**Research article**

# Human exploitation and conservation of sea snakes in Sabah

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***ABSTRACT***. This study looks into the exploitation of sea snakes in relation to fish harvesting where sea snakes are frequently caught in fishing nets, on the west coast of Sabah. Commercial fishing operations have increased tremendously, with a 36-fold increase of marine fish landing by using trawl nets since 1988 to 1997. This study found that mean number of sea snakes caught per trawl was 23 specimens, and 46 sea snakes per trawler per landing. For the last ten years, a total of 1.3 million sea snakes are estimated to have died. It is remarkable that trawlers killed more than six hundred thousand sea snakes per year recently, yet the sea snakes continued to survive. Compared with the previous study (carried out 10 years ago before this study), the species diversity and abundance of sea snakes on the west coast of Sabah is still high. This might be explained by the presence of suitable habitats, adequate food resources and healthy environment.

## INTRODUCTION

At present, it is difficult to ascertain the impact of human activities on sea snakes due to insufficient existing data. The aquatic and secretive habits of these snakes probably minimize their contact with humans. On the other hand, local abundance of populations, their movements, and the need to breathe air periodically render sea snakes potentially vulnerable to exploitation. There are two areas of concern regarding the conservation of sea snakes from the subfamily Hydrophiinae: one is the direct exploitation of the snakes by killing; the other is the indirect destruction attributable to depletion of the quantity and quality of habitat.

This study looks into the threat to sea snakes from fish harvesting for commercial purposes, as sea snakes are frequently caught in fishing nets used by fishermen on the west coast of Sabah. Commercial operations have increasingly invested in large, efficient trawls and dredges. Although this gear is deployed to catch fish and prawns, it scoops up everything in its path as it plows the ocean floor (Raloff, 1999). Also, the fishermen generally use nets with small mesh size for catching prawns and fish, and sea snakes appear to be attracted to the trapped prawns and fish. The heads of snakes get caught in the mesh and are squeezed, pulled or crushed

*Key words*: by-catch, Borneo, Malaysia, trawling

when the fishermen extract the snakes from the nets. Survival of sea snakes caught by prawn-trawler nets is about 60% (Wassenberg *et al.*, 1994). These trawlers generally haul nets for 2 ½ to 3 hours. The chances that a sea snake would survive depend on when it enters the net, the duration of the trawl, and how it is treated on the deck. Under natural conditions, the sea snakes may remain submerged for up to 213 minutes (Heatwole 1975; Rubinoff *et al.* 1986). In a trawling net, fish are buffeted and tossed around, which result in injuries and death (Maclean, 1972; Juhl & Drummond, 1976; Saila, 1983). Sea snakes are very likely to suffer the same trauma from trawling as fish, suffering stress and lack of oxygen that often result in death.

## MATERIALS AND METHODS

Marine surveys were carried out in coastal seas in Pulau Tiga Park and its adjacent areas off the west coast of Sabah, from Kota Kinabalu in the east to Labuan in the west, within the area demarcated by latitudes 5 ° 36' N to 6° 00' N and longitudes 115° 15' E to 115° 50' E (Fig. 1). The range of depth was between 20 to 50 metres and the distance to the shoreline was between 10 to 50 km. Pulau Tiga Park and its adjacent area is where the fishing boat trawlers normally trawl for fish and prawns.

The samplings were carried out once a month for twelve months from March 1998 to February 1999 by using individual trawler boats. There were two fishing boats used to catch sea snakes, boat numbers 2828/F and 17/F, with trawls measuring 40 m long and 122 m wide each (30 to 60 cm mesh) but reduced to 10% or 12 m wide (8 cm mesh), when pulled. The following trawl pull data were recorded: date, time of start and end of each pull, with the GPS reading (latitude and longitude) at the start and end of each pull, respectively. Each pull took approximately two and a half hours and there was only one pull per day for this study. A colour video sounder was used to obtain depth data at each site of pull.

## RESULTS AND DISCUSSION

There were 12 locations designated randomly for all the pulls throughout the year within the study area and each pull was represented by a letter to indicate the exact location of the pull, with the depth measurements as shown in Figure 2.

A total of 277 specimens representing 11 species of sea snakes (subfamily: Hydrophiinae) were caught in approximately 30 hours of trawling throughout the year with a 12 m net in Pulau Tiga and adjacent area.

These were *Aipysurus eydouxii*, *Hydrophis klossi*, *H. brookii*, *H. caerulescens*, *H. cyanocinctus*, *H. fasciatus*, *H. ornatus*, *Kerilia jerdoni*, *Lapemis curtus*, *H. gracilis*, and *Praescutata viperina*. *P. viperina* is a new record for Sabah. In this study, *Lapemis curtus* was the most abundant species encountered (43.7%), followed by *Aipysurus eydouxii* (17%), *Hydrophis brookii* (14.4%), *H. cyanocinctus* (7.6%), *Kerilia jerdoni* (5.8%), *H. fasciatus* (4.0%), *H. caerulescens* (3.2%), *H. gracilis* (2.2%), *H. ornatus* (1.4%), *H. klossi*, and *Praescutata viperina* (0.3%). The total number of specimens for each species is shown in Figure 3. Simpson's Index (1949) was used for diversity of sea snakes for the entire sample, registering a high diversity index (Ds = 0.74) as compared to UKMS collections (Ds = 0.61; Han, 1988), and maximum diversity was 0.91; evenness was 0.82 and the dominance was quite low (ds = 0.18), as shown in Appendix A.

No samplings were made at night. Most were done in the morning between 0800 to 1200 hrs. Mean number of sea snakes caught per trawl throughout the year was 23 specimens and at

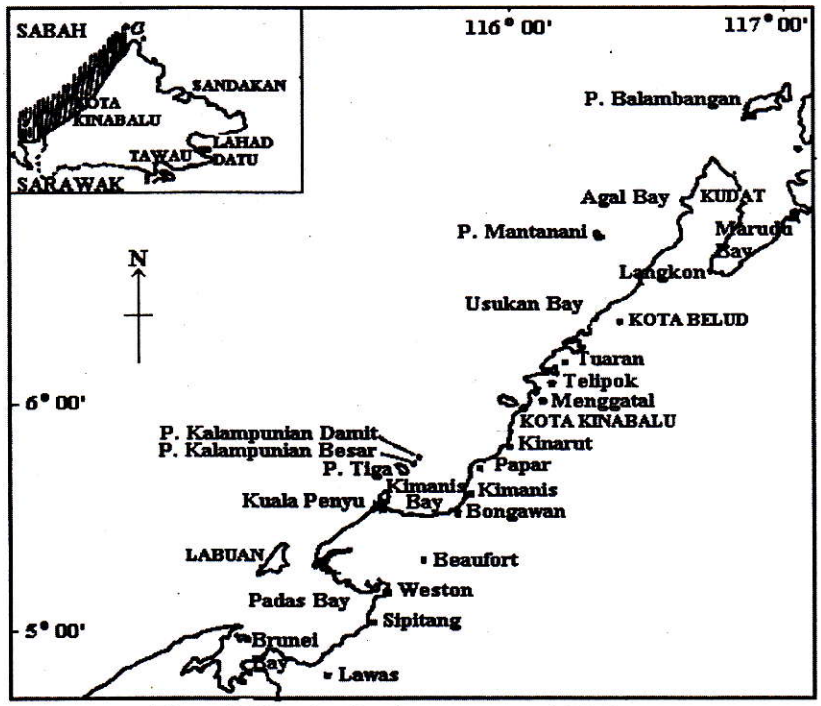


**Figure 1.** Map showing the west coast of Sabah

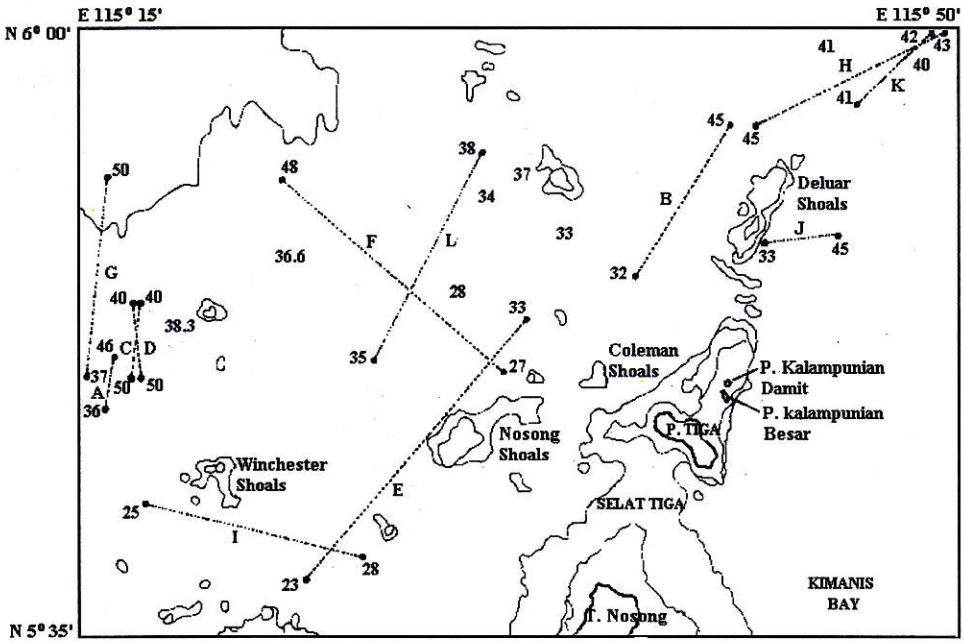


**Figure 2.** Location (A-L) of start and end of each trawl per month with depth (m) in Pulau Tiga area

**Table 1.** Catch rates of sea snakes Per hour in Pulau Tiga area by commercial trawlers during March 1998 - February 1999.

| Date | Net Dimension (m) | Hours of Trawling | Numbers of Sea Snakes | Catch Rate |
|---|---|---|---|---|
| March 1998 | 12.0 | 2.45 (2.75) | 57 | 1.727 |
| April 1998 | 12.0 | 3.30 (3.50) | 14 | 0.333 |
| May 1998 | 12.0 | 2.30 (2.50) | 11 | 0.367 |
| June 1998 | 12.0 | 2.30 (2.50) | 30 | 1.000 |
| July 1998 | 12.0 | 2.52 (2.87) | 4 | 0.116 |
| August 1998 | 12.0 | 2.45 (2.75) | 24 | 0.727 |
| September 1998 | 12.0 | 3.00 (3.00) | 49 | 1.361 |
| October 1998 | 12.0 | 2.50 (2.83) | 8 | 0.236 |
| November 1998 | 12.0 | 2.30 (2.50) | 4 | 0.133 |
| December 1998 | 12.0 | 2.30 (2.50) | 28 | 0.933 |
| January 1999 | 12.0 | 3.40 (3.67) | 12 | 0.272 |
| February 1999 | 12.0 | 2.45 (2.75) | 36 | 1.091 |

Mean=0.691

least twice (two trawls) per trip for commercial fishing, and there were 46 sea snakes per trawler for each time of landing. The number of sea snake specimens and species caught per month is shown in Figure 4. The overall catch rates of sea snakes by commercial trawlers was 0.691 sea snakes per metre of headrope length per hour of trawling (Table 1). Throughout the year, the highest catch rate of sea snakes per hour was in March (1.727), followed by September (1.361), February (1.091), June (1.000), December (0.933), August (0.727), whereas July and November had the lowest catch rates, 0.116 and 0.133, respectively.

In all, 269 of the 277 sea snakes were captured between 33 to 50 metres below sea level, the remaining eight, two juveniles and six adults, in 23-33 m. There was a correlation between the number of sea snakes caught and the depth, with $r = 0.40$. However, in this study, it was found that there was an optimum depth of approximately 45 m below sea level for sea snakes in the Pulau Tiga area and fewer caught in shallower areas (Figs. 5, 6).

Based on the annual fisheries statistics (Department of Fisheries Sabah, 1997), the trawl net comprised 14% of the total of 9,836 fishing vessels by gear group in Sabah in 1997. The production of marine fish landing in 1997 was 174,300 metric ton with wholesale value of RM 569,163,000 which had increased tremendously with about three and a half times compared to 1988 when it was just 46,200 metric ton and RM 183,300,000.

In 1997, the number of fishing gear by trawl nets on the west coast of Sabah was 168 in Kota Kinabalu, 14 in Beaufort, two in Kuala Penyu, two in Kota Belud, five in Sipitang, and none in Papar and Tuaran. The trawlers landing in Sipitang are operating in Brunei Bay

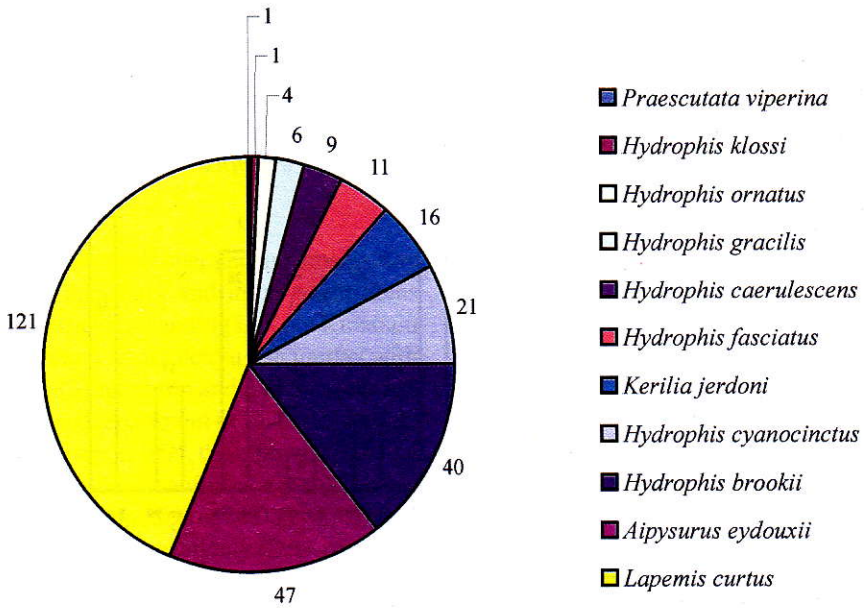


**Fig. 2: Total number of specimens and species of sea snakes caught per month**

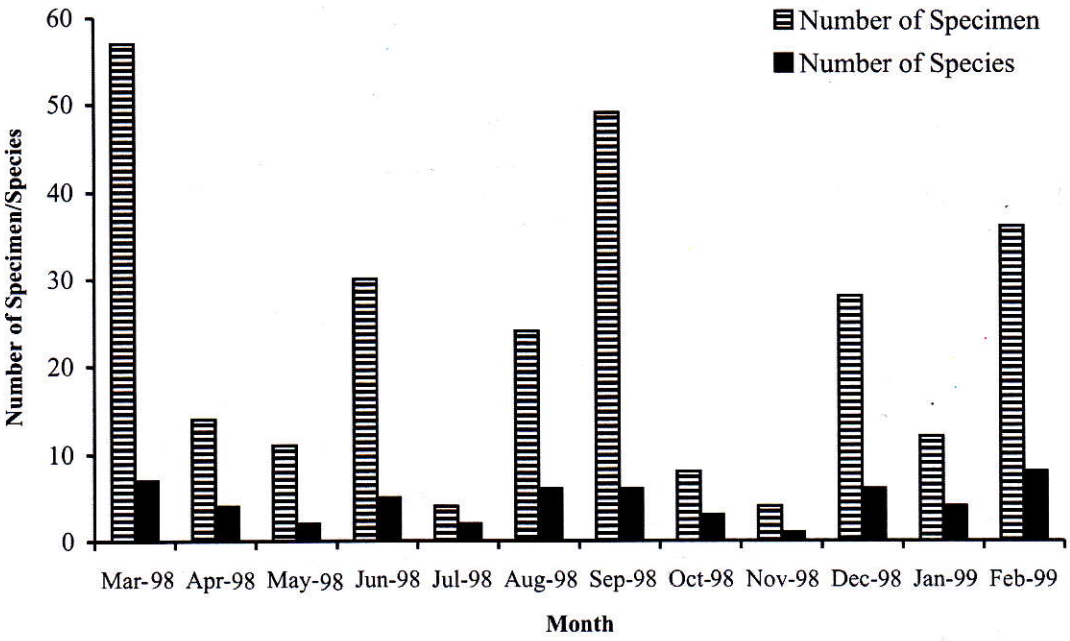


**Figure 4**. Total number of specimens and species of sea snakes caught per month

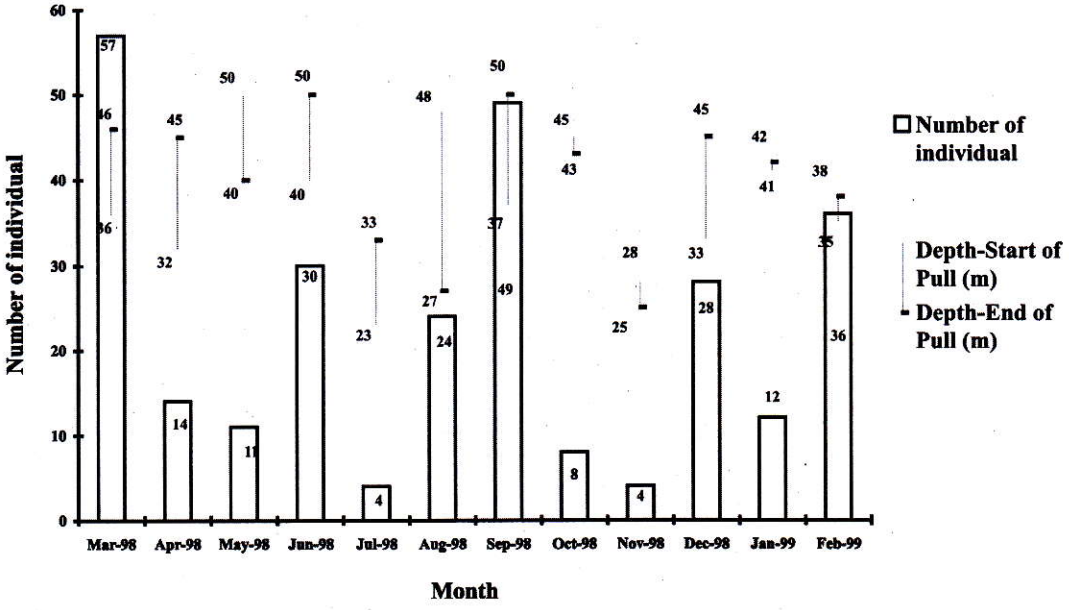


**Figure 5.** Total number of specimens caught per month according to depth

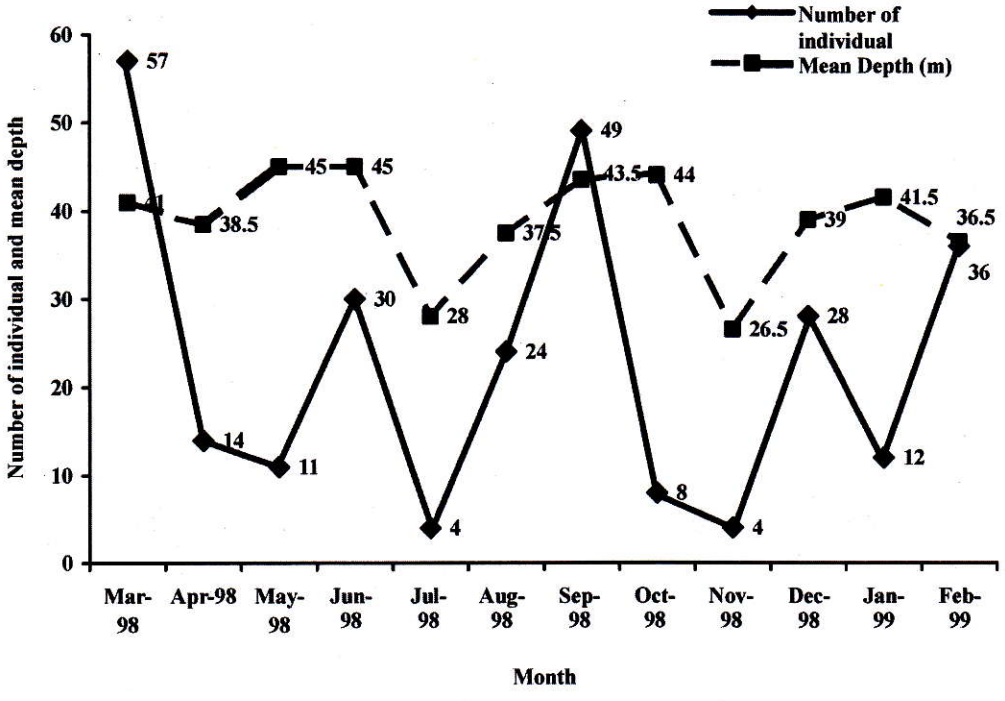


**Figure 6.** Total number of sea snakes versus mean depth

while trawlers landing in Kota Belud normally operate at Usukan Bay. All together the trawlers operate in Kimanis Bay and Pulau Tiga Park and its adjacent areas are from Kota Kinabalu, Beaufort and Kuala Penyu with a total number of 184 trawlers including prawn trawlers.

In 1988, trawlers that operated in Kimanis Bay and Pulau Tiga Park and its adjacent areas were those trawlers landing in Kota Kinabalu fish market and Kuala Penyu fish market with a total of 682 metric ton and 298.9 metric ton respectively (Department of Fisheries Sabah, 1989). However, in 1997, those trawlers landing in Kota Kinabalu, Beaufort and Kuala Penyu had marine fish landings of 36,000, 188.12 and 14.23 metric ton, respectively (Department of Fisheries Sabah, 1997). Within ten years, the marine fish landing had increased more than 52 times in Kota Kinabalu and new landing districts such as Beaufort had been added, but it had decreased sharply in Kuala Penyu. From 1988 to 1997, on the average, there was an increase of more than 36 times of marine fish landing by using trawl nets. Thus, this means a lot of sea snakes were being exploited yearly. It was estimated that about one metric ton of marine fishes was caught per trawler for each time of landing in the market (Chua Aik Tak, pers. comm.), that is 36,202 metric ton of fishes or trawlers landing on the west coast of Sabah in 1997. The survival rate of sea snakes from commercial trawlers was about 60% (Wassenberg *et al.*, 1994). Factors like mesh size and trawlers' capacity, which might influence the catches of sea snakes, should be excluded. Hence, it was estimated that a total of 666,117 sea snakes in Sabah were being exploited in 1997. For the last ten years, the marine fish landing increased exponentially, the total number of sea snakes exploited by trawlers activity also increased tremendously, with a total of about 1.3 million sea snakes estimated to have died (Appendix B).

## CONCLUSION AND RECOMMENDATION

Any trawl hauls of shorter duration should decrease the incidental catch and increase the probability of survival of sea snakes. People in some areas often kill sea snakes that are accidentally encountered, out of fear or ignorance. However, such killings are considered to have little impact on populations.

The impact of commercial trawlers on sea snake populations can be minimized by carrying out the trawl activities at least 50 m depth on the west coast of Sabah. In addition, snakes tend to feed more readily and can capture fish more easily in shallow waters (< 50 m) than in deep sea (Wassenberg *et al.*, 1994).

For instance, the commercial fin-fish-trawling activities in the Gulf of Carpentaria showed that 73% of sea snakes tend to be caught in coastal water less than 30 m deep, and commercial finfish are generally found in deeper waters further offshore (Blaber *et al.*, 1994). Fish trawlers are also encouraged to use larger mesh (100 mm) in the codend than do prawn trawlers (50 mm), to allow sea snakes to escape.

It is remarkable that trawlers killed tens of thousands and even more than six hundred thousands of sea snakes per year recently, and yet the snakes somehow still survive in spite of the fact that the trawlers operating on the west coast of Sabah have increased tremendously over the years, and rates of even more efficient trawling have increased. Since the previous study of Han *et al.* (1991) was carried out ten years ago as compared to this study, the species diversity (11 species, Ds=0.74) and abundance of sea snakes was still high. This might be caused by suitable habitats, adequate food resources and a healthy environment. Anyhow, a positive finding would automatically trigger at least

some awareness in conservation – a move that could bring some baseline information on these ignored marine reptiles which can offer a little protection in the future. Sea snakes are therefore both an indicator of the marine environment and a potentially key player in the marine food chain. Thus, they must be included and considered as important as marine fishes while promoting sustainable management of Sabah's marine resources.

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**APPENDIX A.** Species Diversity : Simpson Index

Diversity Index,
$Ds = 1 \ \sum ni\ (ni - 1)/ N\ (N - 1)$ *or* $Ds = 1 - `1$

Maximum Diversity, where, $ni$= number of individual for a species
$Dmax = (S - 1)/ S \ X \ N /( N - 1)$ $N$ = total number of individual

Uniform, $Es = Ds/ Dmax$

Dominance, $ds = 1 - Es$

**Diversity Index:**
$Ds = 1 - [\,121\,(120)/277\,(276) + 47\,(46)/277\,(276) + 40\,(39)/277\,(276) + 21(20)/277(276) + 16\,(15)/277\,(276) + 11\,(10)/277\,(276) + 9\,(8)/277\,(276) + 6\,(5)/277\,(276) + 4\,(3)/277\,(276) + 1(0)/277(276) + 1(0)/277\,(276)]$

$Ds = 1 - 0.2501$
$= \mathbf{0.7499}$

**Maximum Diversity:**
$Dmax = (S - 1)/S \ X \ N/ (N - 1)$
$= (11 - 1)/11 \times 277 / (277 - 1)$
$= \mathbf{0.9124}$

**Uniform:**
$Es = Dx /Dmax$
$= 0.7499 / 0.9124$
$= \mathbf{0.8219}$

**Dominance:**
$ds = 1 - Es$
$= 1 - 0.8219$
$= \mathbf{0.1781}$

**Appendix B**: Fisheries statistic: data of fishes and sea snakes caught in the west coast of Sabah over 10 years.

| Year | Quantity of fishes caught by trawlers (metric ton) |
|---|---|
| 1988 | 682 + 299 = 981 |
| 1997 | 36,000 + 188 + 14 = 36,202 |

Calculation was based on assumption of geometric progression

$Sn = a\,(r^{9} - 1)/(r - 1)$ — $Sn$= total number of fishes caught over 10 years period; $r$= common ratio; Let 1988 be the base year, first number $a$= 981,

$ar^9 = 36{,}202$
$ar^9/a = 36{,}202/981$
$r^9 = 36{,}903$
$9 \lg r = \lg 36.903$
$\lg r = 1.567064/9$
$\lg r = 0.174111$
$r = 1.493$

$Sn = 981\,(1.493^{9} - 1)/(1.493 - 1)$
$= 71435.9$ metric ton

According to research, 46 sea snakes caught in 1 metric ton of fishes
Thus, 71435.9 metric ton x 46 sea snakes = 3,286,051.4 sea snakes caught
Survival rate =60%, died=40%
3,286,051.4 x 40% = 1,314,420.5 sea snakes died over 10 years
~1.3 millions of sea snakes died over 10 years.