve my goals.

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ABSTRACT

Walvis Bay is located in the Benguela Current System (BSC) is a highly productive upwelling system which supports a larger biomass of fish. The BSC has been occupied by a jellyfish known as *Chrysaora hysoscella* increasing at an alarming rate and competing with the fish species for food. The Global International Water Assessment (GIWA) characterizes the Benguela Current as severely impacted in the area of overexploitation, biological and genetic diversity of fisheries. The Benguela current ecosystem, even exceeding the biomass of the commercially valuable finfish due to the change in the Benguela Current System (Crawford, 1989),

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Thirty species of C. Hysoscella were collected in the Walvis Bay harbour on the 14th of July 2010. Their diameter length was recorded and ranged from 14-57cm with a weight ranging from 127cm-6374cm and the settling volume ranging from 5cm^3-25cm^3. The gut content was collected and analysed in the laboratory and the following zooplankton species were identified: Echinoderm, unidentified zooplankton, crustacean, fish larvae, isopoda, chaetognaths, shellfish, amphipods, fish eggs, euphausiids and few seaweed were also found in the sample.

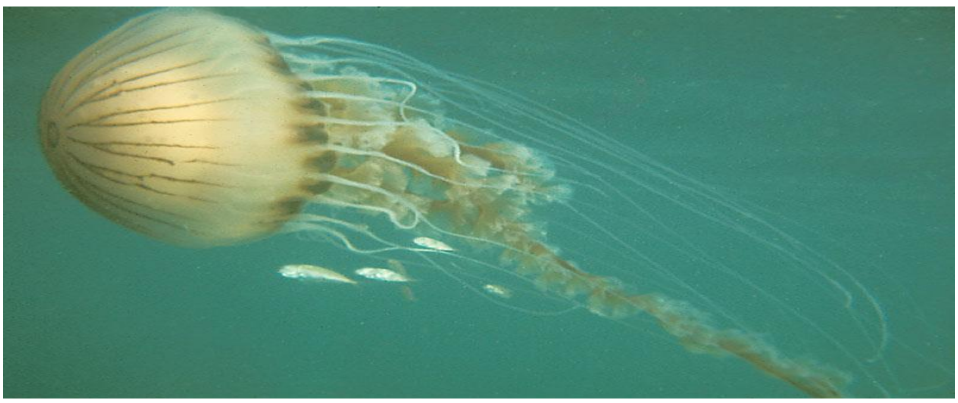
Thus identifying the gut content of the *C. Hysoscella* and deducing its diet, the effect that the jellyfish has on the fishery sector and fish population can be determined, through effective research into jellyfish feeding ecology.

CHAPTER ONE

1. INTRODUCTION

The term jellyfish also known as (jellies or sea jellies) are free-floating gelatinous animals belonging to the Phylum Cnidaria. Jellyfish come in a wide variety of sizes, shape and colours. The Chrysaora hysoscella have a radial symmetry (body parts radiating from a central axis), this symmetry allows jellyfish to detect and respond to food or danger from any direction (Arai, 2001).

Jellyfish are composed of an outer layer (epidermis) which covers the external body surface, and an inner layer (gastrodermis) which lines the gut. Between the epidermis and gastrodermis is a layer of thick elastic jellylike substance called mesoglea. Jellyfish have a simple digestive cavity (coelenteron) which acts as a gullet, stomach and intestine with one opening for both the mouth and anus. Four to eight oral arms known as tentacle located near the mouth have stinging cells called nematocysts that are used to poison or stun prey and transport food that has been captured to the mouth. The Chrysaora hysoscella are usually colored yellowish white with some brown, they have a diameter of up to 30cm and 24 tentacles which are arranged in eight groups of three(Arai, 2001).



Jellyfish inhabit every major oceanic area of the world and are capable of withstanding a wide range of temperatures and salinities. Jellyfish reproduce sexually and individuals are either male or female. The life cycle of jellyfish is complex and involves an alternation of generations in which the animal passes through two different body forms; the dominant and conspicuous medusa is the familiar form, while the smaller polyp form is restricted to the larval stage. Jellyfish are carnivorous, feeding mostly on a variety of zooplankton such as copepods, isopods, cladocerans, polycheates, cructecean eggs etc. Jellyfish are themselves preyed upon by spadefish, sunfish, sea turtles and other marine organisms (Flynn and Gibbons, 2003).

The Chrysaora hysoscella jellyfish species which will be studied belongs to the class Scyphozoa, it is also known as the compass jellyfish. It is a pelagic species within the Benguela Current System (BCS) and other parts of the world such as United Kingdom most frequently found in Turkey (Fish, 1989).


ATLANTIC COASTLINE
WIND DIRECTION
WALVIS BAY LAGOON
WALVIS BAY YACHT CLUB & LAUNCH AREA
FREE AIR CENTRE

Figure 1: Map showing the Walvis Bay Lagoon

2. BENGUELA CURRENT SYSTEM

The Benguela Current System (BCS) is one of four major eastern boundary upwelling system of the world oceans. It spans three countries on the west coast of Africa from about 14°S in Angola, through the entire coast of Namibia to about 37°S off the southern tip of Africa. It extends along the south coast of South Africa to the eastern edge of the Agulhas Bank at about 37°E (Sherman, 2000).

Walvis Bay is found in the Benguela Current System (BCS) which is one of the world's large marine ecosystems (LMEs), bordering the Atlantic Ocean. This strong wind-driven coastal upwelling western boundary ecosystem has the principal upwelling centre which is situated off southern Namibia (Arai, 2003).

The BCS LME is an important centre of marine biodiversity and is one of the most productive ocean areas in the world, with a high productivity (>300 grams of Carbon per square meter per year (gC/m2-yr). This in turn supports a large biomass of fish, especially small pelagic, herrings, sardines, anchovies and crustaceans, sea birds and marine mammals (FAO, 1999).

The Global International Water Assessment (GIWA) characterizes the Benguela Current LME as severely impacted in the area of overexploitation of fisheries, and biological and genetic diversity. These impacts and other indicators of unsustainable exploitation of fisheries are increasing. There is heavy exploitation of resources by foreign fleets, resulting in severe depletion and the collapse of several fish stocks such as sardine and anchovy. Global climate change could intensify coastal winds such as the El Nino which disrupt the balance of upwelling. *Chrysaora hysoscella* have recently been observed to be on the increase in the Benguela current ecosystem, even exceeding the biomass of the commercially valuable finfish due to the change in the Benguela Current System (Crawford, 1989),

3. LITERATURE REVIEW

Most medusa are carnivorous and their individual growth rates may be rapid when food is abundant. The diet of jellyfish consists mainly of carnivorous pelagic and benthic prey items such as; copepods, isopods, cladocerans, polycheates, cructecean eggs and even other gelatinous zooplanktons (Sherman, 2000). In the Britain waters Chrysaora feed on small planktonic animals such as arrowworms (Sagitta), ctenophore (Comb jellies), and young polycheates e.g. Tomopteris (Flynn and Gibbons, 2003). It is of particular interest that several jellyfish species are known to consume the eggs and larvae of fish like herring and feed on young fish and this might be detrimental to fish population (Cornelius, 1997).

Because of this voracious appetite the Chrysaora hysoscella is a concern in the Benguela Current System as it consume zooplankton at alarming rates. Jellyfish are known to eat at least a pound of zooplankton a day hence studies on jellyfish diets are essential to find out how this will affect commercial fisheries (Brodeur, 1999).

There are many assumptions as to why the jellyfish population is increasing; one reason is overfishing which is associated with several negative ideas such as depletion of fish stock because when commercial fisheries targets certain species they begin to wipe out all of that type of fish, a classical example is the overfished Sardine and Anchovy fish species in the Namibian coast during the Colonial Era and as a result many jellyfish species such as the Chrysaora hysoscella are taking over the overfished waters (Mayer,1910).

The growth of jellyfish population throughout the world's oceans has been linked to global warming as well as an increase in pollution that has depleted oxygen in coastal waters. Researchers at the Institute of Marine Sciences at the National Research Council in Barcelona have said that the increase in jellyfish numbers from Spain to Australia, Japan and Hawaii is a sign of the declining health of the world's oceans. These jellyfish near the shore are a message the sea is sending to us saying look how badly you are treating me said Dr Josep-Maia Gili, a leading jellyfish expect at the council to the New York Times.

The National Science Foundation 2003 has listed Australia, the Gulf of Mexico, Hawaii, the Black Sea, Namibia, and Britain, the Mediterranean, the Sea of Japan and the Yangtze estuary as the main problem areas. Thus effective research into jellyfish feeding ecology and fisheries management through sustainable fishing methods requires government responses globally to reduce global warming and pollution of coastal water bodies.

4. PROBLEM STATEMENT

The project is aimed to detect the feeding behaviour and diet of the compass jellyfish (*Chrysaora hysoscella*), in the Walvis Bay Lagoon area. The diets of the Chrysaora hysoscella was investigated before by Flynn and Gibbons in 2003 from 55 species caught near the surface throughout 24hours in the Walvis Bay lagoon during September 2003. *Chrysaora hysoscella* has recently been observed to be increasing in the Benguela current ecosystem, even exceeding the biomass of the commercially valuable finfish (Crawford, 1989). As such there is a concern that their increasing population abundance will make them explore new or alternative prey. However there is no or little information regarding the shift in their feeding patterns.

5. AIM

The aim of the research is to find out the diet of *Chrysaora hysoscella*, so that we can understand their feeding ecology and deduce its feeding impacts on the Benguela Current System.

6. OBJECTIVES

- **Main objective:** is to identify the stomach contents towards attaining the diet of *Chrysaora hysoscella*.
- **Specific objective:** is to elucidate the relationship between the diets, body weight and diameter length of the medusa.

7. **HYPOTHESES TO BE TESTED**

H11: There is a significant difference in the type of prey items consumed by the *C. hysoscella.*

H12: There is a significant difference in the relationship between size (bell diameter and weight) of the *C. hysoscella* and the diversity of prey items.

CHAPTER 2

8. MATERIALS AND METHOD

STUDY AREA:

The study was conducted in the Walvis Bay Lagoon (14.41° -14.5°E, 22.92-22.98°S), Namibia. At the time of the study the sea surface temperature was 17 degree Celsius.

SAMPLING:

A total of 30 compass jellyfish were collected individually from a ski boat by scooping them from the near-surface waters using a well designed 100µm mesh net to avoid loss of gut content. Environmental data such as temperature was recorded using a thermometer and regular plankton collected in 250ml collecting jars.

The diameter of each specimen was determined by measuring across the central disk to the nearest 0.5 cm using a measuring tape. The weight was determined to the nearest gram using a portable balance. The 30 specimens were each rinsed with filtered seawater in a 20l bucket several times, and poured through a 100µm mesh sieve. The retained gut contents was preserved in 5% borate-buffered formalin in sea water in a 250ml marked collecting jars for laboratory analysis.

LABORATORY ANALYSIS:

The 250ml collecting jar containing the sample was allowed to pass through a 100um sieve in the flame box and rinsed into a beaker several times to get rid of formalin. The solution in the beaker was then gently placed in a splitter so that it can be divided into two. The solution from the first splitter was used to identifying the different zooplanktons by using a 500ml stopper to transfer the organisms onto the bovogro tray and counted from three 2ml sub samples. The amount of macro-organisms such as amphipods was estimated and not counted in their entirely. The second solution from the splitter was placed into a measuring cylinder over 24hrs to determine the settling volume.

PHYTOPLANKTON ANALYSIS:

Four phytoplankton samples were collected in 250ml sampling jars, observed and counted under an electronic microscope in the laboratory and counted following NatMIRC guidelines.

STATISTICAL ANALYSIS

Data was entered into a Microsoft spreadsheet and transferred into GENSTAT statistical package for analysis in which a one-way ANOVA was used there was no blocking factor. The results from this research will be presented using tables and graphs.

CHAPTER THRE RESULTS

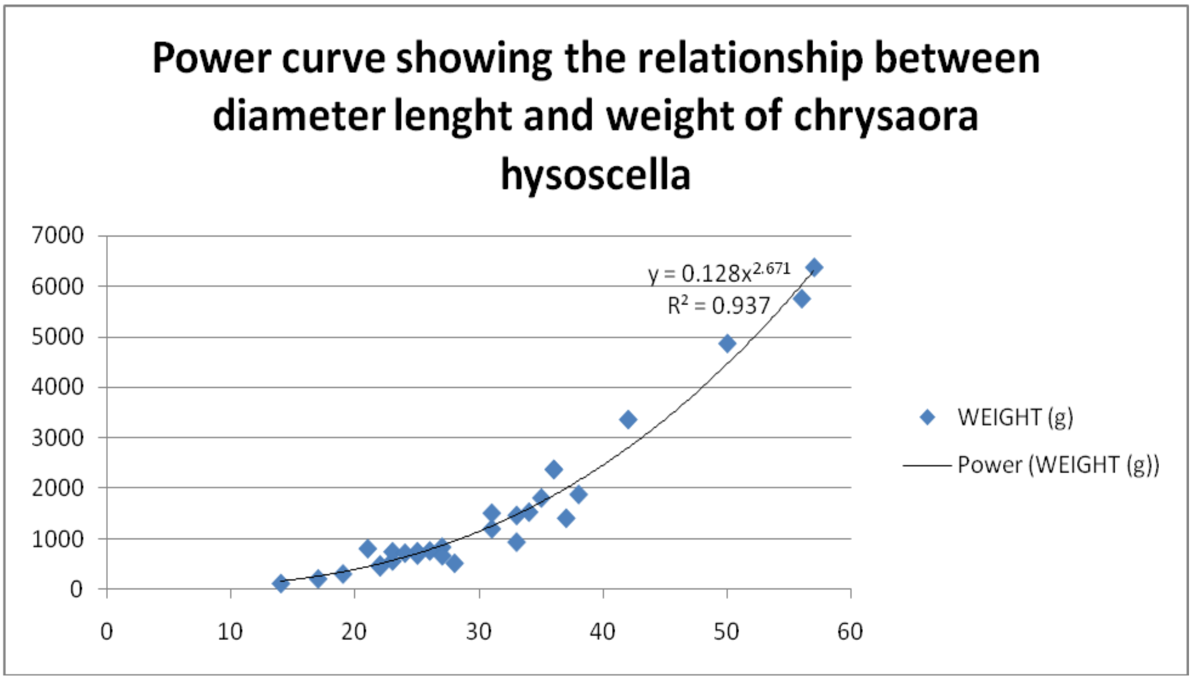
- PHYTOPLANKTON

TABLE 1: show the amount of phytoplankton in the Walvis Bay Harbour

Phytoplankton	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Total**
Procentrium Micans	52	61	81	76	**270**
Thalasiosira	38	22	49	28	**137**
Gyrodinium	35	51	66	47	**199**
Sciplidla Trachoidea	69	78	81	34	**264**
Amount	**194**	**212**	**277**	**185**	**870**

Availability of phytoplankton stimulates the growth of zooplankton. The most common phytoplankton was Procentrium micans. These results can be related to the high abundance of isopods, amphipods, copepods, cyclopoids and unidentified zooplankton found in the 30 jellyfish sample.

- DIAMETER AND WEIGHT RELATIONSHIP



The graph shows that there is a positive relationship between the weight of the medusae and the length of its diameter because R^2 is equal to 0.937. R^2 represents the goodness of fit which is always equal to 1.

Interpretation of results: This means that the larger the diameter the more zooplankton the jellyfish will consume hence its weight increases.

The 30 medusae studied had a mean diameter of 30.6cm. The length of the C. Hysoscella ranged from 14-57cm. Results show that bigger jellyfish e.g. jellyfish with a diameter of 57cm tend to consume a diversity of prey, the shrimp was found on the biggest jellyfish which had a weight of 6374g as compared to smaller jellyfish with the weight of 0.127 and a diameter length of 14cm which consumed a small amount of prey.

- THE MEAN COUNTS OF THE DIFFERENT PREY TAXA

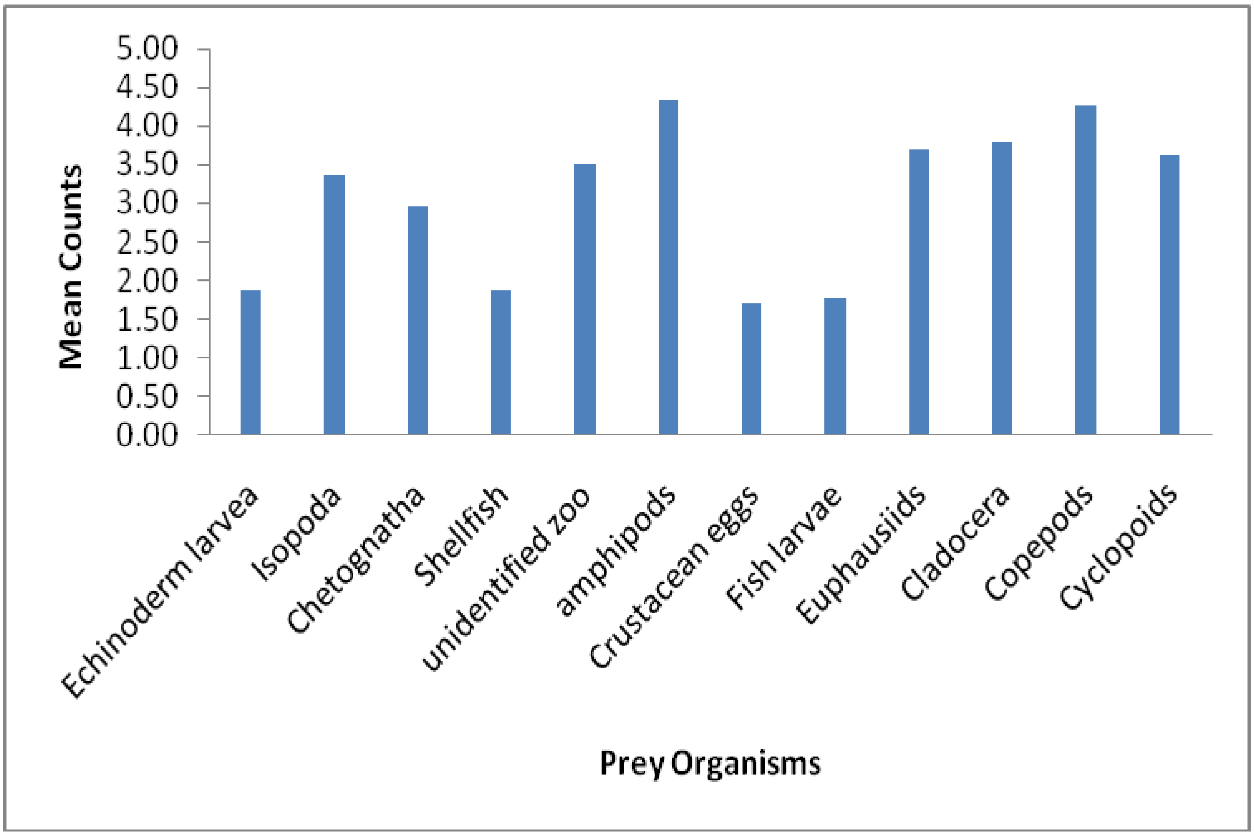


Figure 1 : showing the relationship between the diameter and mass of C. Hysoscella sampled in Walvis Bay harbour on the 14th of July 2010.

The results also show that there is no clear overall relationship between medusa size and the number or type of prey ingested between the sizes of the jellyfish the amount of zooplankton. Positive relationships between size and ingested prey diversity have been noted by Graham and Koutril (2001) for *Aurelia aurita* (but not for any species of *Chrysaora*). It was observed that fish larvae, echinoderm larvae were least consumed and amphipods as well as copepods were most consumed (Appendix 3) analysis of variance. Analysis also show that there were significant difference in the mean prey taxon Presented in Appendix 3.

- RESULTS

The samples analysed in the laboratory also contained seaweeds which is unfamiliar because jellyfish are known to be carnivores and not herbivores it might be that this shift in diet can be reason why they are in abundance as well hence further studies need to be carried out.

A shrimp was found on the larger jellyfish and this is another strange matter because shrimps are not known to be consumed by jellyfish because they are fast swimmers so this might mean that the jellyfish has developed a new mechanism through the effective use of its tentacles to catch the fast moving shrimp.

CONCLUSION

The diet of the Chrysaora hysoscella mostly contains copepods and amphipods. And fish larvae and crustacean eggs a least consumed. The linear relationship between the diameter length and the weight of the jellyfish indicates that the larger the diameter the more zooplankton the jellyfish will consume. Results also show that most zooplankton species found in the jellyfish are important to fish species, and this is might have severe impact on commercial fisheries

The present results should be viewed as preliminary: they were collected from a relatively small number of specimens and there is poor supporting environmental data with which to contextualise them. However, they represent the only information on the diet of *Chrysaora hysoscella* in the region. Perhaps the key finding to come from the study is the large number of benthic prey items in the diet.

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PROJECT: THE DIET AND THE FEEDING OF THE COMPASS JELLYFISH CHYRSAORA HYSOSCELLA

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2ml subsample

SPECIES FOUND	**Echinoderm larvae**	**isopoda**	**chaetognatha**	**shellfish**	**unidentified zooplankton**	**amphipods**	**crustacean eggs**	**fish larvea**	**euphausiids**	**cladocera**	**copepods**	**cyclopoids**
JELLYFISH 1												
Subsample 1	1	0	0	2	1	1	0	1	2	1	2	1
subsample 2	1	0	1	0	0	4	1	1	1	1	3	2
subsample 3	2	1	0	1	0	2	1	0	2	0	2	3
TOTAL	**4**	**1**	**1**	**3**	**1**	**7**	**2**	**2**	**5**	**2**	**7**	**6**
JELLYFISH 2												
Subsample 1	0	1	1	0	2	3	1	1	3	2	3	2
subsample 2	1	1	0	1	1	2	0	2	2	1	2	1
subsample 3	0	1	1	0	0	1	1	0	0	2	0	1
TOTAL	**1**	**3**	**2**	**1**	**3**	**6**	**2**	**3**	**5**	**5**	**5**	**4**
JELLYFISH 3												
Subsample 1	0	3	2	3	2	0	3	2	1	3	2	1
subsample 2	2	0	0	1	0	3	3	0	2	0	3	2
subsample 3	1	2	1	1	1	2	2	1	0	2	2	0
TOTAL	**3**	**5**	**3**	**5**	**3**	**5**	**8**	**3**	**3**	**5**	**7**	**3**
JELLYFISH 4												
Subsample 1	2	1	2	1	1	0	3	2	1	2	0	3

subsample 2	1	1	0	0	3	1	0	3	0	1	0	1
subsample 3	0	0	1	1	2	0	1	1	3	0	3	1
TOTAL	**3**	**2**	**3**	**2**	**6**	**1**	**4**	**5**	**4**	**3**	**3**	**5**
JELLYFISH 5												
Subsample 1	0	1	2	0	1	1	1	1	2	2	3	1
Subsample 2	0	0	1	1	2	1	0	0	2	3	3	1
Subsample 3	0	3	0	1	1	0	2	1	2	1	1	0
TOTAL	**0**	**4**	**3**	**2**	**4**	**2**	**3**	**2**	**6**	**6**	**7**	**2**
JELLYFISH 6												
Subsample 1	1	0	0	1	3	0	0	2	3	3	1	2
Subsample 2	0	0	1	1	2	1	0	2	1	2	1	2
subsample 3	0	1	0	1	2	0	1	1	1	3	2	2
TOTAL	**1**	**1**	**1**	**3**	**7**	**1**	**1**	**5**	**5**	**8**	**4**	**6**
JELLYFISH 7	0	2	1	2	0	0	2	3	1	1	0	1
Subsample 1	1	1	1	0	0	0	2	1	2	1	0	2
Subsample 2	1	0	1	0	0	1	2	1	1	1	1	2
Subsample 3												
TOTAL	**2**	**3**	**3**	**2**	**0**	**1**	**6**	**5**	**4**	**3**	**1**	**5**
JELLYFISH 8												
Subsample 1	2	3	1	0	1	1	1	0	1	2	2	1
Subsample 2	1	0	1	0	2	2	2	0	1	1	3	2
Subsample 3	0	1	1	0	1	1	1	0	1	1	3	1
TOTAL	**3**	**4**	**3**	**0**	**4**	**5**	**4**	**0**	**3**	**4**	**8**	**4**

JELLYFISH 9												
Subsample 1	1	2	0	0	1	0	0	0	3	2	3	2
Subsample 2	1	2	1	0	2	0	0	1	3	1	1	1
Subsample 3	1	0	0	1	2	1	0	0	1	2	1	2
TOTAL	**3**	**4**	**1**	**1**	**5**	**1**	**0**	**1**	**7**	**5**	**5**	**5**
JELLYFISH 10												
Subsample 1	2	3	1	1	1	1	0	0	0	1	3	1
Subsample 2	1	2	2	1	1	1	1	0	1	1	1	1
Subsample 3	2	1	1	2	1	1	1	0	1	2	1	2
TOTAL	**5**	**6**	**4**	**4**	**3**	**3**	**2**	**0**	**2**	**4**	**5**	**4**
JELLYFISH 11												
Subsample 1	1	2	2	1	2	1	0	0	1	1	3	2
Subsample 2	1	2	1	1	1	1	1	1	1	1	2	1
Subsample 3	2	1	1	1	1	1	0	1	0	1	1	1
TOTAL	**4**	**4**	**4**	**3**	**4**	**3**	**1**	**2**	**2**	**3**	**6**	**4**
JELLYFISH 12												
Subsample 1	1	1	1	1	1	2	1	1	0	2	2	1
Subsample 2	1	1	2	1	0	1	1	0	1	1	1	2
Subsample 3	1	2	1	2	2	2	0	0	2	2	3	1
TOTAL	**3**	**4**	**4**	**4**	**3**	**4**	**2**	**1**	**3**	**5**	**6**	**4**
JELLYFISH 13												
Subsample 1	1	1	2	2	2	1	1	0	0	1	1	1
Subsample 2	2	2	1	1	1	2	1	0	0	1	2	1
Subsample 3	1	2	1	1	1	1	1	1	1	2	1	1

TOTAL	**4**	**5**	**4**	**4**	**4**	**4**	**3**	**1**	**1**	**4**	**4**	**3**
JELLYFISH 14												
Subsample 1	1	2	1	1	1	1	0	0	1	2	1	1
Subsample 2	1	2	1	1	2	1	0	0	4	1	2	3
Subsample 3	1	1	0	0	1	0	0	1	1	1	2	1
TOTAL	**3**	**5**	**2**	**2**	**4**	**2**	**0**	**1**	**6**	**4**	**4**	**4**
JELLYFISH 15												
Subsample 1	0	1	2	0	2	0	0	1	3	2	1	2
Subsample 2	1	1	1	0	1	2	1	1	3	1	3	1
Subsample 3	1	2	0	1	2	0	0	2	1	3	2	2
TOTAL	**2**	**4**	**3**	**1**	**5**	**2**	**1**	**4**	**7**	**6**	**6**	**5**
JELLYFISH 16												
Subsample 1	1	1	1	1	1	3	0	0	2	2	2	2
Subsample 2	1	3	0	0	1	2	1	0	1	2	2	1
Subsample 3	1	1	2	1	2	2	1	1	2	1	2	1
TOTAL	**3**	**5**	**3**	**2**	**4**	**7**	**2**	**1**	**5**	**5**	**6**	**4**
JELLYFISH 17												
Subsample 1	1	2	2	1	2	4	0	2	2	2	1	1
subsample 2	0	1	3	1	1	3	0	1	1	3	1	2
subsample 3	1	2	2	0	1	2	0	1	2	1	2	1
TOTAL	**2**	**5**	**7**	**2**	**4**	**9**	**0**	**4**	**5**	**6**	**4**	**4**
JELLYFISH 18												

Subsample 1	0	2	2	1	2	4	0	0	2	2	2	1
Subsample 2	0	1	2	0	1	3	1	0	1	1	1	1
Subsample 3	1	1	1	0	0	2	0	1	1	1	1	1
TOTAL	**1**	**4**	**5**	**1**	**3**	**9**	**1**	**1**	**4**	**4**	**4**	**3**
JELLYFISH 19												
Subsample 1	0	1	2	0	1	1	0	0	1	2	2	1
Subsample 2	0	2	1	0	2	2	0	0	1	1	1	1
Subsample 3	0	2	1	0	1	2	0	0	1	1	1	1
TOTAL	**0**	**5**	**4**	**0**	**4**	**5**	**0**	**0**	**3**	**4**	**4**	**3**
JELLYFISH 20												
Subsample 1	0	0	0	1	2	4	0	0	2	1	2	2
Subsample 2	1	0	1	1	2	3	1	0	2	1	1	1
Subsample 3	0	2	1	1	1	2	0	0	2	1	1	1
TOTAL	**1**	**2**	**2**	**3**	**5**	**9**	**1**	**0**	**6**	**3**	**4**	**4**
JELLYFISH 21												
Subsample 1	0	1	1	0	1	2	0	0	1	1	1	1
Subsample 2	0	1	2	0	0	1	0	0	1	0	1	0
Subsample 3	0	1	1	0	0	1	0	0	0	1	1	1
TOTAL	**0**	**3**	**4**	**0**	**1**	**4**	**0**	**0**	**2**	**2**	**3**	**2**
JELLYFISH 22												
Subsample 1	0	0	1	0	1	1	0	0	1	0	0	1
Subsample 2	0	1	1	0	0	1	0	0	0	0	1	1
Subsample 3	1	0	0	0	0	1	0	0	0	0	1	1

TOTAL	**1**	**1**	**2**	**0**	**1**	**3**	**0**	**0**	**1**	**0**	**2**	**3**
JELLYFISH 23												
Subsample 1	0	1	1	0	1	1	0	0	1	1	1	0
Subsample 2	0	1	0	0	1	1	0	0	1	0	1	0
Subsample 3	0	1	0	0	0	1	0	1	0	0	0	1
TOTAL	**0**	**3**	**1**	**0**	**2**	**3**	**0**	**1**	**2**	**1**	**2**	**1**
JELLYFISH 24												
Subsample 1	1	2	1	1	2	4	1	1	2	1	1	1
Subsample 2	0	1	2	1	2	1	2	1	1	1	2	1
Subsample 3	1	2	1	0	1	1	1	1	2	2	1	1
TOTAL	**2**	**5**	**4**	**2**	**5**	**6**	**4**	**3**	**5**	**4**	**4**	**3**
JELLYFISH 25												
Subsample 1	0	2	1	1	1	0	1	2	2	1	2	1
Subsample 2	1	1	1	1	2	1	0	1	1	1	1	2
Subsample 3	1	1	1	0	1	0	0	1	1	1	1	1
TOTAL	**2**	**4**	**3**	**2**	**4**	**1**	**1**	**4**	**4**	**3**	**4**	**4**
JELLYFISH 26												
subsample 1	0	1	1	0	1	2	0	0	0	1	1	1
subsample 2	0	1	0	0	0	1	1	0	0	1	0	1
subsample 3	0	0	0	0	0	1	1	0	0	0	0	1
TOTAL	**0**	**2**	**1**	**0**	**1**	**4**	**2**	**0**	**0**	**2**	**1**	**1**
JELLYFISH 27												

subsample 1	0	1	0	0	1	1	0	0	1	1	0	1
subsample2	0	0	0	0	1	0	0	0	0	0	0	0
Subsample 3	0	0	1	0	0	1	0	0	0	0	0	0
TOTAL	**0**	**1**	**1**	**0**	**2**	**2**	**0**	**0**	**1**	**1**	**0**	**1**
JELLYFISH 28												
Subsample 1	0	1	1	1	2	2	0	0	1	1	1	1
Subsample 2	0	1	0	0	1	2	0	1	1	2	2	1
Subsample 3	0	0	0	0	1	2	0	0	0	1	1	1
TOTAL	**0**	**2**	**1**	**1**	**4**	**6**	**0**	**1**	**2**	**4**	**4**	**3**
JELLYFISH 29												
Subsample 1	0	1	1	1	1	2	0	0	1	1	1	1
subsample 2	1	1	2	1	1	2	0	0	2	1	2	2
subsample 3	0	1	1	0	1	3	0	1	1	1	1	1
TOTAL	**1**	**3**	**4**	**2**	**3**	**7**	**0**	**1**	**4**	**3**	**4**	**4**
JELLYFISH 30												
Subsample 1	1	1	2	1	2	3	1	1	1	2	1	2
subsample 2	1	2	1	1	2	2	0	1	2	2	2	1
subsample 3	1	0	1	1	2	3	0	0	1	1	1	2
TOTAL	**3**	**3**	**4**	**3**	**6**	**8**	**1**	**2**	**4**	**5**	**4**	**5**

DIAMETER LENGTH(cm)	WEIGHT (g)	SETTLED VOL (ml)	Echinoderm larvea	Isopoda	Chetognatha	Shellfish	unidentified zoo	amphipods	Crustacean eggs	Fish larvae	Euphausiids	Cladocera	Copepods
33	1473	5	5	1	1	3	1	7	2	2	5	2	7
34	1538	20	1	3	2	1	3	6	2	3	5	5	5
42	3367	10	3	5	3	5	3	5	8	3	3	5	7
36	2381	10	3	2	3	2	6	1	4	5	4	3	3
37	1418	5	0	4	3	2	4	2	3	2	6	6	7
35	1819	20	1	1	1	3	7	1	1	5	5	8	4
27	846	20	2	3	3	2	0	1	6	5	4	3	1
25	691	15	3	4	3	0	4	5	4	0	3	4	8
25	738	25	3	4	1	1	5	1	0	1	7	5	5
31	1208	10	5	6	4	4	3	3	2	0	2	4	5
22	494	20	4	4	4	3	4	3	1	2	2	3	6
26	772	25	3	4	4	4	3	4	2	1	3	5	6
57	6374	25	4	5	4	4	4	4	3	1	1	4	4
56	5756	25	3	5	2	2	4	2	0	1	6	4	4
50	4871	25	2	4	3	1	5	2	1	4	7	6	6
19	315	10	1	3	5	3	4	7	2	1	5	5	6
23	573	20	2	5	7	2	4	9	0	4	5	6	4
38	1887	5	1	4	5	1	3	9	1	1	4	4	4
27	676	20	0	5	4	0	4	5	0	0	3	4	4
36	2381	20	1	2	2	3	5	9	1	0	6	3	4
22	456	10	0	3	4	0	1	4	0	0	2	2	3

17	219	19	1	1	2	0	1	3	0	0	1	0	2
25	756	15	0	3	1	0	2	3	0	1	2	1	2
31	1518	21	2	5	4	2	5	6	4	3	5	4	4
21	816	15	2	4	3	2	4	1	1	4	4	3	4
28	527	10	0	2	1	0	1	4	2	0	0	2	1
14	127	15	0	1	1	0	2	2	0	0	1	1	0
23	754	20	0	2	1	1	4	6	0	1	2	4	4
24	727	22	1	3	4	2	3	7	0	1	4	3	4
33	946	25	3	3	4	3	6	8	1	2	4	5	4

2ml subsample **SPECIES FOUND**	**Echinoderm larvae**	**isopoda**	**chaetognatha**	**shellfish**	**unidentified zooplankton**	**amphipods**	**crustacean eggs**	**fish larvea**	**euphausiids**	**cladocera**	**copepods**	**cyclopoids**
JELLYFISH 1												
Subsample 1	1	0	0	2	1	1	0	1	2	1	2	1
subsample 2	1	0	1	0	0	4	1	1	1	1	3	2
subsample 3	2	1	0	1	0	2	1	0	2	0	2	3
TOTAL	**4**	**1**	**1**	**3**	**1**	**7**	**2**	**2**	**5**	**2**	**7**	**6**
JELLYFISH 2												
Subsample 1	0	1	1	0	2	3	1	1	3	2	3	2
subsample 2	1	1	0	1	1	2	0	2	2	1	2	1
subsample 3	0	1	1	0	0	1	1	0	0	2	0	1
TOTAL	**1**	**3**	**2**	**1**	**3**	**6**	**2**	**3**	**5**	**5**	**5**	**4**
JELLYFISH 3												
Subsample 1	0	3	2	3	2	0	3	2	1	3	2	1
subsample 2	2	0	0	1	0	3	3	0	2	0	3	2
subsample 3	1	2	1	1	1	2	2	1	0	2	2	0
TOTAL	**3**	**5**	**3**	**5**	**3**	**5**	**8**	**3**	**3**	**5**	**7**	**3**
JELLYFISH 4												
Subsample 1	2	1	2	1	1	0	3	2	1	2	0	3
subsample 2	1	1	0	0	3	1	0	3	0	1	0	1
subsample 3	0	0	1	1	2	0	1	1	3	0	3	1
TOTAL	**3**	**2**	**3**	**2**	**6**	**1**	**4**	**5**	**4**	**3**	**3**	**5**
JELLYFISH 5												
Subsample 1	0	1	2	0	1	1	1	1	2	2	3	1
Subsample 2	0	0	1	1	2	1	0	0	2	3	3	1

Subsample 3	0	3	0	1	1	0	2	1	2	1	1	0
TOTAL	**0**	**4**	**3**	**2**	**4**	**2**	**3**	**2**	**6**	**6**	**7**	**2**
JELLYFISH 6												
Subsample 1	1	0	0	1	3	0	0	2	3	3	1	2
Subsample 2	0	0	1	1	2	1	0	2	1	2	1	2
subsample 3	0	1	0	1	2	0	1	1	1	3	2	2
TOTAL	**1**	**1**	**1**	**3**	**7**	**1**	**1**	**5**	**5**	**8**	**4**	**6**
JELLYFISH 7	0	2	1	2	0	0	2	3	1	1	0	1
Subsample 1	1	1	1	0	0	0	2	1	2	1	0	2
Subsample 2	1	0	1	0	0	1	2	1	1	1	1	2
Subsample 3												
TOTAL	**2**	**3**	**3**	**2**	**0**	**1**	**6**	**5**	**4**	**3**	**1**	**5**
JELLYFISH 8												
Subsample 1	2	3	1	0	1	1	1	0	1	2	2	1
Subsample 2	1	0	1	0	2	2	2	0	1	1	3	2
Subsample 3	0	1	1	0	1	1	1	0	1	1	3	1
TOTAL	**3**	**4**	**3**	**0**	**4**	**5**	**4**	**0**	**3**	**4**	**8**	**4**
JELLYFISH 9												
Subsample 1	1	2	0	0	1	0	0	0	3	2	3	2
Subsample 2	1	2	1	0	2	0	0	1	3	1	1	1
Subsample 3	1	0	0	1	2	1	0	0	1	2	1	2
TOTAL	**3**	**4**	**1**	**1**	**5**	**1**	**0**	**1**	**7**	**5**	**5**	**5**

JELLYFISH 10												
Subsample 1	2	3	1	1	1	1	0	0	0	1	3	1
Subsample 2	1	2	2	1	1	1	1	0	1	1	1	1
Subsample 3	2	1	1	2	1	1	1	0	1	2	1	2
TOTAL	**5**	**6**	**4**	**4**	**3**	**3**	**2**	**0**	**2**	**4**	**5**	**4**
JELLYFISH 11												
Subsample 1	1	2	2	1	2	1	0	0	1	1	3	2
Subsample 2	1	2	1	1	1	1	1	1	1	1	2	1
Subsample 3	2	1	1	1	1	1	0	1	0	1	1	1
TOTAL	**4**	**4**	**4**	**3**	**4**	**3**	**1**	**2**	**2**	**3**	**6**	**4**
JELLYFISH 12												
Subsample 1	1	1	1	1	1	2	1	1	0	2	2	1
Subsample 2	1	1	2	1	0	1	1	0	1	1	1	2
Subsample 3	1	2	1	2	2	2	0	0	2	2	3	1
TOTAL	**3**	**4**	**4**	**4**	**3**	**4**	**2**	**1**	**3**	**5**	**6**	**4**
JELLYFISH 13												
Subsample 1	1	1	2	2	2	1	1	0	0	1	1	1
Subsample 2	2	2	1	1	1	2	1	0	0	1	2	1
Subsample 3	1	2	1	1	1	1	1	1	1	2	1	1
TOTAL	**4**	**5**	**4**	**4**	**4**	**4**	**3**	**1**	**1**	**4**	**4**	**3**
JELLYFISH 14												
Subsample 1	1	2	1	1	1	1	0	0	1	2	1	1
Subsample 2	1	2	1	1	2	1	0	0	4	1	2	3
Subsample 3	1	1	0	0	1	0	0	1	1	1	2	1

TOTAL	**3**	**5**	**2**	**2**	**4**	**2**	**0**	**1**	**6**	**4**	**4**	**4**
JELLYFISH 15												
Subsample 1	0	1	2	0	2	0	0	1	3	2	1	2
Subsample 2	1	1	1	0	1	2	1	1	3	1	3	1
Subsample 3	1	2	0	1	2	0	0	2	1	3	2	2
TOTAL	**2**	**4**	**3**	**1**	**5**	**2**	**1**	**4**	**7**	**6**	**6**	**5**
JELLYFISH 16												
Subsample 1	1	1	1	1	1	3	0	0	2	2	2	2
Subsample 2	1	3	0	0	1	2	1	0	1	2	2	1
Subsample 3	1	1	2	1	2	2	1	1	2	1	2	1
TOTAL	**3**	**5**	**3**	**2**	**4**	**7**	**2**	**1**	**5**	**5**	**6**	**4**
JELLYFISH 17												
Subsample 1	1	2	2	1	2	4	0	2	2	2	1	1
subsample 2	0	1	3	1	1	3	0	1	1	3	1	2
subsample 3	1	2	2	0	1	2	0	1	2	1	2	1
TOTAL	**2**	**5**	**7**	**2**	**4**	**9**	**0**	**4**	**5**	**6**	**4**	**4**
JELLYFISH 18												
Subsample 1	0	2	2	1	2	4	0	0	2	2	2	1
Subsample 2	0	1	2	0	1	3	1	0	1	1	1	1
Subsample 3	1	1	1	0	0	2	0	1	1	1	1	1
TOTAL	**1**	**4**	**5**	**1**	**3**	**9**	**1**	**1**	**4**	**4**	**4**	**3**
JELLYFISH 19												

Subsample 1	0	1	2	0	1	1	0	0	1	2	2	1
Subsample 2	0	2	1	0	2	2	0	0	1	1	1	1
Subsample 3	0	2	1	0	1	2	0	0	1	1	1	1
TOTAL	**0**	**5**	**4**	**0**	**4**	**5**	**0**	**0**	**3**	**4**	**4**	**3**
JELLYFISH 20												
Subsample 1	0	0	0	1	2	4	0	0	2	1	2	2
Subsample 2	1	0	1	1	2	3	1	0	2	1	1	1
Subsample 3	0	2	1	1	1	2	0	0	2	1	1	1
TOTAL	**1**	**2**	**2**	**3**	**5**	**9**	**1**	**0**	**6**	**3**	**4**	**4**
JELLYFISH 21												
Subsample 1	0	1	1	0	1	2	0	0	1	1	1	1
Subsample 2	0	1	2	0	0	1	0	0	1	0	1	0
Subsample 3	0	1	1	0	0	1	0	0	0	1	1	1
TOTAL	**0**	**3**	**4**	**0**	**1**	**4**	**0**	**0**	**2**	**2**	**3**	**2**
JELLYFISH 22												
Subsample 1	0	0	1	0	1	1	0	0	1	0	0	1
Subsample 2	0	1	1	0	0	1	0	0	0	0	1	1
Subsample 3	1	0	0	0	0	1	0	0	0	0	1	1
TOTAL	**1**	**1**	**2**	**0**	**1**	**3**	**0**	**0**	**1**	**0**	**2**	**3**
JELLYFISH 23												
Subsample 1	0	1	1	0	1	1	0	0	1	1	1	0
Subsample 2	0	1	0	0	1	1	0	0	1	0	1	0
Subsample 3	0	1	0	0	0	1	0	1	0	0	0	1

TOTAL	**0**	**3**	**1**	**0**	**2**	**3**	**0**	**1**	**2**	**1**	**2**	**1**
JELLYFISH 24												
Subsample 1	1	2	1	1	2	4	1	1	2	1	1	1
Subsample 2	0	1	2	1	2	1	2	1	1	1	2	1
Subsample 3	1	2	1	0	1	1	1	1	2	2	1	1
TOTAL	**2**	**5**	**4**	**2**	**5**	**6**	**4**	**3**	**5**	**4**	**4**	**3**
JELLYFISH 25												
Subsample 1	0	2	1	1	1	0	1	2	2	1	2	1
Subsample 2	1	1	1	1	2	1	0	1	1	1	1	2
Subsample 3	1	1	1	0	1	0	0	1	1	1	1	1
TOTAL	**2**	**4**	**3**	**2**	**4**	**1**	**1**	**4**	**4**	**3**	**4**	**4**
JELLYFISH 26												
subsample 1	0	1	1	0	1	2	0	0	0	1	1	1
subsample 2	0	1	0	0	0	1	1	0	0	1	0	1
subsample 3	0	0	0	0	0	1	1	0	0	0	0	1
TOTAL	**0**	**2**	**1**	**0**	**1**	**4**	**2**	**0**	**0**	**2**	**1**	**1**
JELLYFISH 27												
subsample 1	0	1	0	0	1	1	0	0	1	1	0	1
subsample2	0	0	0	0	1	0	0	0	0	0	0	0
Subsample 3	0	0	1	0	0	1	0	0	0	0	0	0
TOTAL	**0**	**1**	**1**	**0**	**2**	**2**	**0**	**0**	**1**	**1**	**0**	**1**
JELLYFISH 28												

Subsample 1	0	1	1	1	2	2	0	0	1	1	1	1
Subsample 2	0	1	0	0	1	2	0	1	1	2	2	1
Subsample 3	0	0	0	0	1	2	0	0	0	1	1	1
TOTAL	**0**	**2**	**1**	**1**	**4**	**6**	**0**	**1**	**2**	**4**	**4**	**3**
JELLYFISH 29												
Subsample 1	0	1	1	1	1	2	0	0	1	1	1	1
subsample 2	1	1	2	1	1	2	0	0	2	1	2	2
subsample 3	0	1	1	0	1	3	0	1	1	1	1	1
TOTAL	**1**	**3**	**4**	**2**	**3**	**7**	**0**	**1**	**4**	**3**	**4**	**4**
JELLYFISH 30												
Subsample 1	1	1	2	1	2	3	1	1	1	2	1	2
subsample 2	1	2	1	1	2	2	0	1	2	2	2	1
subsample 3	1	0	1	1	2	3	0	0	1	1	1	2
TOTAL	**3**	**3**	**4**	**3**	**6**	**8**	**1**	**2**	**4**	**5**	**4**	**5**

DIAMETER LENGTH(cm)	WEIGHT (g)	SETTLED VOL (ml)	Echinoderm larvea	Isopoda	Chetognatha	Shellfish	unidentified zoo	amphipods	Crustacean eggs	Fish larvae	Euphausiids	Cladocera	Copepods
33	1473	5	5	1	1	3	1	7	2	2	5	2	7
34	1538	20	1	3	2	1	3	6	2	3	5	5	5
42	3367	10	3	5	3	5	3	5	8	3	3	5	7
36	2381	10	3	2	3	2	6	1	4	5	4	3	3
37	1418	5	0	4	3	2	4	2	3	2	6	6	7
35	1819	20	1	1	1	3	7	1	1	5	5	8	4
27	846	20	2	3	3	2	0	1	6	5	4	3	1
25	691	15	3	4	3	0	4	5	4	0	3	4	8
25	738	25	3	4	1	1	5	1	0	1	7	5	5
31	1208	10	5	6	4	4	3	3	2	0	2	4	5
22	494	20	4	4	4	3	4	3	1	2	2	3	6
26	772	25	3	4	4	4	3	4	2	1	3	5	6
57	6374	25	4	5	4	4	4	4	3	1	1	4	4
56	5756	25	3	5	2	2	4	2	0	1	6	4	4
50	4871	25	2	4	3	1	5	2	1	4	7	6	6
19	315	10	1	3	5	3	4	7	2	1	5	5	6
23	573	20	2	5	7	2	4	9	0	4	5	6	4
38	1887	5	1	4	5	1	3	9	1	1	4	4	4
27	676	20	0	5	4	0	4	5	0	0	3	4	4
36	2381	20	1	2	2	3	5	9	1	0	6	3	4
22	456	10	0	3	4	0	1	4	0	0	2	2	3
17	219	19	1	1	2	0	1	3	0	0	1	0	2
25	756	15	0	3	1	0	2	3	0	1	2	1	2
31	1518	21	2	5	4	2	5	6	4	3	5	4	4
21	816	15	2	4	3	2	4	1	1	4	4	3	4
28	527	10	0	2	1	0	1	4	2	0	0	2	1

14	127	15	0	1	1	0	2	2	0	0	1	1	0
23	754	20	0	2	1	1	4	6	0	1	2	4	4
24	727	22	1	3	4	2	3	7	0	1	4	3	4
33	946	25	3	3	4	3	6	8	1	2	4	5	4

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Copepods	8	1278.75	159.84	3.47	0.011
Residual	21	968.75	46.13		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Crustacean_eggs	6	792.91	132.15	2.09	0.094
Residual	23	1454.59	63.24		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Cyclopoids	5	674.57	134.91	2.06	0.106
Residual	24	1572.93	65.54		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Echinoderm_larvea	5	599.80	119.96	1.75	0.162
Residual	24	1647.70	68.65		
Total	29	2247.50			

**** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Fish_larvae	5	646.54	129.31	1.94	0.125
Residual	24	1600.96	66.71		
Total	29	2247.50			

**** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Isopoda	5	214.20	42.84	0.51	0.769
Residual	24	2033.30	84.72		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Shellfish	5	420.90	84.18	1.11	0.383
Residual	24	1826.60	76.11		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
amphipods	8	513.62	64.20	0.78	0.627
Residual	21	1733.88	82.57		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Chetognatha	5	372.37	74.47	0.95	0.465
Residual	24	1875.13	78.13		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Cladocera	7	431.33	61.62	0.75	0.636
Residual	22	1816.17	82.55		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Copepods	8	1278.75	159.84	3.47	0.011
Residual	21	968.75	46.13		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Crustacean_eggs	6	792.91	132.15	2.09	0.094
Residual	23	1454.59	63.24		
Total	29	2247.50			

***** Analysis of variance *****

Variate: SPECIMEN

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
unidentified_zoo	7	432.77	61.82	0.75	0.634
Residual	22	1814.73	82.49		
Total	29	2247.50			