A NEMATODE INFECTION IN THE NORTHERN ANCHOVY FROM SAN FRANCISCO BAY

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ABSTRACT.

Larvae from the Nematode Contracaecum sp. were found in the body cavity of 62% of 53 Northern Anchovies collected from the San Francisco Bay during the months of April, June, July, August, September, and October of 1981. The fish were collected from two sites in the southern part of the Bay, between the Dumbarton and San Mateo Bridges. Parasite larvae were removed from the fish, stained with acetocarmine and identified to genera.

The effect that fish size, water temperature, salinity, cyanide (CN), and dissolved oxygen (D.O.) levels in the water had on the frequency of parasitism in the anchovy was examined for statistical significance by means of a chi-squared analysis. The parasite freqency increased as water temperature and fish size increased. The parasite frequency was highest when the salinity was 28-29 ppt and when the CN and D.O. levels were at the lowest consentrations. These situations occurred during the months of July and August, indicating a possible seasonal relationship between Contracaecum sp. infections in the anchovy and a changing aquatic environment.

INTRODUCTION

Marine fish will provide an important protein source for man when we can increase the effectiveness of our aquaculture techniques. In order to accomplish this, we need to know not only the farming techniques, but also what possible diseases to which fish may be susceptible under various conditions. With this information, we can attempt to control these diseases and therefore increase the yields in our fisheries.

One area of fish diseases which has been studied too little is that of zooparasites of marine fish--specifically from the western coast of the United States.

Olsen (1978) found that juvenile English Sole (Parophrys vetulus), from an Oregon estuary, had a different parasite makeup than did adult English Sole caught off the coast of Oregon. He concluded that this difference could be due to changes in the environment or changes in the feeding habitats of the fish as it ages and then leaves the estuary.

Dogiel (1958), Kennedy (1972), and Ribeline and Migaki (1975) found that environmental changes such as water temperature, salinity, or dissolved oxygen can reduce the effectiveness of the fish to combat diseases, and so increase the risk of parasitism.

Information such as this can be used to control the artificial environment in which man may culture fish and in this way, help to control potential diseases.

Another reason the study of marine fish parasites should continue is because of the many parasites in these fish which are transferable to man. An example can be found in the Striped Bass (Roccus saxtilis) found on the west coast of California. For the last several years these fish have been found with tapeworm (Trypanorhyncha sp.), which can cause anemia and loss of nutrients in man. The fish has also been harboring two Nematodes of the Anisakidae family; Anisakis; and Contracaecum. If ingested by man, these worms can cause an elevated eosinophil count, bloody stools, ulcerations of the intenstinal tract and granulomatous nodules which could block the intestine (Smith and Wooten, 1978).

For these reasons and for the knowledge which may contribute to the success of marine fish aquaculture, I have been studying the parasites of fish from the San Francisco Bay. In this paper I am reporting on the presence of larval stages of the Nematode Contracaecum sp. found in the Northern Anchovy (Engraulis mordax) caught in the San Francisco Bay.

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MATERIALS AND METHODS

Anchovies were collected twice a month on board the Marine Ecological Institute's vessel the "Inland Seas." Fish were collected from two stations, monitored by the Marine Ecological Institute, located at the channel outside of Redwood Creek and the channel south of the San Mateo Bridge. The fish were collected by means of 10 minute otter trawls. At this time, water samples were collected and examined for, among other things, temperature, salinity, cyanide (CN), and dissolved oxygen (D.O.).

The anchovies were examined within five hours after capture. They were weighed and measured for standard length. Fecal samples were taken for use in a future study.

The body cavity and gastro-intestinal organs were examined for lesions and parasites. Any found were fixed in a 7% formalin, and if necessary, stained with acetocarmine.

The parasites were identified to genera by the use of guides by Hoffman (1967), and Yamaguichi (1961), and by the use of a paper by Myers (1975). The defining characteristics for this genus are: several lips on the head, presence of interlabia on the head, presence of intestinal caeca and ventricular appendix, position of excretory pore, and shape of tail.

Fish from 60-110 mm were examined. A chi-squared analysis was performed in order to determine the effect that fish size, water temperature and salinity, and CN and D.O. levels had on the frequency of parasitism in the anchovy population (Bailey 1959, Bancroft 1957).

RESULTS

The larvae of the Nematode Contracaucum sp. were found in the body cavity of 33 of 53 (63%) Northern Anchovies collected from San Francisco Bay during the months of April, June, July, August, September and October 1981.

The anchovy is a recently discovered host for this parasite. M.B. Mizrahi from San Diego State University in 1977 was the first to find Contracaecum sp. in the anchovy, however, to my knowledge, this information has not been published (personal communication, Dr. M. Moser, UCSC). This parasite is a member of the Anisakidae family, and as such can cause a disease known as anisakiasis in humans if ingested.

Since the Northern Anchovy from San Francisco Bay has never been examined for parasitic infections before, the findings of Contracaecum sp. larvae in juvenile anchovies can be considered as new information in this parasites life cycle.

A) Fish Length and Parasitism:

The anchovies were examined for an association between the fish length and the percent of the fish infected. For the purpose of statistical calculations, the fish were divided into two groups. These groups were the 60-79 mm size range and the 80 mm size range.

The fish >80 mm had a higher frequency of parasitism than the 60-79 mm group of fish (71.9% vs. 52%). This difference was significant at $P<.1$ indicating that a longer fish length correlates with an increased frequency of parasitism (Figure 1).

There appears to be a relationship between the size of the anchovy and the months of the year. This is evidenct in Figure 2 which shows the mean fish (host) length was longest during the months of July and August. Data published by Aplin (1967) showed that anchovies are caught in this region of the Bay from April to October, with the highest number being caught during the summer months. This indicates a seasonal flucuation in the anchovy population.

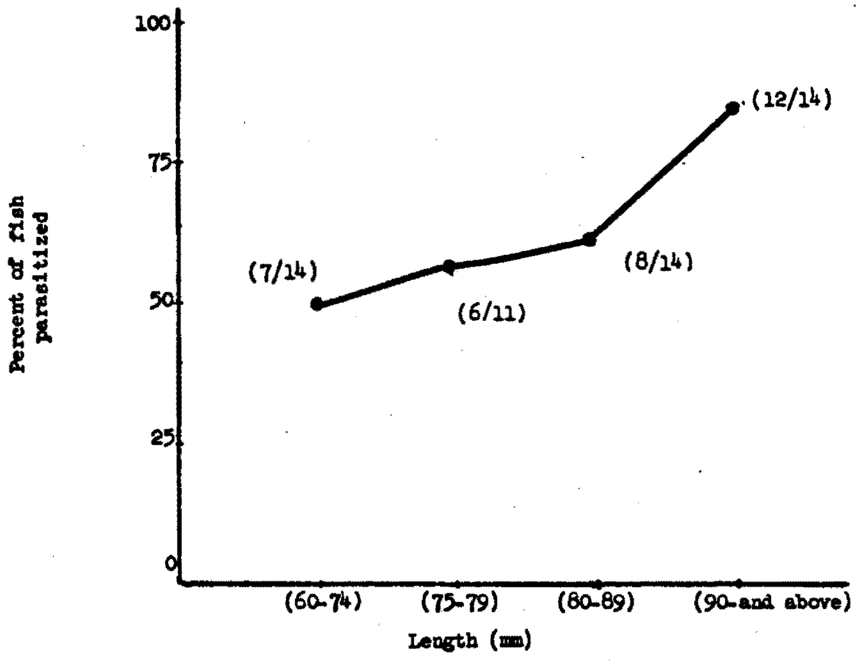


Figure 1. Percent of Northern Anchovies parasitized by Contracaecum sp. in relation to Anchovy size.

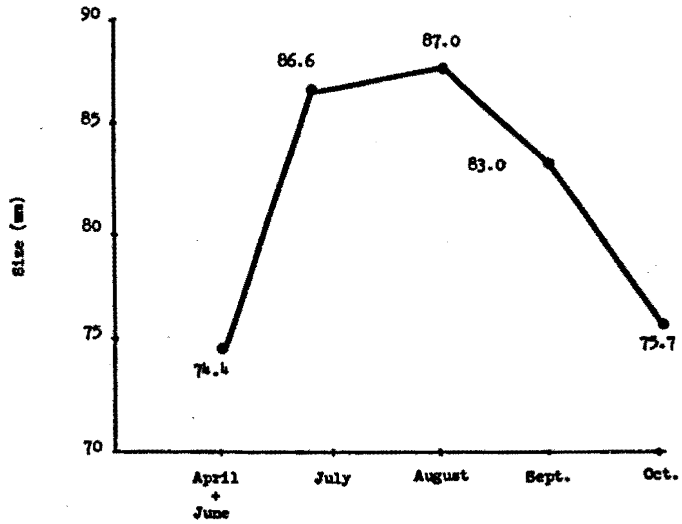


Figure 2. Mean size of Northern Anchovies by month.

Figure 3 shows that the fish are at their highest frequency of parasitism in July and August. When this is compared to Figure 2, it becomes apparent that the anchovies are not only longer in these two months, but also the fish are at their highest risk of parasitism. This indicates a possible relationship between parasitism, hot length, and the time of the year. This correlates with information gathered by Bishop and Margolis (1955), Khalil (9169) Sinderman (1970), and Wickens and MacFarlane (1973). All of these authors found that members of the Anisakidae family tend to increase in frequency as juvenile fish size increases. Dogiel (1958) found it to be a common occurrance for a parasite to increase in frequency as the fish ages.

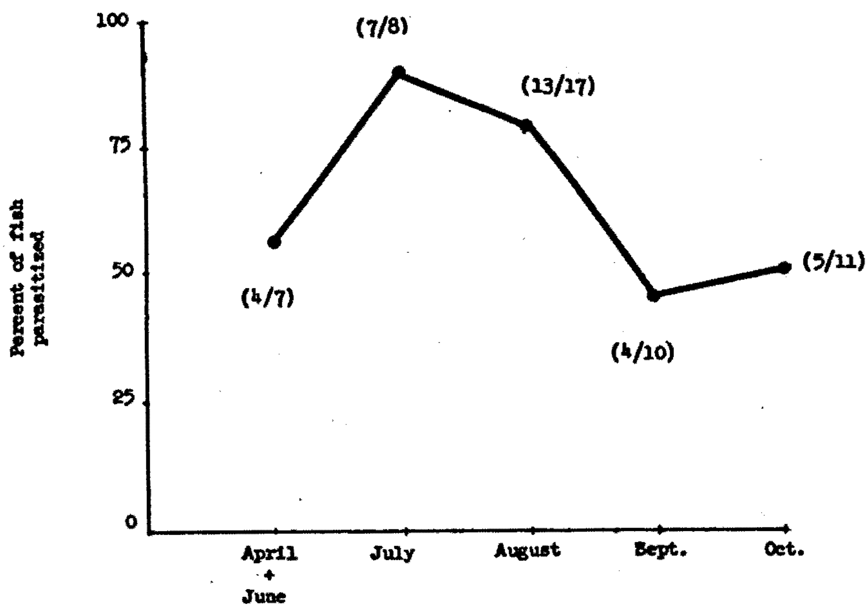


Figure 3. Percent of Northern Anchovies parasitized by Contracaecum sp. by month.

B) Water Temperature and Parasitism:

For calculations, the fish were divided into two groups: those found when the water temperature was 16-20°C, and those found when it was >21°C. The fish from the >21°C group had a higher frequency of parasitism than the 16-20°C group (76.0% vs. 50.0%). This difference was significant at $P<.1$ indicating an increased risk of parasitism for the fish living in the warmer waters (Figure 4). This correlates with information gathered by Dogiel (1958), Kennedy (1972), and Ribelin and Migaki (1975). These authors found that increases in temperature can reduce the effectiveness with which a fish may combat disease.

The water temperature was 20°C or more during the months of July and August. These were also the months when the frequency of parasitism was highest (Figures 3 and 5), indicating a seasonal relationship may exist between the temperature and the frequency of parasitism in the fish.

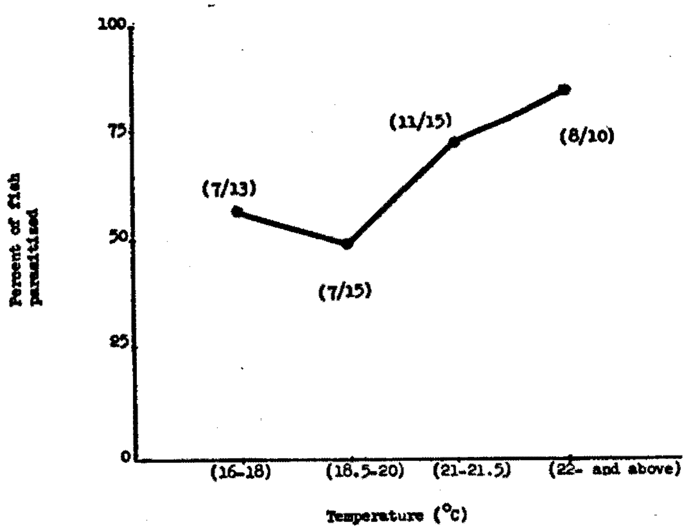
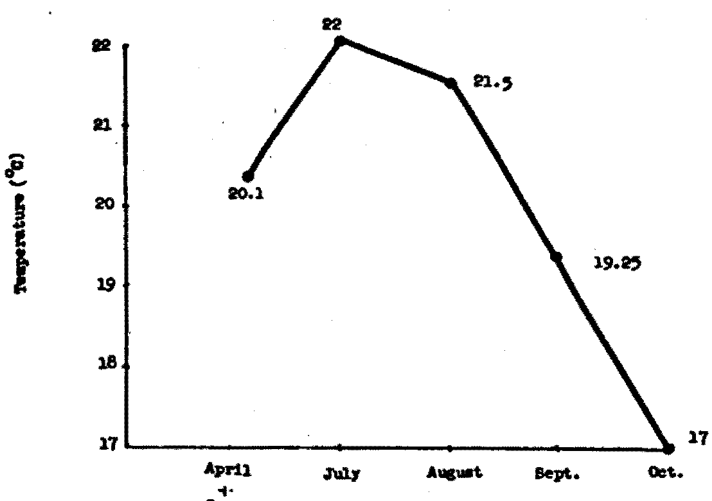


Figure 4. Percent of Northern Anchovies parasitized by Contracaecum sp. in relation water temperature.



Figur 5. Average temperature of San Francisco Bay by month.

C) <u>Salinity and Parasitism</u>:

The fish were divided into two groups: those caught when the salinity was 26-29 ppt and those caught when it was >30 ppt. Those fish from the 26-29 ppt group had a higher frequency of parasitism than the fish from the higher salinity levels (80.0% vs. 46.4%). This difference was significant at P<.05 indicating a correlation between parasitism and salinity (Figure 6).

In July and August when the salinity levels were at 28-29 ppt, the frequency of parasitism was highest (Figures 3 and 7), indicating a relationship between salinity, parasitism, and the months of the year.

Dogiel (1958) found that fish from less saline waters had a higher number of parasites species present as well as a higher percent incidence of infection than fish from a more saline environment.

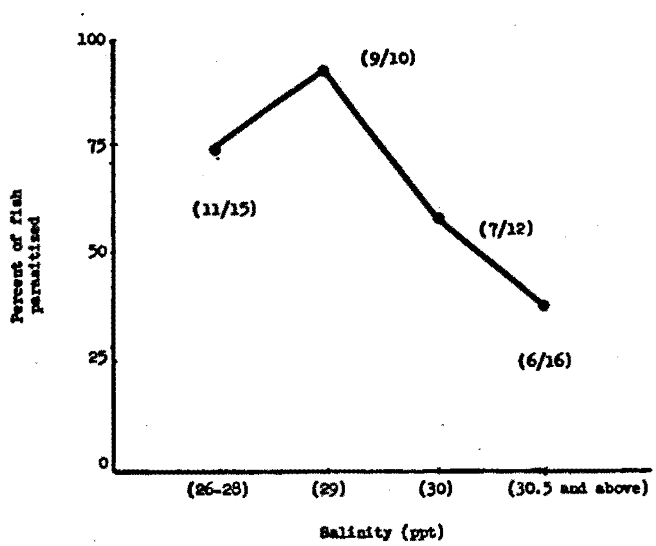


Figure 6. Percent of Northern Anchovies parasitized by <u>Contracaecum</u> sp. in relation to salinity.

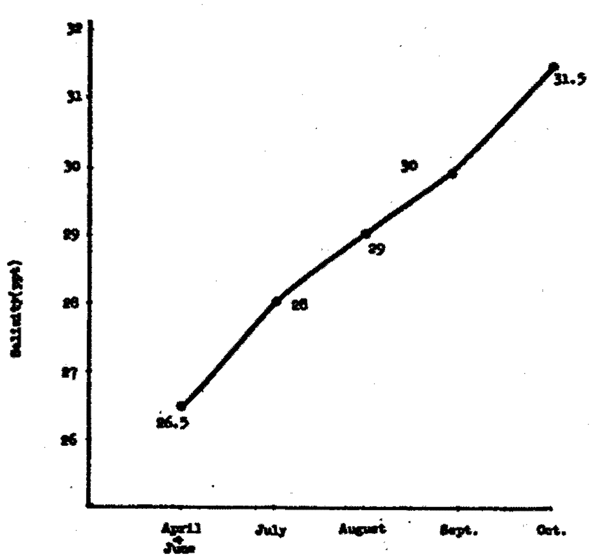


Figure 7. Mean Salinity of San Francisco Bay by month.

D) Cyanide (CN) Levels and Parasitism:

The fish were divided into two groups. Those caught when the CN levels were from 0.1-0.15 ppm and those caught when the CN levels were 0.2 - 0.25 ppm. Those fish caught when the CN levels were 0.1 - 0.15 ppm had a higher frequency of parasitism than the other group. (86.3% vs. 45.1%). This difference was significant at P<.01 (Figure 8).

In July and August when the frequency of parasitism in the fish was highest (Figure 3), the CN levels were lowest (Figure 9), indicating an inverse relationship between CN levels (low CN levels) and an increase in parasitism. This will be discussed later.

E) Dissolved Oxygen Levels and Parasitism:

The frequency of Contracaecum sp. in the anchovies was examined in relation to the dissolved oxygen (D.O.) levels in the water, however no statistically significant differences were found. Figure 10 indicates that there may be an association between D.O. levels and parasitism. When the D.O. levels were lowest the frequency of parasitism was highest. Figure 11 indicates that two of the lowest mean D.O. levels occurred in July and August. These were the months when the frequency of parasitism was highest in the fish (Figure 3). The idea of seasonally low D.O. levels correlating with an increase in incidence of parasitism is consistent with a study mentioned by Dogiel (1958).

DISCUSSION

The life cycle of the Anisakidae family of parasites is approximated by the following: the first intermediate hosts are microcrustaceans from the plankton which are filter feeders; these organisms pick up the parasites from the water. Fish eat these microcrustaceans and acquire the parasite. Larger fish eat the smaller fish and birds or mammals eat both. The bird or mammal then defecates and releases the parasitic ova.

The anchovies are filter feeders and acquire the parasite by ingesting the microcrustacean intermediate host. The anchovy has a higher frequency of parasitism than other more predatory fish in the Bay such as sharks, flatfishes, and surfperch (Eaton, unpublished data) because there are less steps between the parasite and the Anchovy.

Aplin (1967) shows that in the same region of the Bay as this study, anchovies were caught from April through October with the highest numbers being caught during the summer months. The anchovies from this study were longer and probably older during July and August, indicating a seasonal flucuation in the anchovy population within the Bay. During these months there is also an increase in the number of fish infected with the parasite Contracaecum sp.

In July and August, when the frequency of parasitism is highest, the salinity is between 28-29 ppt. Above the 28-29 ppt level the frequencies of parasitism decline. This may show a dependence, by the parasite, on specific salinity levels, and give reason to suspect that Contracaecum sp. may be involved in a seasonal cycle with the anchovy and a changing environment.

In July and August the water temperature is highest, the D.O. levels are lowest and the frequency of parasitism is highest.

According to Aplin (1967), plankton and Anchovies are more prevalant during the summer months. This can explain why the D.O. levels could be low, since there is more demand for oxygen. Data gathered by Dogiel (1958), Kennedy (1972), and Ribelin and Migaki (1975), state that fish susceptibility to diseases increases with a decrease in D.O. levels and when a change in salinity or water temperature occurs. This information indicates that the changing aquatic environment may correlate with a change in parasite populations.

In July and August, the CN levels were lowest and the frequency of parasitism was highest. I think that there is less CN available in the water at this time because much of it is tied up in the excess plankton from the plankton bloom. This does not explain why the frequency of parasitism was highest when CN was lowest. Especially when CN is respiratory toxin to fish.

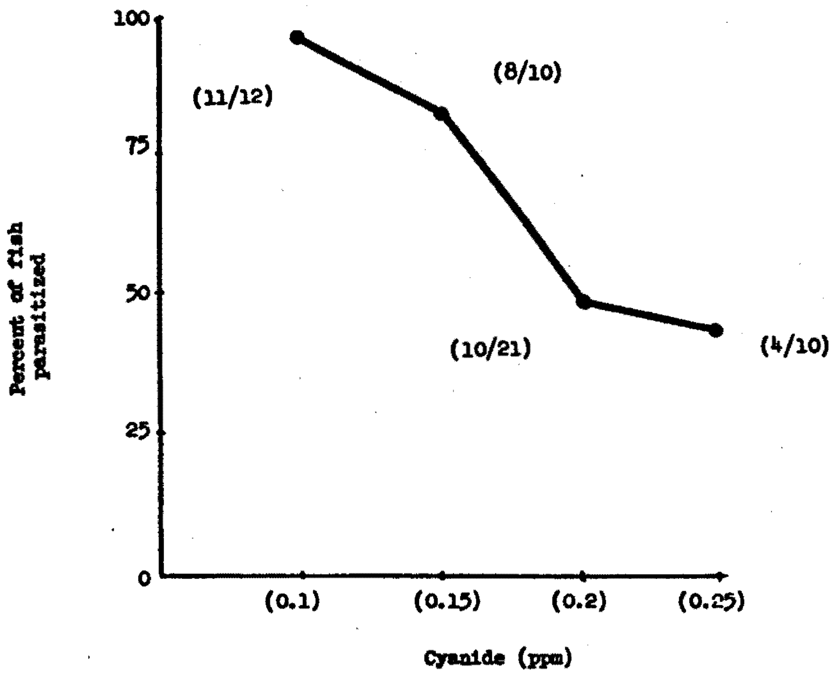


Figure 8. Percent of Northern Anchovies parasitized by Contracaecum sp. in relation to cyanide (CN) levels in San Francisco Bay.

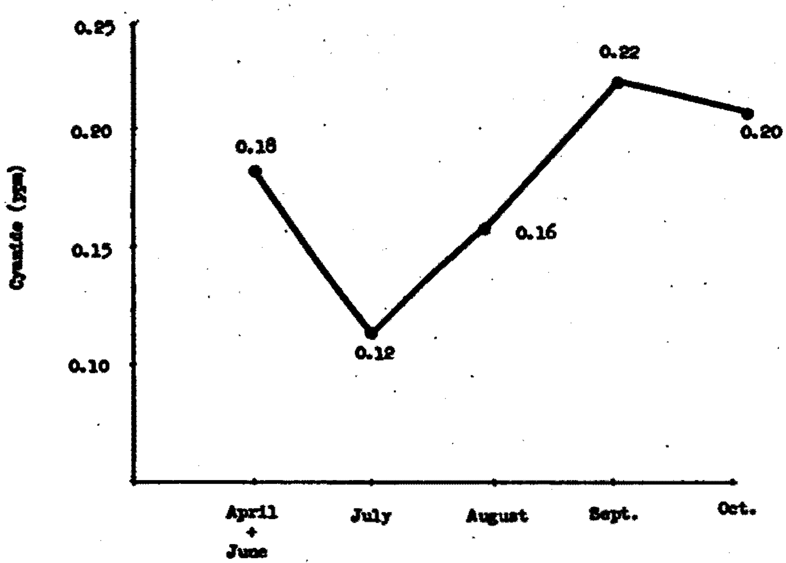


Figure 9. Mean CN levels in San Francisco Bay by month.

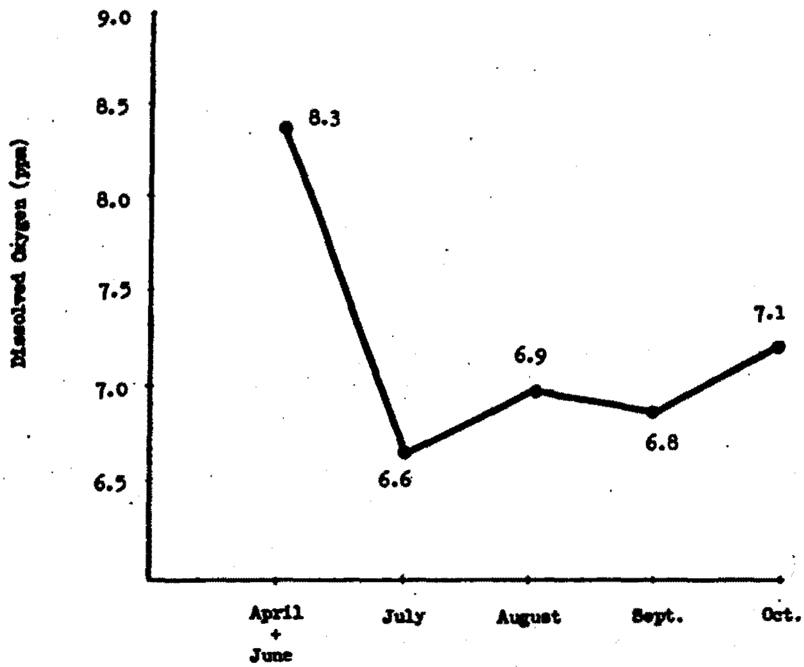


Figure 10. Percent of Northern Anchovies parasitized by <u>Contracaecum</u> sp. in relation to dissolved oxygen (D.O.) levels in San Francisco Bay.

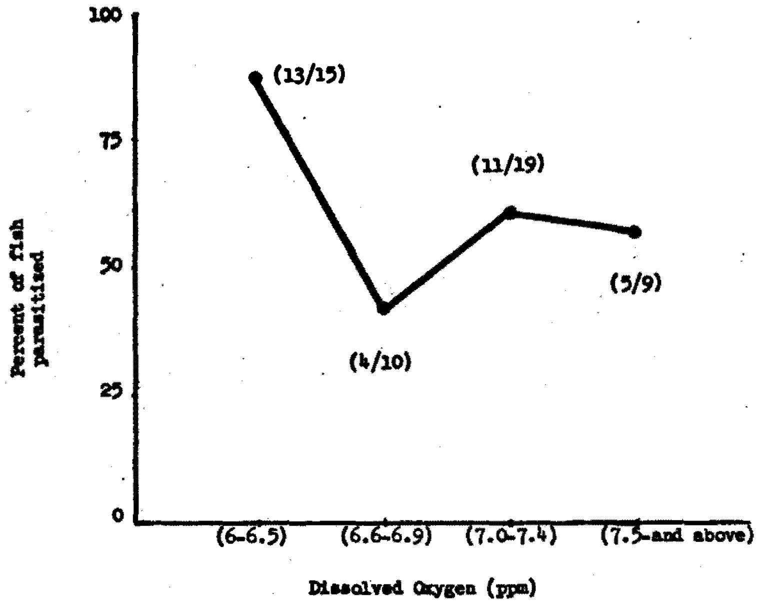


Figure 11. Mean D.O. levels in San Francisco Bay by month.

According to Sittig (1980), levels of CN as low as 0.014 ppm over a long exposure time can have a toxic effect on fish. The levels of CN in the Bay ranged from 0.1 - 0.25 ppm. This should have made the fish more susceptible to disease due to the stress it may have caused. Yet, it wasn't until the CN levels fell below 0.15 ppm that parasitism became significantly high. My theory is that at the higher CN levels the microcrustaceans which serve as a necessary intermediate host for the parasite were destroyed, consequently, there were not as many parasites available for the fish to acquire.

This hypothesis was tested by exposing microscopic copepodes and shrimp larvae (intermediate hosts for Contracaecum sp.) to known levels of CN mixed with Bay water. When this was done, 100% of the intermediate hosts died in 9 minutes when exposed to 1.0 ppm CN; at 0.5 ppm, 100% of the intermediate hosts died in 29 minutes; at 0.25 ppm CN, 50% of the intermediate hosts died in two hours; and at 0.15 ppm CN, none of the intermediate hosts died in two hours. This indicates that the higher CN levels the necessary intermediate hosts for Contracaecum sp. are reduced in number, and therefore there are less parasites available in the water for the fish to acquire.

This study indicates that there may be a relationship between Contracaecum sp. infection in the anchovy and changing seasonal water quality factors. The size of the fish seems to be important also.

More studies of this type need to be attempted as the information is of great value to fishery biologists. Perhaps of even more importance is the fact that Contracaecum sp., and many other marine fish parasites, are transferable to man. This alone gives reason to study this topic more so that we can become aware of the hazards that exist and in this way we, as biologists, can help prevent a potential public health problem from occurring.

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