

The relationship between pelagic fish catch rates and oxycline depth in Kigoma Bay, Lake Tanganyika

Student: Peter Nestory

Mentors: Ismael Kimirei & Catherine O'Reilly

Introduction

Fish are a source of animal protein in Tanzania where the availability of other sources of animal protein is scarce, particularly in the Kigoma area where the rate of population increase/growth (ca 4.8% per year) is alarming, resulting in an increased demand for this source of protein. Fish provide the cheapest source of animal protein in this area. Although, there are no direct estimates for animal protein need, the importance of fish, especially 'dagaa' (*Stolothrissa tanganyicae*), 'lumbu' (*Limnothrissa miodon*), and 'migebuga' (*Lates stappersii*) in the daily diet of people in the Kigoma area is undoubtedly high (Kimirei, 2005). The Lake Tanganyika pelagic fishery, for example, provides between 25 to 40% of animal protein to the riparian countries namely, Tanzania, Zambia, Burundi and The Democratic Republic of Congo (Molsa *et al.*, 1999)

Fishing for dagaa in Lake Tanganyika is done at night using catamarans and by the aid of light using pressure lamps. There have been developments in the size of the lift-net units used today. The boats are separated by poles that range between 10 to 25 meters and nets are lowered to about 100 m deep about twice as much as they have been previously (50 m). The setting of the nets does not take into consideration the depth of concentration of the target species and sometimes large amounts of effort are put in to bringing in very few or sometimes no fish at all. Some factors that govern spatial-temporal distribution of the pelagic ichthyomass have been explored; however, more knowledge is required in this line that can be used to guide fishers to improve efficiency in their hunting and probably lead to increased fish catches. These factors range from moon phase effect, weather changes, productivity of the waters, limnological characteristics and changes, and predator-prey interrelationships.

The effect of moon phase on the catch rates have been studied in the D.R. Congo by Japanese researchers (Mukirania, 1988). Little has been done in the Tanzanian sector. Vertical movements of fishes in relation to the diel vertical migration of zooplankton have received considerable attention; however, much remains to be explored. Limnological changes that are governed by wind-induced hydrodynamics have received some attention by the LTR project (Plisnier, 1997) and Kimirei (2005). The variability of depth occupied by the pelagic fishes during the night, save for echo-sounding studies, in relation to environmental conditions (DO, conductivity, pH, temperature) have also been attempted (Chapman, 1976; Coulter, 1991) however, little is known about the Tanzanian sector of the lake. This has been attempted for demersal fishes in Southern Lake Tanganyika (Eccles, 1974) and in Lake Victoria (Wanink *et al.*, 2001; Kaufman, 1992; Hecky, 1993)

The project was designed to use pre-marked ropes to lower a lift net to study catch rates in relation to oxycline depth and to see if there is a significant effect of this depth on catch rates fluctuations during a fishing season. This was and is still important because if we know the area of concentration of our targeted species and send the net to that particular area/depth, we save the energy that would otherwise be used to pull the net from far below the depth; and it may help fishers to haul the net several times, rather than the present mean of 2 hauls per fishing night, thereby increasing their chances of catching more.

Study Area

This study was conducted in Lake Tanganyika, particularly in the Kigoma Bay. Fishing sites were recorded using a GPS (Fig. 1).

Objective

To determine the relationship between oxycline depth and pelagic fish catches.

Hypothesis

There is a significant relationship between the oxycline depth and pelagic fish catches.

Materials & Methods

Limnological parameters

The following parameters were measured during night fishing visits on the lake using manual probes and a water sampler: dissolved oxygen, temperature, conductivity and pH. Two zooplankton samples were collected per fishing trip, at the oxycline and surface, using a 100 µm zooplankton net and preserved in 10% formalin. Zooplankton abundance at those particular depths were studied and related to catch rates.

Fish sampling and Fisherman questionnaire

The fish data were collected during five night fishing trips, on 17th, 19th, 29th, 31st of July and 3rd of August 2005. Two fishing canoes, with three fishermen in each, went to a site of their choice in Kigoma Bay. After arriving at the fishing site (at around 20.00 to 21.00 hours), the fishermen lighted and secured their pressure lamps above the water to begin attracting fish. At around 23.00 hours, the canoes were joined with long poles forming a two-canoe catamaran. After that, pre-marked ropes were used to lower the lift net to desired depth after determining the oxycline depth. After a considerable time had passed, the net was hauled up and the haul's total catch recorded. Usually two hauls were done per night, collected fish samples were sorted and identified to species level using FAO identification guide by Eccles (1992). Total catch was determined by multiplying the number of boxes filled with fish by 60, because standard boxes weigh about 60 kg (= weight of fish in the box).

Individual length and weight were measured for the different fish species. They were also sexed and maturity stages determined. Stomach contents were analyzed on a qualitative basis.

Total catches from other fishing units fishing nearby were recorded so as to make comparison between the test fishing and normal fishing practices comparable. Lift-net fishermen were interviewed by means of a questionnaire. Two landing beaches, Kigodeko and Kibirizi, were visited. I interviewed fishermen on their total catch, fishing site, depth of fishing, number of hauls and factors hindering their normal fishing activities.

Results

(a) From fishermen questionnaires

A total of 7 fishermen were interviewed. The majority of them fished near our fishing sites, hence it was easy to make comparisons between our catch data in the test fishing and fishermen's data in the normal fishing practices (Table 1). In the first two sampling days (17th and 19th July), there were low catches for both fishing practices. This might have been caused by wind effect and currents. In the last three sampling days (29th, 31st of July and 3rd of August) test fishing had good catches compared to normal fishing.

(b) From test fishing

There was a remarkable change in fish catch composition over a three-week sampling period (Table 1). Length frequency distributions of the dominant fish species sampled in different areas and dates are illustrated in Figures 2-4. These species includes *Stolothrissa tanganicae*, *Limnothrissa miodon* and *Lates stappersii*. Over 80% of the fish species caught during the study period were *S. tanganicae*. 99% of all *S. tanganicae* caught on 17th July were greater than 70 mm. The proportion of individuals < 70 mm increased progressively over the sampling period, except on 3rd August where most of the *S. tanganicae* caught were larger than 70 mm (Fig. 2). The second most important species was *Lates stappersii* and was mostly caught on 29th and 31st July. Size distribution of *L. stappersii* presented in Figure 3 indicates the dominance of juveniles. *Limnothrissa* was the least abundant species caught and was completely absent during the first three fishing nights. All of *L. miodon* caught were mature (Fig. 4).

Limnological Parameters

(a) Zooplankton abundance

With regard to the zooplankton abundance, there was a greater zooplankton abundance in the sample collected from the surface waters as compared to the samples collected at the oxycline (Table 2). Cyclopoid copepods were the most abundant zooplankton, then calanoids.

(b) Physical parameters

Generally, water temperatures decreased with depth. The minimum surface (0 m) water temperature was 25.6 °C on 31st July and the maximum was 26.1 °C on 17th July, 2005. The minimum bottom (100 m) temperature was 24.2 °C on 17th, 29th and 31st July, while maximum temperature (24.3 °C) was recorded on 19th July and 3rd August. The thermocline depth fluctuated between 55 m and 70 m (Fig. 1a). The highest surface dissolved oxygen concentration (7.1 mg/l) was recorded on 3rd August while the lowest (6.67 mg/l) was recorded on 17th July and dropped to 0.11 mg/l at 100 m on 29th July, 2005. The oxycline was between 55 m and 70 m (Fig. 1b) over the sampling period. Conductivity ranged between 670 µS/cm at the surface (0 m) to 701 µS/cm at 100 m (Fig. 1c) over the sampling period. Deep water movement towards the surface was observed on 31st July as exemplified by conductivity, temperature and dissolved oxygen depth-time graphs (Fig. 6). The study showed that pH decreased with depth. Surface pH was 6.85 and 8.52 at 100 m. However, on the last sampling day (3rd August) an inverted pH profile, with the minimum value (6.86) at the surface and the maximum (8.21) at 100 m, was observed (Fig. 1d).

Discussion

Tropodiptomus is thought to be the most important food item in the diet of adult *Stolothrissa tanganicae* (Coulter, 1991). This is in line with the relative abundances of these copepods in the surface waters than at the oxycline depth; the data therefore strongly indicate diel vertical migration of zooplankton. That is why schools of *Stolothrissa tanganicae* were seen near the surface of the water chasing zooplankton that aggregate around light. The great abundance of cyclopoids as compared to calanoids could be explained by their size differences. Cyclopoids are smaller while calanoids are comparatively larger, so they are easily seen by predators, *S. tanganicae*, which feed on them selectively because of their large size.

Although our data set is small, to the extent that no solid conclusion can be reached, it supports the observation by Chapman *et al.* (1974) that pelagic fishes in Lake Tanganyika rarely go into waters containing less than 3mg/l of dissolved oxygen. Also the pelagic catch in the lake is affected by the phase of the moon, because during our first three sampling days, during the last quarter of the moon age, the catch was very low. This was not only for our fishing unit, but also for the rest of the units that were still fishing during those dates. This is because light fishing is ineffective during moon-lit days (Mukirania, 1988; Kimirei, 2005). The relationship between catch and oxycline showed a negative correlation in this survey because there was a lack of sufficient replicate data (Fig.5). The high abundance of juvenile *Stolothrissa tanganicae* is indicative of recruitment of this species to the pelagic fishery, which is thought to be during the dry season (July – September) in the Kigoma area (Kimirei, 2005).

The majority of fishermen interviewed preferred to fish below 100 m depth. This is, according to them (fishermen), because the net is maximally opened at about 30 m during hauling so if they put the net very close to the school of fish they are likely to miss the fish as the net might open at a depth where they are not concentrated.

The solubility of oxygen in water decreases as temperature increases (O'Reilly lecture notes – Nyanza 2005). The waters had relatively more dissolved oxygen during the last three sampling days. This agrees well with decreased surface water temperatures as compared to that of 17th July. The change in temperatures on these dates as indicated by upward movements of deeper waters, suggesting mixing, probably by internal waves (Figure 6).

Conductivity of the water increased with depth except for the two first sampling dates, when the surface waters was more conductive than at 100 m. This is indicated by an inverted depth profile for this parameter.

The reason for this could be two fold: (1) it could have resulted from deep mixing of the water column (0-100 m) causing deep water to come to the surface and vice versa for the surface waters. However this is unlikely because the temperatures on these dates were higher than the proceeding dates; (2) could have been a result of bad readings from the probe. This is the most likely explanation because when we used another probe for the rest of the sampling period, the data were reasonably in the expected ranges; unless the observation is phenomenal.

On the other hand, the pH of the water apart from showing a normal trend, the readings for the last sampling date was inverted meaning that there was higher pH at 100 m and lower at the surface. This is attributed to instrument error because the probe was not calibrated on that day.

Conclusion

This project has provided an insight into the pelagic fish catch-oxycline depth interactions of Lake Tanganyika. More repeated sampling using the same protocol is needed to clearly identify the above relationships, because being able to know the area of concentration of our targeted species and send the net to that depth will save energy that would otherwise be used to pull the net from far below the depth. It will help fishers to haul the net several times, rather than the present mean of 2 hauls per fishing night, thereby increasing their chances of catching more. Also, some more local knowledge on the subject matter will shape the understanding of the subject.

Future Work

This study lacked sufficient replicate data. This problem was due to limited time allocated for the survey. Enough time could have provided room for adequate coverage and thus the collection of representative samples from night fishing. It is therefore recommended that subsequent survey should last at a minimum of 30 to 35 days as opposed to 5 days allocated to the current survey.

Acknowledgements

I would like to show my appreciation to my mentors, Dr. Catherine O'Reilly and Ismael Kimirei. I would like to thank the Nyanza Project, TAFIRI and CLIMFISH Project for giving me the opportunity to explore my interest. The fishermen who we went out with are hereby greatly acknowledged for their expertise and lastly Kiram Lezzar for head counting during the field trips here in Kigoma. This project was supported by CLIMFISH.

References

- Chapman, D.W., 1976. Acoustic estimates of pelagic ichthymass in Lake Tanganyika with an inexpensive echo sounder. *Transactions of the American Fisheries Society* 105:581-587.
- Chapman, D. W., Bayona, J. D. R., Ellis, C., 1974. Preliminary analysis of test fishing and limnological sampling in Tanzanian waters of Lake Tanganyika. UNDP/FAO Project FI: DP/URT/71/012, *Working Paper* No. 12. 40 pp.
- Coenen, E.J., 1994. Historical data report on fisheries, fisheries statistics, fishing gears and water quality of Lake Tanganyika (Tanzania) 30pp.
- Coulter, G. W. (Ed.), 1991. Lake Tanganyika and its life. Natural History Publications, Oxford University Press, London. 354 pp.
- Eccles, D. H., 1974. An outline of the physical limnology of Lake Malawi (Lake Nyasa). *Limnology and Oceanography*, 19: 730-742.
- Eccles, D.H., 1992. Field guide to the Freshwater Fishes of Tanzania. FAO, Rome. 145pp
- Kimirei, I., 2005. Variability in pelagic fish catches and physico-chemical parameters in Kigoma Bay, Lake Tanganyika, Tanzania. M.Sc. Thesis, University of Dar es Salaam, Tanzania. 176pp
- Mukirania, M. -S., 1988. The effect of moon-age, time of catch and number of lamps on the amount of catch in a lamp fishing fleet. *In: Kawanabe, H and Kwetuenda, M.K (Eds.), Ecological and limnological study on Lake Tanganyika and its adjacent Regions.* University, Kyoto, Japan. V, 48-49.
- Plisnier P-D. 1997. Climate, limnology and fisheries changes of Lake Tanganyika. FAO/FINIDA Research for the Management of Fisheries on Lake Tanganyika GCP/RAF/271/FIN-TD/72(En): 50pp
- Molsa H, Reynolds J.E, and Lindqvist O.V. 1999. Fisheries Research Towards Resource Management of Lake Tanganyika, *Hydrobiologia* 407: 1-24

Table.1 Test fishing catch vs. normal fishing catch

Date	Test fishing		Normal fishing	
	Catch (kg)	Oxycline	Catch (Kg)	Fishing depth
17-7-2005	8	70	5	100
19-7-2005	3.5	65	5	150
29-7-205	80	65	15	100
31-7-2005	83	55	30	100
03-7-2005	165	65	60	<100
			120	<100

Table 2. Zooplankton abundance

Date	Surface		Oxycline	
	<i>Cyclopoid</i>	<i>Calanoid</i>	<i>Cyclopoid</i>	<i>Calanoid</i>
17-07-2005	325	105	75	32
19-07-2005	407	222	32	18
29-07-2005	348	169	58	28
31-07-2005	625	216	60	11
03-08-2005	394	80	28	4

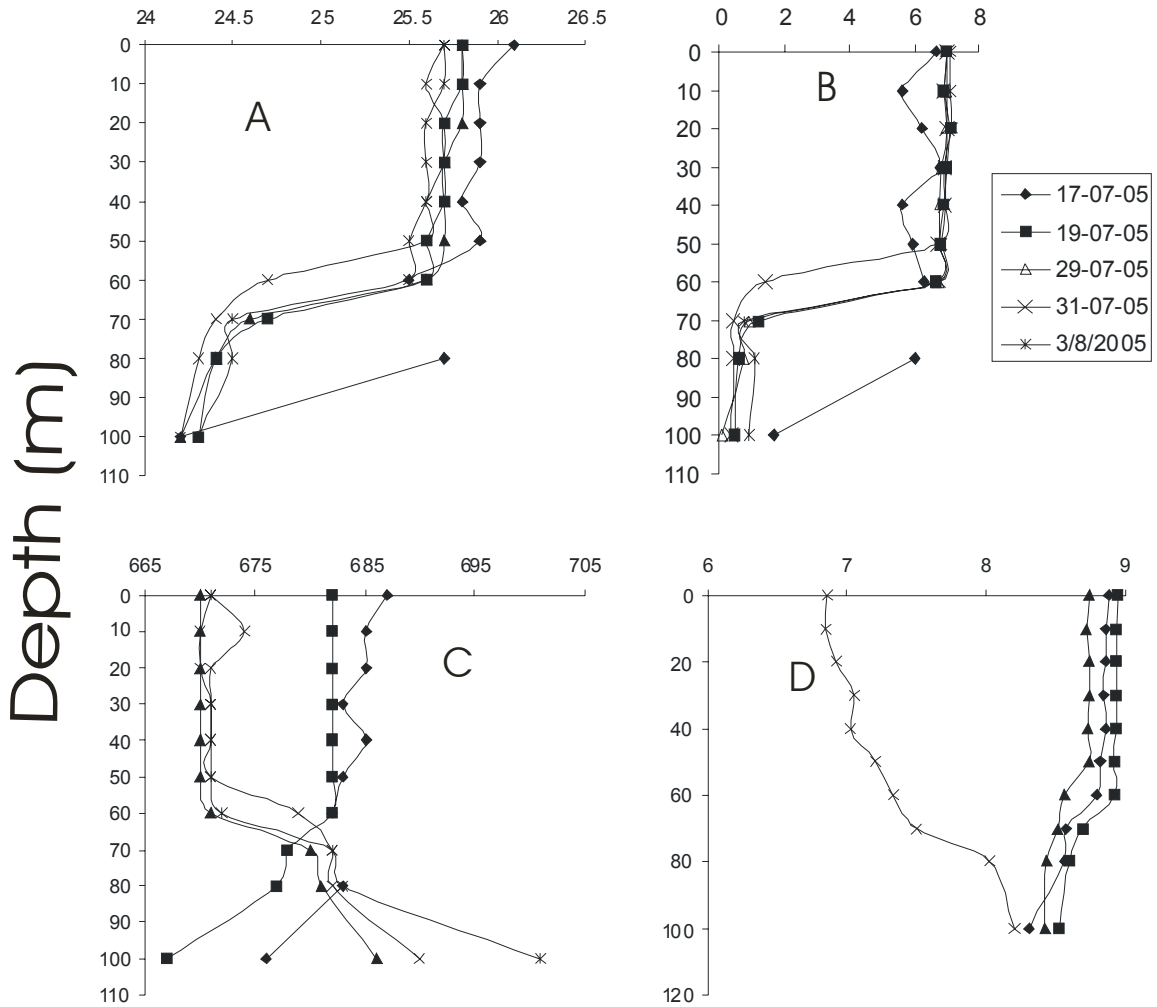


Fig.2 Depth profiles for A: temperature, B: dissolved oxygen, C: conductivity and D: pH

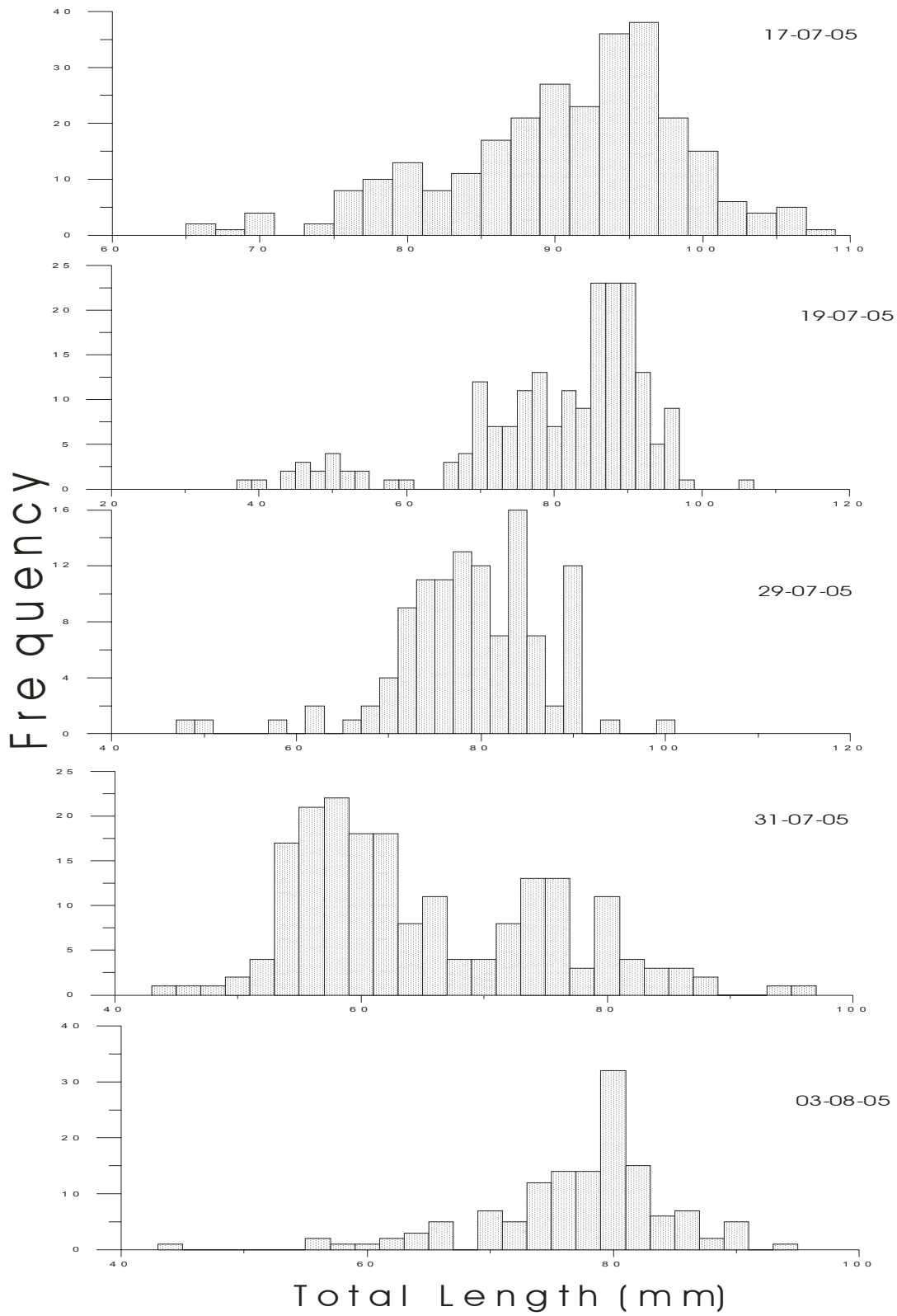


Fig.3 Population structure of *Stolothrissa tanganyica* collected in Kigoma Bay by Lift-net during July/August 2005.

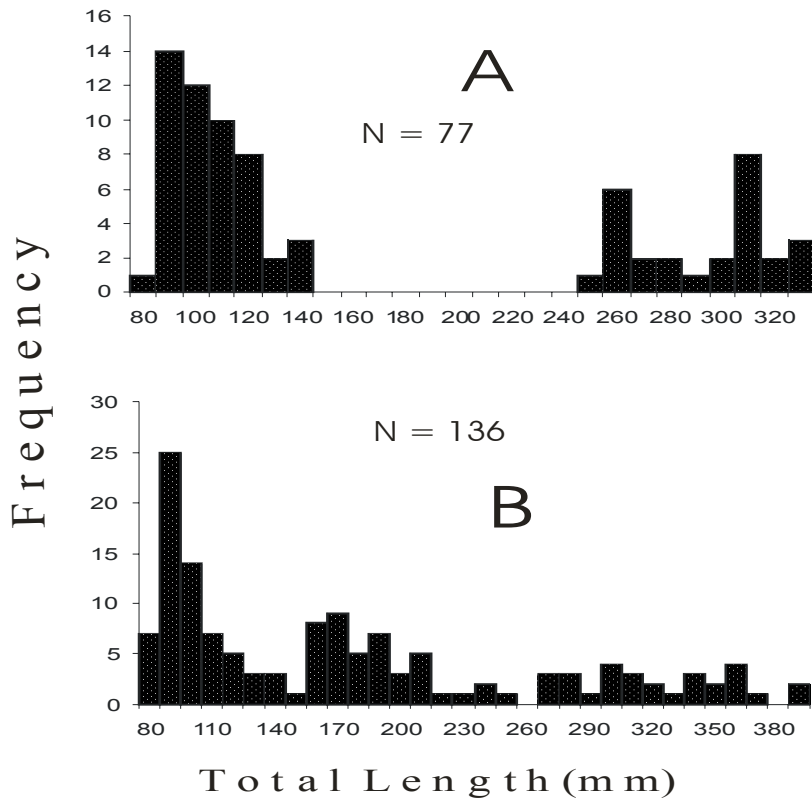


Fig.4 Population structure for *Lates stappersii* sampled on 29th (A) and 31st (B) July

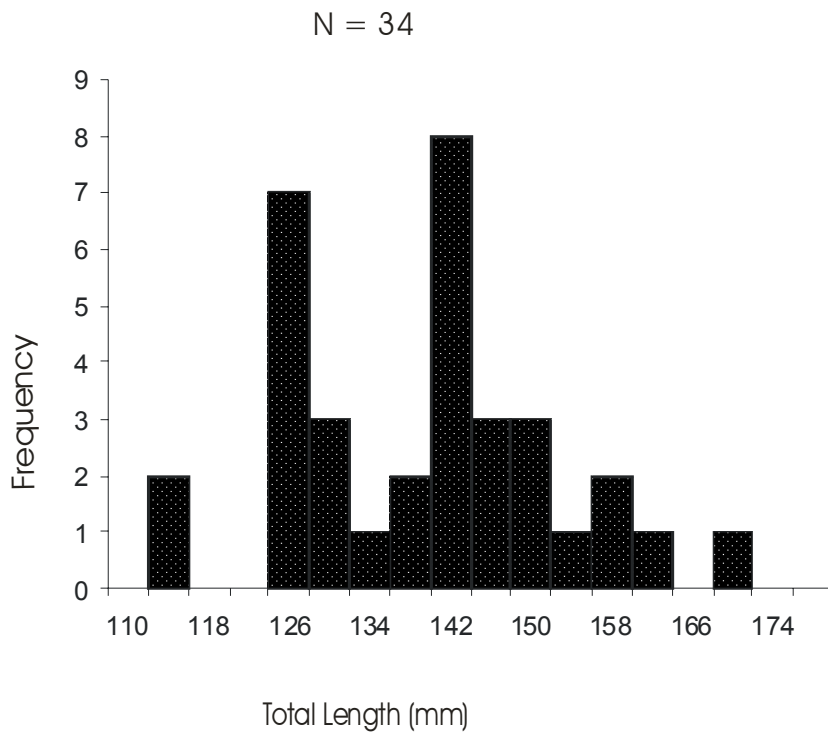


Fig.5 Population structure of *Limnothrissa miodon* sampled on 31st July

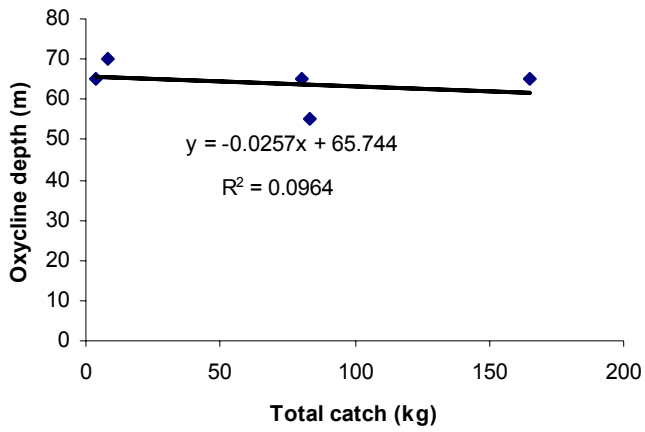


Fig.6 Oxycline depth vs. Pelagic catch

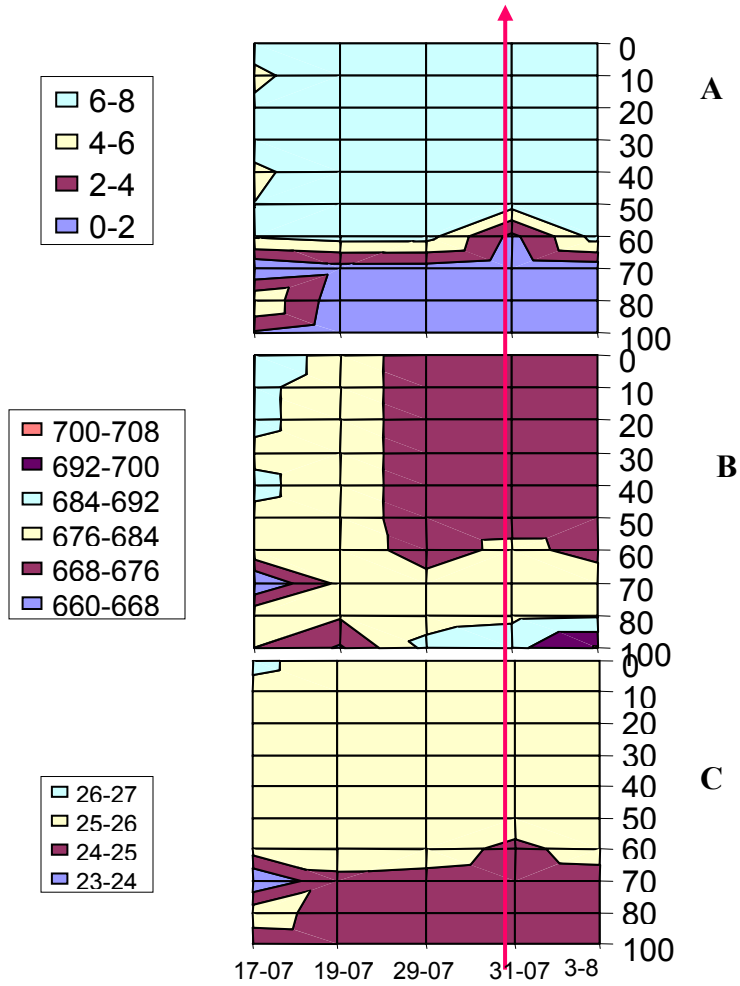


Fig. 7 Depth-time diagram for DO (A), conductivity (B) and temperature (C). Arrow indicates time of upwelling.