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REPORT ON A MARINE BIOLOGICAL SURVEY OF
ST. LUCIA ESTUARY, ST. LUCIA LAKE
AND THE UMFOLOSI RIVER, ZULULAND.

I left Cape Town by train at 6.45 p.m. on June 28th, 1940, and arrived in Durban at 4 p.m. on June 30th. I entrained at Durban at 11 p.m. on the same day and arrived at Mtubatuba at 9.30 A.M. on July 1st. Thence I proceeded to St. Lucia Estuary by motor lorry, arriving there at 1 p.m. the same day.

At Mtubatuba I was met by Captain H. B. Potter, Game Warden of the Zululand Game Reserves and Parks Board. Mr. N. van Rooyen, Warden of the Lake Area and Mr. T. Sharp, Health Officer, met me on arrival at St. Lucia Estuary Hotel.

The afternoon of July 1st was spent in discussing local matters with Mr. van Rooyen, from whose vast and intimate knowledge of the whole area I intended examining, I obtained much useful information.

On July 2nd Mr. van Rooyen conducted me by motor boat to the Lake, the Estuary and also some distance along the courses of the Umfolosi and Umsunduzi Rivers so as to permit of my obtaining a general impression of the terrain at various stages of the tide.

The subsequent days up to the time of my departure on the 10th July were spent in detailed examination of specialised areas, the collection of plankton by means of a plankton net which I had taken with me, and the taking of samples of the bottom deposits and water.

Owing to the limited time at my disposal it was not possible to carry out comprehensive surveys of the various areas, as such work would entail many months spent on the collection of samples of fish, plankton, water, bottom of the lake, estuary and rivers, to ascertain seasonal fluctuations and variations. But during the 9 days I was able to give to this preliminary survey, I was able to concentrate my work to such an extent that I could form a good opinion of the conditions governing

the presence of fish life in the various areas I examined and surveyed.

Various questions were enumerated in the Secretary's letter to me dated the 24th June, 1940, and I wish firstly to deal with these seriatim.

1. SHOULD RESERVES BE ESTABLISHED FOR THE BREEDING OF SHRIMPS AND PRAWNS?

Through the kindness of Mr. Sharp, numerous specimens of shrimps and prawns were procured for me, and I was able to examine them on the spot. From an interest point of view it should be noted that shrimps and prawns, although resembling each other, are somewhat different biologically in minute details and there are various species. Prawns are usually larger than shrimps. Prawns usually go up rivers and estuaries into fresh water, while one family lives exclusively in fresh water and inland lakes.

One of the specimens of shrimps was a female in berry so that it may be taken that shrimps actually breed in the upper reaches of the Estuary at St. Lucia.

Both shrimps and prawns seemed to be fairly plentiful at the time of my visit.

At present there is a closed area or reserve for the protection of these crustacea, extending southwards from the Pont to the mouth of the Estuary.

I consider this reserve sufficient at present and do not advocate the establishment of further reserves. From an examination of the effects of the present restrictions in the established reserve it may be possible, after it has been left undisturbed for say three years, to gauge the results of such a closed area.

Under no circumstances should licences be granted for the commercial utilization of shrimps and prawns as this would inevitably lead to over-exploitation with the concomitant complete eradication of these crustaceans.

2. SHOULD FISH RESERVES BE ESTABLISHED?

The establishment of fish reserves is a factor which in many cases tends to increase the supply of fish since such reserves or sanctuaries provide areas where fish may reproduce and grow to maturity undisturbed. But the establishment of such reserves would obviously include close seasons and as, from what I could glean, St. Lucia affords a perennial attraction for anglers, the proclamation of close seasons and reserves would debar anglers from their sport and would tend to detract from the attractiveness of the area. During my visit there fish seemed to be quite plentiful and veritable tyros who had never fished before were being amply rewarded for their labours by good sport. As a matter of fact the fishing results appeared to be so good at this particular time that there appeared to be nothing wrong with St. Lucia as far as angling was concerned! However, there are seasonal variations and fluctuations of supply to be considered, which make it necessary to examine the causes which may be contributory factors in these variations and depreciations in the fishing.

Another factor which militates against reserves is the difficulty of controlling and patrolling these areas. In a commercial fishery obviously steps should be taken to conserve a natural resource by combating overfishing, but where only angling is indulged in, the catches do not amount to proportions approximating overfishing, and, provided the suggestions contained in paragraph 3 hereunder are rigorously enforced, there need be no fear that the areas in question would be denuded.

I therefore think that fish reserves are not necessary and should not be established.

3. IS IT DESIRABLE TO LIMIT CATCHES OF FISH DURING CERTAIN SEASONS?

Where a non-commercial fishery is being examined the reasons for conservation are just as forceful as those apper-

taining to a commercial fishery. Overfishing does not enter into angling to such a great extent but sometimes one is faced with the apparent needless greed for recording big catches. Any sportsman worthy of the name should be satisfied with a sufficiency of fish taken per day, but as such a sufficiency obviously is a variable quantity owing to human nature, it becomes necessary to lay down "bag limits" per boat per day.

In most countries where fish are protected for anglers a bag limit is imposed and rigorously enforced. In the United States of America and in the Union of South Africa, fresh water fish like Black Bass are protected by bag limits and size limits and I consider that both these impositions should be enforced. I therefore recommend that a total number of only twelve fish per boat per day be permitted.

A corollary to this is the question of adequate size limits. The biological concept of the successful conservation of any species of fish is to permit of such a species reproducing itself at least once, so that the continuance of the species may to a certain extent be assured.

It is universally recognised that the best means of securing a continuity of supply is to prevent the capture of fish below a certain size. This method is preferable to any other since there would be no object in catching fish below the legal limit and there would be little or no interference with the implements of fishing, provided the latter were not unduly destructive.

It has become necessary to think of our natural resources in terms of generations. To the layman the term "conservation" is often something of a misnomer implying a mere hoarding of natural wealth, whereas all who examine the matter properly are aware that this is not the true object at all. The real purpose of intelligent conservation is simply to guard against "wilful waste" so that future generations need not be handicapped by "woeful want." At the same time, while we are aiming

to prevent the depletion of the present resources, it follows logically that these resources must not be permitted to lie in a state of unproductive idleness. Modern industry says that "he is idle who is not best employed", and it is equally true that if raw materials required for present want are not utilized to the best advantage they are wasted. The real problem of conservation then, is plainly a problem of efficient development and wise utilization.

While most of the foregoing may be said to appertain to industrial fishing, nevertheless the basic concept fits a problem such as is afforded by the case of St. Lucia and for this reason drastic steps should be taken to enforce the size limits and methods of fishing enumerated subsequently.

The present size limits enforced in terms of the Natal Fisheries Ordinance No. 11 of 1916 are, to my mind, inadequate, and I am given to understand by the Principal Fisheries Officer that the minimum size limits are shortly to be increased.

Section 14(1)(h) of the Zululand Game Reserve and Parks Ordinance No. 6 of 1939 gives powers to protect fish and I recommend that the following size limits be proclaimed to supersede those at present in operation. In all cases sizes are to mean the overall length of the species enumerated.

<u>Mullet</u>	minimum size	10 inches.
<u>Shad</u>	" "	12 "
<u>Grunter</u>	" "	14 "
<u>Salmon</u>	" "	16 "
<u>Rockcod</u>	" "	14 "
<u>Bream</u>	" "	12 "
<u>Kingfish</u>	" "	14 "

Closely related to the question of conservation by the imposition of size limits is the use of barbless hooks which permit of the return to the water of small fish with a minimum of injury and I recommend that the use of barbless hooks be enforced for the catching of all fish other than the species of sharks or for rockfishing outside the Estuary or the Lake and False Bay.

4. IS IT NECESSARY TO REGULATE THE USE OF OUTBOARD MOTORS ON ACCOUNT OF THE NOISE?

This is a question that has exercised the attention of experts the world over whenever causes for the fluctuations or falling off of fish intensity are sought.

Fishes' reactions to noise are in the nature of conditioned responses and since the exhausts of the outboard motors or any boat's motors are above the surface of the water, and there is no penetration of noise through the water from sources above the surface, such noises do not affect fish in any degree whatsoever. This assertion is borne out by experiments conducted especially to ascertain the pros and cons of the oft-repeated views held that noise could have a disturbing effect on fish movements. Recently various experiments have been conducted where fish were kept in a submerged cage and a noisy motor boat was started at a distance and run close to them. Most of the fish showed no sign of being disturbed until the wash of the boat struck the cage, when the fish would dive.

It is not necessary here to elaborate further on other experiments of a similar nature, but all the researches do not give weight to the idea that noise is a very powerful contributing factor in driving fish away from their usual abodes. Fish become accustomed to noises and their reactions are in the nature of conditioned responses.

In view of these observations it can be concluded that noises from motor engines may be discounted as contributory factors in the disturbance of fish and the question need not be considered any further.

5. IS THE SILT WHICH HAS BEEN DEPOSITED IN THE WESTERN CHANNEL HARMFUL TO FISH LIFE AND IF SO TO WHAT EXTENT?

The attached photograph showing the Umfolosi River, the Western Channel, a portion of the St. Lucia Estuary and its entrance to the sea should give a good idea of the various

aspects of this area to the uninitiated.

During various tow-netting experiments it was obvious that the Estuary from its mouth to some distance above the Pont was very badly silted, this silt being composed of dark brown mud lying in various depths on the bottom of the Estuary.

It is obvious that the mud has been brought into the Estuary from time to time by the Umfolosi River, which makes its way not only through its own channel but also through the Western Channel into the Estuary.

As this channel enters the Estuary some distance from the sea, it is obvious that the major portion of the mud has been conveyed through this channel at various stages of the tide. I have studied with interest the Durban Harbour Engineer's Report of the 17th December, 1938, dealing with the question of soundings at various places in the lake and Estuary. I also discussed the question of silting with various people at St. Lucia who have known the region for many years and who are emphatic in their statements that the Estuary is gradually becoming shallower and shallower.

An examination of the mud procured by me proved that it was completely devoid of any form of animal life, and the analysis of Mr. Kloot of Durban, dated 11th June, 1940, states that the mud would be innocuous to fish.

I am of the opinion, however, that the constant deposition of mud and silt in the Estuary and other areas has a distinct tendency towards covering up the natural feeding grounds of bottom-feeding fish and would also affect to a certain extent the natural habitat of shrimps and prawns. From this it may be inferred that a continuation of such deposits would in time have a very deleterious effect on fish life in general, and ways and means should be sought to combat or at least decrease such deposits.

Closely related to this problem is the question of the amount of fresh water which makes its way via the Estuary past

the Pont up into the lower reaches of the Lake.

I took numerous samples of water and tested them for the presence of salt which is naturally present in most estuarine waters, but at certain stages of the tide it was very apparent that even in the vicinity of the pont and southwards in the waters immediately adjoining the hotel the water was almost completely fresh. With an ebb tide these conditions were also determined even within a few hundred yards of the actual mouth of the Estuary.

During the flow and at high tides it was noticeable that detritus and other floating and suspended matter, such as sugar cane, etc., were hemmed in by the bore of the incoming tide and forced up the Estuary.

All tow-nettings at all stages of the tide revealed the fact that there was always an immense amount of matter in suspension, this matter being mostly in the form of detritus and fine mud and sand.

Having already stated that such mud would have the effect of impairing fish life by means of the spoiling of the natural environment, it is necessary to examine ways and means whereby such effects could be combated or at least improved.

With this in view I gave very careful attention to the letters of Messrs. N. F. Griffin and S. Stephen, who obviously know conditions appertaining in the Estuary from first-hand observation, and I paid special attention to the suggestion that the Western Channel should be closed at its Southern end where it forks from the Umfolosi River.

During my examinations of conditions at St. Lucia, the Western Channel showed conclusive evidence of a heavy deposition of mud and silt, and at high tides and during the flow, this mud and silt was seen to make its way via the Western Channel into the Estuary and was helped along by the appreciable bore of the tide. At the turn of the tide deposition of the suspended matter takes place all along the course.

While fully appreciating the fact that this is rather a question which falls in the province of a Marine Engineer and not of a Marine Biologist, nevertheless I am convinced that the closing of the southern end of the Western Channel, where it leaves the Umfolosi River, is a practical solution, as then less silt and weed would be forced into the Estuary. This closure does not seem to entail much work or expense if a dredger from the Umfolosi Co-operative Sugar Planters Ltd. could be obtained. The dredging of the Umfolosi higher up its reaches must obviously have the effect of causing an immense amount of silt to be carried in suspension by the river itself, especially during the rainy seasons.

Closely allied to this question is that of the discharge of fresh water into the Lake and Estuary. This is, of course, a natural phenomenon, as numerous rivers discharge their waters into False Bay, St. Lucia Lake and the Estuary. I refer to the Msinene, Hluhluwe, Nyalazi Rivers discharging into False Bay; the Mkuzi River into the Lake and the Umfolosi and Umsunduzi Rivers into the Estuary.

Obviously when these rivers are in spate there is an enormous volume of fresh water discharged into the whole area and this would cause a mortality of fish and also tend to drive fish away from the waters of low salinity.

During my stay at St. Lucia there were some instances of mortality amongst the salmon. I examined some of the dead fish and formed the conclusion that the cause of death was due rather to physical changes in the water than to organic diseases or pathological factors in the fish. There were no signs of disease in the fish at all.

There is obviously nothing that can be done about the spates of fresh water during the rainy seasons and an occasional sporadic phenomenon such as this must cause a mortality.

Causes of fish mortality have been studied in many parts of the world from time to time and these researches afford

interesting parallels to these phenomena occurring at St. Lucia.

In the Indaw River in Upper Burma fish die in large numbers three or four times a year. This always follows a heavy fall of rain on the hills, the water of which is collected by the Namtig Stream. During the rainy season the Namtig brings down an exceptionally large quantity of water, some of which forces its way up the Indaw (c.f. the Umfolosi River). The deadlock caused by the upstream of Namtig water and the downstream from the lake brings about the fish mortality. Death is probably due to the water being fouled, preventing respiration.

Certain cases of mortality of fish are due to some form of suffocation in the wide sense of a poisoning of the blood of the animals concerned, by some asphyxiant present in the water. The symptoms are distinctively those of this form of death - the gills are dark and livid and movements sluggish. Theories have been advanced that asphyxiation may be brought about by exhaustion of oxygen in the water, or by poisoning due to the excretion of waste products on the part of Euglenids (microscopic Protozoans), or it may be semi-mechanical in cases where bottom-feeding animals have come within an area where vast masses of the Euglenids have settled to the bottom and have there passed into the jelly-forming resting stage.

The first suggestion is the least likely as Euglenids possess chloroplasts and are more likely to set free oxygen in quantity than to absorb it. On the other hand poisoning of the water by the excretions of myriads of individuals and by the decomposition products liberated through the death of the short-lived generations of these organisms is sufficient cause for much of the mortality noted. The third, or mechanical factor, has a particularly harmful influence upon the burrowing and sedentary organisms which form the food of bottom feeders as they are unable to escape the blanketing effects.

Other factors examined are the mortality of fishes due to intense cold and sudden temperature fluctuations.

Fishes can adapt themselves to gradual fluctuations of temperatures but sudden drops are likely to cause death. This is the case more often amongst tropical and sub-tropical fishes than in temperate ones.

As all these contributory factors in fish mortality are due to natural phenomena, human agencies are powerless in preventing them.

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Summing up the pros and cons of the question one is led to the conclusion that the silt and mud deposited in the Western Channel has a deleterious effect upon fish life, such effect becoming gradually more and more noxious if nothing is done to combat it, or at least an attempt is made to minimise its cause.

By closing the Western Channel at its southern end, the Umfolosi River will be forced to flow through a single channel and most of its muddy waters will be discharged through its mouth into the sea. The river flows when the tide is going out, and, owing to the presence of the strong Mozambique Current along this part of the Coast - the rate is 4 - 5 knots - the silt and mud would tend to be taken down the coast by the current and much of this harmful matter would be removed from the Estuary.

As Mr. Griffin happened to be at St. Lucia for a few days during my stay there, we had an opportunity of discussing the matter in detail and I think that there ^{is} much to be said for the views expressed by him in his letter to Captain Potter dated 3rd. February, 1939.

Muddy water at any time tends to form an impassable barrier to fish, as the mud gets into the gills and eventually causes congestion there, with resultant impairing of respiration.

6. WHAT EFFECT HAS THE PARTIAL CLOSING OF THE MOUTH OF THE ESTUARY ON THE ENTRANCE OF FISH TO THE LAKE?

The effect of such a closing is to produce a barrier to the passage of fish. Most of the fish pass into the Estuary on

a spawning migration and a closure of the Estuary, even though it be only a partial one, tends to divert the course of the fish.

If the suggestions embodied in paragraph 5 above are given effect to, then the natural scour of the river and tides would tend to keep the mouth of the Estuary open at all states of the tides.

7. DO FISH AND SHRIMPS BREED IN THE LAKE?

The migrations of certain species of fish frequenting the Lake and Estuary are definitely anadromous, that is to say, the fish migrate from the sea into the brackish waters to spawn.

During tow-netting experiments I found numerous small larval fishes about $\frac{1}{2}$ " to $\frac{3}{4}$ " in length and these on examination proved to be the young of the Salmon. Also, the gonads of certain fish like the Salmon and Grunter which were examined by me proved to be gravid. Certain other specimens of Grunter were spent, which means that the eggs were already laid.

From these factors it may be taken for granted that the above-mentioned species do breed in the waters of the St. Lucia Reserve.

The same conclusion may be accepted in regard to the shrimps and prawns. Certain of the former collected showed females in berry. As most species of prawns simply shed their eggs in the water and the females do not carry them on the underside of the abdomen like other crustaceans do, it was not possible to arrive at the same conclusions in regard to the prawns as it was in regard to the shrimps, but as the prawns are principally fresh and brackish water species, it can safely be concluded that they also breed in their immediate environment.

8. IS IT NECESSARY TO CLEAR CERTAIN AREAS OF WEEDS WHICH HAVE ACCUMULATED IN THE VICINITY OF BRODIE'S CROSSING?

Brodie's Crossing lies towards the southern end of the Lake and is indicated on the attached photograph. At this point the Lake is very narrow and at the time of my visit the weeds were extremely dense there. The presence of these weeds tends to form a virtually impenetrable barrier to the migration of fish both to and from the Lake.

I have studied the Durban Harbour Engineer's Report on this matter and have noted with interest his views, with which I concur.

It is obvious that the cutting of the weeds would only be in the form of a temporary expedient and such palliative measures can only be purely temporary in nature, since the weeds would soon grow again. Unless the roots could be destroyed, a recurrence of the conditions must be faced. The eradication of these weeds would be an extremely expensive matter and I should recommend that it be made only after the closing of the Western Channel has been effected and the results of this noted over a period.

Should the weeds eventually become too dense then ways and means should be examined to make their eradication effective.

As this question of the impeding of migrating fish ultimately affects the upper reaches of the Lake, I wish to suggest that experiments be conducted to stock these reaches and also False Bay with fresh water fish which have a decided tolerance for a certain degree of salinity.

I refer to the Black Bass which in the last few years have been planted in various inland waters of the Union with marked success. From personally conducted experiments carried out a few years ago I was able to acclimatise Black Bass to a tolerance of 55% of sea water, which would represent a salinity of about 18.8 parts per 1000.

False Bay and the upper reaches of the Lake would never assume such a degree of salinity and I consider them admirably

suited for stocking with this excellent fish, which grows rapidly to quite an appreciable size. Black Bass is a favourite game fish in the inland waters of the United States of America and is highly appraised there.

I was given to understand that Lake Bangazi has already been stocked, but I could get no information about the results of this experiment.

Specimens could be procured from Swaziland or from the Natal Inland Waters Fisheries Department, and, as it is a particularly hardy species, it is bound to thrive there and even make its way southward towards the Estuary at certain times.

The presence of Black Bass, which have attained a weight of over 5 lbs. in the Inland waters of the Union, would be of great value to anglers using light tackle and should afford an extra attraction to St. Lucia.

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I have dealt with the above points as comprehensively as possible as I consider that they cover the various questions affecting the problems at St. Lucia on general and specific lines.

It is interesting to note that tow-nettings revealed a comparative abundance of fish food in the form of zoo- and phyto-plankton. The presence of larval fishes in the plankton is also of interest.

The suggestion that a new exit for the Umfolosi River should be cut further southwards than the present mouth through the sandy beach so as to keep the fresh water away from the Estuary was also raised, but I do not consider this a practical solution owing to the fact that the expense entailed in cutting a channel about 350 yards long through the sand would be too great and there is no guarantee that the new mouth would not soon become silted up.

RECOMMENDATIONS AND SUGGESTIONS.

1. That no licences for netting additional to those at present in operation be granted for use in any part of the St. Lucia area.
2. That the commercial exploitation of shrimps, prawns, or fishes be at no time permitted.
3. That the Department of Lands be asked to set aside under the control of the Zululand Game Reserves and Parks Board, a strip of land about half a mile wide immediately surrounding the waters of the Estuary, Lake and False Bay. The Board could then be in a position to control campers and afford them the necessary sanitary conveniences and so combat any tendency towards pollution.
4. That the southern end of the Western Channel where it forks from the Umfolosi River be closed and that the effect of this on the conditions as to the deposition of silt and mud in the Estuary and other reaches be carefully noted.
5. That the size limits set out in paragraph 3 above be introduced without delay and that they be rigorously enforced by the Fisheries Officers.
6. That no one boat be permitted to take more than a total of 12 fish per day.
7. That only barbless hooks be permitted for fishing for species of fish other than sharks in the Estuary, Lake and False Bay.
8. That the present shrimp and prawn reserve established last year be proclaimed for a further period of two years and that the effect of this closure be carefully studied. At present it is not necessary to proclaim any further areas for shrimps and prawns or for fish life.
9. That after the effect of recommendation No. 4 has been carefully studied, the question of the eradication of weeds in Brodie's crossing be examined with a view to opening this


Channel for the free passage of fish.

10. That the Northern end of the Lake and also False Bay be stocked with Black Bass.
11. That any tendency towards pollution of the Umfolosi River by effluents from the Sugar Mills be immediately combated.
12. I wish to stress the fact that my investigations were primarily only in the form of a preliminary survey as, owing to the limited time I could spare from my other duties, it was not possible to give the detailed attention to this important problem that it warrants. I wish to suggest, therefore, that when world conditions again approximate normality, a detailed survey as indicated on page 1 of the Report be conducted by the Division of Fisheries when the R.S. "Africana" is operating in Natal Waters.

I am of the opinion, however, that conditions would doubtless improve if the above recommendations, which I consider of primary importance, could be given immediate effect to. Then when a more comprehensive survey is embarked upon, the effects of these experiments could be studied in detail.

CONCLUSION.

This Report would not be complete without my recording my grateful thanks to the Secretary of the Board, Mr. A. E. Charter, for analysing the various suggestions put before the Board and by so doing facilitating the progress of my work; to Mr. N. van Rooyen whose local knowledge and unstinted help greatly assisted me in my survey; and to Mr. T. Sharp, for obtaining the samples of shrimps and prawns for my examination.



DIRECTOR OF FISHERIES.

SEA POINT,
July 19th, 1940.

