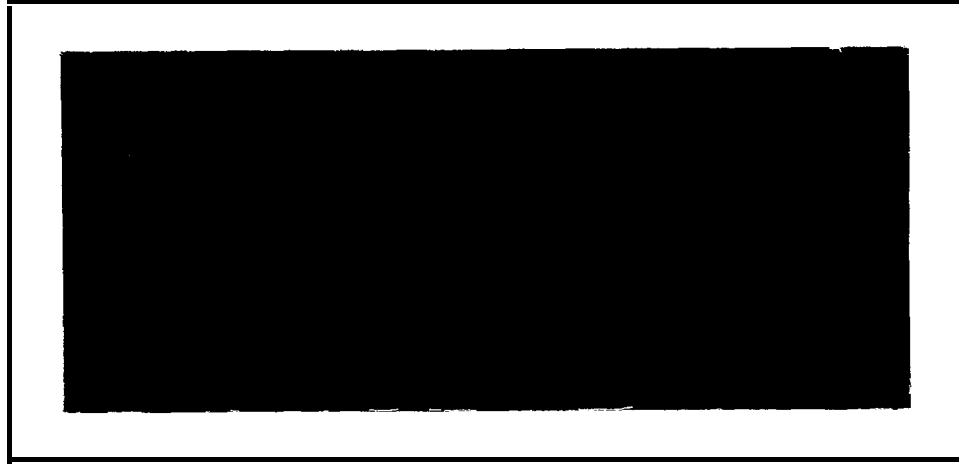


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FINAL REPORT  
VOLUME 11, REPORT 10.0

TRACE METALS IN SELECTED BENTHIC MARINE ORGANISMS

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P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92037

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John H. Martin  
George Knauer

Moss Landing Marine Laboratory

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## 10.0 TRACE METALS IN SELECTED BENTHIC MARINE ORGANISMS

### 10.1 INTRODUCTION

In order to accurately characterize metal levels in benthic marine biota, a number of criteria should be considered. The first and most obvious is that the organisms selected should concentrate the metals of interest in at least one tissue (organ). In addition, it would be desirable that metal levels in the selected organism reflect changes in ambient metal levels consistent with the desired temporal resolution. (We suspect that this latter condition is not easy to obtain.) Thirdly, the organism must be readily available from many locations which reflect varying environmental conditions (i.e. polluted to pristine). Lastly, the tissues to be analyzed must be available free of sediment inclusion.

During the first year benthic study, we analyzed many species of benthic invertebrates based on literature suggestions that many of these animals would make good monitoring organisms (e.g. see Eustace 1974). However, either a limited geographical distribution or serious problems with obtaining tissue free of sediment inclusion excluded every species of invertebrate collected.

For these reasons, we decided to analyze two relatively ubiquitous fish found in the bight area, each with different feeding habits: Lyopsetta exilis, the slender sole, is a bottom feeder ingesting polychaetes and other benthic infauna (Frey, 1971) and Sebastes saxicola, the stripetail rockfish, feeding almost exclusively on macroplankton, primarily euphausiidae (Best 1961, Phillips 1964).

Although several investigators have indicated that fish may not be good monitoring organisms (Havre, et al., 1972; De Goeij, et al. 1974), our first and second year intertidal study suggested that this may be due to faulty experimental design.

It was our intention, therefore, to analyze a number of individuals of each fish species collected from various locations in both winter and summer with the idea of developing better insight into the biological monitoring problem in a manner similar to the Year II intertidal study.

### 10.2 METHODS AND MATERIALS

Two species of fish, Sebastes saxicola and Lyopsetta exilis, were obtained for trace metal analysis by trawling at four locations in the southern California bight: North Tanner Bank (NTAN) San Miguel Island (MIG), Point Conception (PC) and Coal Oil Point (COP), during March and July 1977 (Figure 11-10.0-1). An otter trawl with an untreated net (no creosote) was used throughout the collection operations.

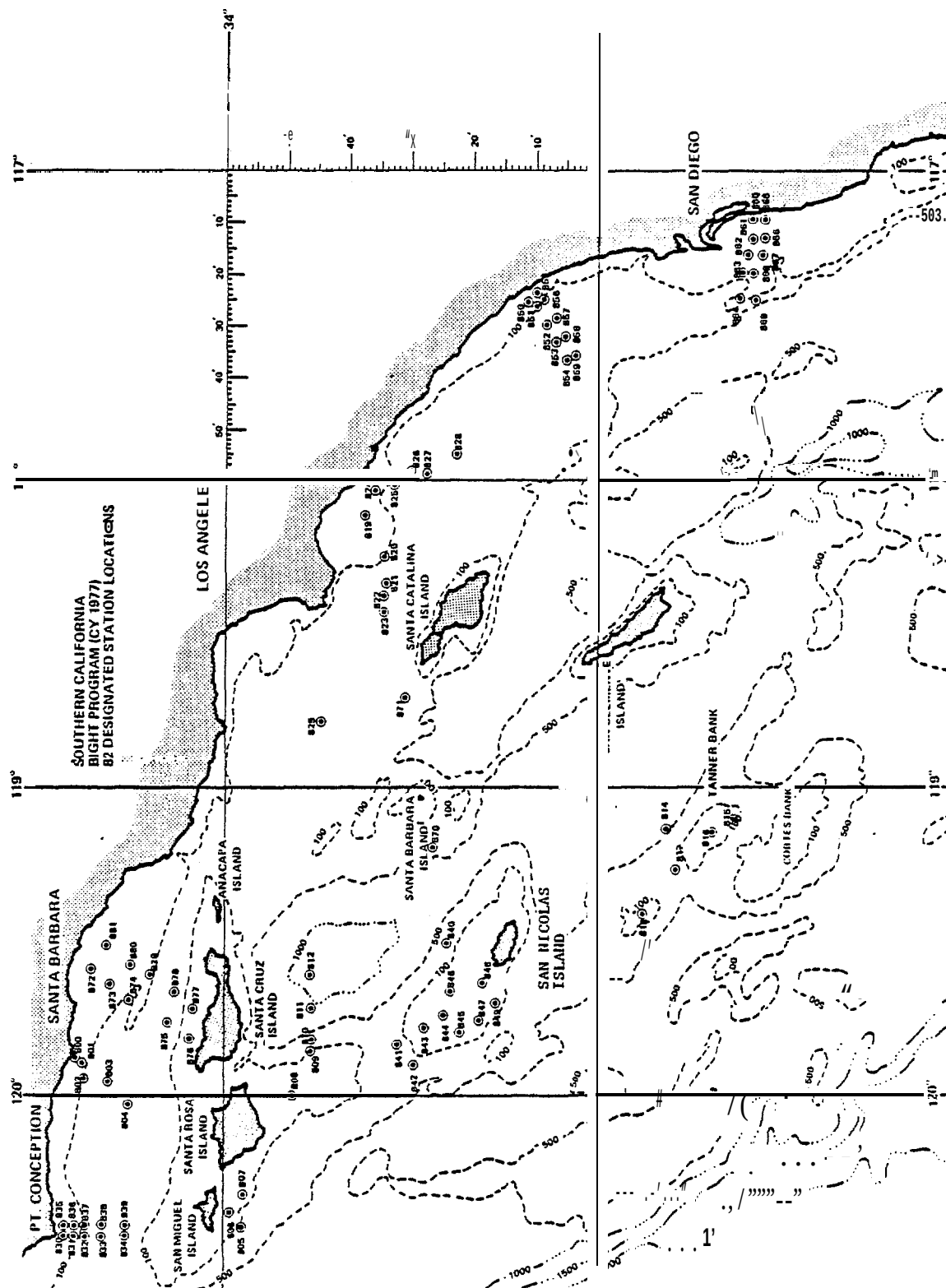


Figure II-10.0-1. Southern California Bight Program (CY 1977). 82 Designated Station Locations.

Trawl samples were brought on-board ship and placed in an aluminum bin which was cleaned after each trawling operation. The selected individuals for trace metal analysis were then removed from the bin, placed on a Nytex screen and washed with sea water to remove mud and debris. The fish were then immediately placed in a clean, all-plastic bucket of fresh sea water prior to dissection.

Liver tissue was selected for analysis because this organ is known to concentrate trace metals and is large enough to provide an adequate amount of sample material. Muscle tissue was not selected due to the characteristically low levels of trace metals which would result in analytical problems.

The liver of each fish was dissected under an all-plastic tent using rigorous precautions to avoid contamination. The entire liver of each fish was placed in an acid-cleaned polyethylene vial and frozen aboard ship for later analysis at the shore-based laboratory.

Liver samples were wet-digested with  $\text{HNO}_3$  and  $\text{H}_2\text{O}_2$  and diluted to a volume of 10 ml. Samples were analyzed for Cd, Cr, Cu, Fe, Ni, Pb and Zn using a Perkin-Elmer Model 603 atomic absorption spectrophotometer coupled to an HGA-2100 graphite furnace.

A Kolmogorov-Smirnov goodness-of-fit test was applied to the data and showed no significant differences from a normal distribution ( $P=.05$ ) after outlying values had been deleted. Comparisons between means were calculated using  $t'$  tests. When variances were found to be unequal by the F test,  $t'$  tests were used (Sokal and Rohlf, 1969). Unless otherwise stated, the word "significant" is used in its statistical sense with  $P<.01$  chosen as the level of significance. This level was chosen since we were performing many statistical comparisons, which implies that the probability of a Type I error occurring increases as probability increases. For example, at  $P=.05$ , a Type I error may be expected in 1 out of 20 comparisons, whereas at the  $P = .01$  level, this potential error is reduced to 1 out of 100 comparisons.

A geometric mean (functional) regression was used to calculate all regression lines. Such regressions are used when the variation of both variates is subject to error (Risser, 1973). Correlation coefficients were calculated using the Kendall tau non-parametric correlation coefficient (Hollander and Wolfe, 1973).

### 10.3 RESULTS

The following data have not been included in the results, but appear in Volume IV, Section 10: 10.1 Benthic Collection Sites and Number of Samples Analyzed; 10.2 Means, Standard Deviations, Number of Samples Analyzed and Ranges for Sebastes saxicola; 10.3 Means, Standard Deviations, Number of Samples Analyzed and Ranges for Lyopsetta exilis; 10.4, Metal Concentration and Total Metal x Length Correlations (Kendall tau).

The results of the geographical comparisons for Sebastes saxicola are presented in Table II-1 0.0-1. Only one comparison was possible for the March 1977 collection, MIG x PC. This comparison revealed that MIG had a significantly higher ( $P < .05$ ) mean level of Cd and Fe compared to PC. The means of Cu, Pb, Ni and Zn were also higher in MIG specimens, but were not significantly different from PC. In addition, the specimens from MIG were significantly longer than those from PC.

The comparison of these two sites in July shows the opposite trend. PC fish had significantly higher mean values of Cu, Ni and Zn compared to MIG. The means of Cd, Fe and Pb were also higher in PC specimens, but they were not significantly different from MIG. The mean length of the fish also showed significantly longer specimens from PC in July compared to MIG.

The results of the geographical comparisons for Lyopsetta exilis are presented in Table II-1 0.0-2. The comparison of the March 1977 NTAN fish with COP, MIG and PC indicate only two significant differences in mean trace metal levels. NTAN appears to have significantly higher mean Cr levels than COP and higher Zn levels than MIG. The NTAN results should be viewed with caution since only a few specimens ( $N = 2$  to  $4$ ) were collected from this site. Because of the low number of samples, NTAN data will not be discussed further; raw NTAN data can be found in Volume IV Section 10.2.

Other March 1977 comparisons showed that MIG fish had significantly lower mean Cd, Pb and Zn levels compared to COP. Mean Ni levels at COP were significantly higher than PC. The July comparisons for Lyopsetta showed only one significant difference. The mean Pb value in COP specimens was higher than PC.

Tables 11-10 .0-3 and 11-10 .0-4 present the seasonal comparison results for S. saxicola and L. exilis, respectively. Many seasonal differences were observed for both species. In some cases, the magnitude of the differences was striking. The MIG collections for S. saxicola showed significant decreases in all metals (except Ni) in the four-month period from March to July 1977. July values showed that Cd decreased 86%, Cr 82%, Cu 79%, Fe 89%, Pb 89% and Zn 50% compared to the March means. The length of Sebastes also showed a significant mean decrease from March to July (Table 11-10. 0-3). The PC specimens also showed large, significant decreases in all mean metal values (except Ni and Fe) from March to July. The July values showed that Cd decreased 55%, Cr 74%, Cu 53%, Pb 76% and Zn 28% compared to the March means. Fe values also decreased by 54%, but the difference was not significant. Mean Ni values showed the opposite trend with the March mean at PC being 49% lower than the July value. Unlike the MIG collections, the mean length of s. saxicola was significantly longer in July.

TABLE 11-10.0-1 Geographical comparisons of mean liver metal conception (ug/g dry wt) and length in S. Saxicola. Levels of significance calculated from t-tests (upper value) and individual mean (lower values) are indicated.

|                   | Cd                               | Cr                    | Cu                             | Fe                    | Ni                             | Pb | Zn                      | Std.<br>Length*       |
|-------------------|----------------------------------|-----------------------|--------------------------------|-----------------------|--------------------------------|----|-------------------------|-----------------------|
| <u>March 1977</u> |                                  |                       |                                |                       |                                |    |                         |                       |
| MIG vs PC         | $\tilde{P} < .01$<br>11.0-7.31** | ns <sup>†</sup><br>-- | ns                             | $P < .001$<br>768-225 | ns<br>--                       | ns | ns                      | $P < .001$<br>126-107 |
| <u>July 1977</u>  |                                  |                       |                                |                       |                                |    |                         |                       |
| MIG VS PC         | ns                               | ns                    | $P < .01$<br>6.21-10.5         | ns<br>--              | $\tilde{P} < .01$<br>1.04-1.73 | ns | $P < .001$<br>70.6-94.0 | ns                    |
| MIG vs COP        | ns                               | ns                    | $\tilde{P} < .01$<br>6.21-10.0 | ns                    | ns                             | ns | ns                      | ns                    |
| COP Vs Pc         | ns                               | ns                    | ns                             | ns                    | $P < .01$<br>0.82-1.73         | ns | ns                      | $P < .01$<br>108-122  |

\*Measurement taken from tip of snout to hypural bone.

\*\*First and second mean values correspond to first and second location.

<sup>†</sup>ns = not significant; see Appendix B for means.

TABLE 11-10.0-2 Geographical comparison of mean liver metal concentrations (µg/g dry wt) and length in L. exilis. Levels of significance calculated from t-tests (upper value) and individual means (lower values) are indicated.

|                   | Cd                 | Cr                   | Cu | Fe | Ni                 | Pb                 | Zn                 | Std.<br>Length* |
|-------------------|--------------------|----------------------|----|----|--------------------|--------------------|--------------------|-----------------|
| <u>March 1977</u> |                    |                      |    |    |                    |                    |                    |                 |
| NTAN vs COP       | ns <sup>†</sup>    | P<.01<br>.095-.055** | ns | ns | ns                 | P<.001<br>.020-.61 | ns                 | ns              |
| NTAN vs MIG       | ns                 | ns                   | ns | ns | ns                 | ns                 | P<.01<br>117-90.2  | ns              |
| NTAN vs PC        | ns                 | ns                   | ns | ns | ns                 | ns                 | ns                 | ns              |
| COP vs MIG        | P<.01<br>7.09-4.21 | ns                   | ns | ns | ns                 | P<.001<br>.61-.16  | P<.001<br>138-90.2 | ns              |
| COP vs PC         | ns                 | ns                   | ns | ns | P<.01<br>2.58-1.64 | ns                 | ns                 | ns              |
| MIG vs PC         | ns                 | ns                   | ns | ns | ns                 | ns                 | ns                 | ns              |
| <u>July 1977</u>  |                    |                      |    |    |                    |                    |                    |                 |
| COP vs MIG        | ns                 | ns                   | ns | ns | ns                 | ns                 | ns                 | ns              |
| COP vs PC         | ns                 | ns                   | ns | ns | ns                 | P<.01<br>.20-.02   | ns                 | ns              |
| MIG vs PC         | ns                 | ns                   | ns | ns | ns                 | ns                 | ns                 | ns              |

\*Measurement taken from tip of snout to hypural bone.

\*\*First and second mean values correspond to first and second location.

<sup>†</sup>ns = not significant; see Appendix B for means.

TABLE 11-10.0-3 Seasonal comparisons of mean liver metal concentrations ( $\mu\text{g/g}$  dry wt) and length in S. saxicola. Levels of significance calculated from t-tests (upper values) and individual means (lower values) are indicated.

|                         | Cd                    | Cr                  | Cu                  | Fe                 | Ni                 | Pb                 | Zn                 | Std.<br>Length*   |
|-------------------------|-----------------------|---------------------|---------------------|--------------------|--------------------|--------------------|--------------------|-------------------|
| March 1977 vs July 1977 |                       |                     |                     |                    |                    |                    |                    |                   |
| MIG                     | P<.001<br>11.0-1.53** | P<.001<br>.089-.016 | P<.001<br>29.3-6.21 | P<.001<br>768-86.9 | ns <sup>†</sup>    | P<.001<br>.74-.079 | P<.001<br>142-70.6 | P<.001<br>126-111 |
| Pc                      | P<.001<br>7.31-3.32   | P<.01<br>.092-.024  | P<.001<br>22.4-10.5 | ns                 | P<.01<br>0.88-1.73 | P<.001<br>.46-.11  | P<.001<br>130-94.0 | P<.01<br>107-122  |

TABLE 11-10.0-4 Seasonal comparisons of mean liver metal concentrations ( $\mu\text{g/g}$  dry wt) and length in L. exilis. Levels of significance calculated from t-tests (upper values) and individual means (lower values) are indicated.

|                         |                     |                     |                     |                   |                     |                  |                     |                     |
|-------------------------|---------------------|---------------------|---------------------|-------------------|---------------------|------------------|---------------------|---------------------|
| March 1977 vs July 1977 |                     |                     |                     |                   |                     |                  |                     |                     |
| MIG                     | P<.001<br>4.21-1.54 | P<.001<br>.055-.019 | P<.001<br>23.1-7.85 | P=.01<br>440-227  | P<.001<br>2.59-0.99 | P<.01<br>.16-.05 | P<.001<br>90.2-65.5 | ns<br>ns            |
| PC                      | ns                  | ns                  | ns                  | P<.01<br>705-233  | ns                  | ns               | ns                  | ns                  |
| COP                     | P<.001<br>7.09-1.92 | P<.001<br>.055-.026 | P<.001<br>32.1-9.26 | P<.001<br>777-187 | P<.001<br>2.58-0.79 | P<.01<br>.61-.20 | P<.001<br>138-72.9  | P<.001<br>167-144 " |

\*Measurement taken from tip of snout to hypural bone.

\*\*First and second mean values correspond to March and July collections, respectively.

<sup>†</sup>ns = not significant; see Appendix B for means.

L. exilis exhibited the same trend as S. saxicola for all metals which showed a significant difference, and for all three locations, MIG, PC and COP. MIG and COP showed large, significant increases from March to July for all metals, while only Fe increased at PC.

Comparison of mean metal levels in the livers of S. saxicola and L. exilis are presented in Table II-1 0.0-5. Comparison of the two species collected from MIG during March showed that, in every case except Ni, Lyopsetta contained significantly lower ( $P < .05$ ) metal concentrations than Sebastes. In contrast, species collected in July from MIG showed no significant species differences except for Fe. In the case of Fe, significant species differences were found for all seasons and sites and; with the exception of the March MIG collection, L. exilis always contained higher levels. March PC collections showed that Lyopsetta contained significantly less Cd than Sebastes, but more Cr. During the summer, Lyopsetta still contained significantly lower Cd levels, but Sebastes contained higher Pb levels. No significant metal differences (except Fe) were found between the species collected from COP in July.

#### 10.4 DISCUSSION .

The trace metal data obtained during the Year 11 benthic study is extremely complex and difficult to interpret. We feel that the use of fish as potential indicators of ambient metal change will require much more basic research before their usefulness can be fully evaluated. It is apparent to us that factors such as age (length), sex, maturity, spawning cycle, geographic location, ecology (feeding habits, etc.), season, and stress (pollution) may all interact to give the observed metal levels. Initially, we had no reason to believe that the interaction of these factors would be as potentially important as they now appear to be. However, our present findings indicate that they are most likely very important. Because of this, the discussion will center around these factors.

##### 10.4.1 Geographical Comparisons

Sebastes was collected during the winter only from MIG and PC (Table 11-10.0-1). The only significant differences found were that MIG samples contained more Cd and Fe and were longer ( $P < 0.01$ ). Inspection of the data shows, however, that all of the winter means were higher at MIG than all other sites, and if a significance level of  $P < 0.05$  is used, then concentrations of Cd, Fe, Cu, Pb and Zn were significantly higher for the MIG collection. Since there were no significant differences in mean liver weights between the two seasons (see seasonal comparisons, below), it is very tempting to suggest that these differences are not geographical, but related to significant size (age) differences (i.e. size MIG  $126 \pm 11$  vs. PC  $107 \pm 7$  mm,  $P < 0.01$ ). The relationship between metal concentration and size

TABLE 11-10.0-5 Species comparison of mean metal concentrations in livers of S. saxicola and L. exilis collected in March and July 1977. Concentrations in  $\mu\text{g g}^{-1}$  dry wt, except Cr and Pb, in  $\text{ng g}^{-1}$  dry wt.

| Metal               | San Miguel                 |                 | Point Conception           |                 | Coal Oil Point            |                 |
|---------------------|----------------------------|-----------------|----------------------------|-----------------|---------------------------|-----------------|
|                     | <u>Lyopsetta</u>           | <u>Sebastes</u> | <u>Lyopsetta</u>           | <u>Sebastes</u> | <u>Lyopsetta</u>          | <u>Sebastes</u> |
| Winter (March 1977) |                            |                 |                            |                 |                           |                 |
| Cd                  | 4.2 $\pm$ 1.7 <sup>†</sup> | 11 $\pm$ 3.8    | 3.9 $\pm$ 3.9 <sup>†</sup> | 7.3 $\pm$ 2.0   | —*                        | —               |
| Cr                  | 55 $\pm$ 16                | 89 $\pm$ 89     | 54 $\pm$ 18 <sup>†</sup>   | 24 $\pm$ 10     |                           |                 |
| Cu                  | 23 $\pm$ 9.6               | 29 $\pm$ 9      | 32 $\pm$ 24                | 22 $\pm$ 5.5    |                           |                 |
| Fe                  | 440 $\pm$ 267 <sup>†</sup> | 768 $\pm$ 468   | 705 $\pm$ 300 <sup>†</sup> | 225 $\pm$ 136   |                           |                 |
| Ni                  | 2.6 $\pm$ 1 <sup>†</sup>   | 1.1 $\pm$ 0.5   | 1.6 $\pm$ 1.1              | 0.9 $\pm$ 0.3   |                           |                 |
| Pb                  | 164 $\pm$ 95 <sup>†</sup>  | 738 $\pm$ 295   | 259 $\pm$ 249              | 465 $\pm$ 197   |                           |                 |
| Zn                  | 90 $\pm$ 15 <sup>†</sup>   | 142 $\pm$ 16    | 123 $\pm$ 46               | 130 $\pm$ 18    |                           |                 |
| Summer (July 1977)  |                            |                 |                            |                 |                           |                 |
| Cd                  | 1.5 $\pm$ 0.8              | 1.5 $\pm$ 0.3   | 0.8 $\pm$ 0.6 <sup>†</sup> | 3.3 $\pm$ 2.1   | 1.9 $\pm$ 1.9             | 2.8 $\pm$ 2.0   |
| Cr                  | 19 $\pm$ 5                 | 16 $\pm$ 11     | 42 $\pm$ 39                | 24 $\pm$ 10     | 26 $\pm$ 22               | 24 $\pm$ 18     |
| Cu                  | 7.8 $\pm$ 3.3              | 6.2 $\pm$ 1     | 7.6 $\pm$ 3.0              | 11 $\pm$ 3      | 9.3 $\pm$ 5.2             | 10 $\pm$ 2.9    |
| Fe                  | 227 $\pm$ 99 <sup>†</sup>  | 87 $\pm$ 36     | 233 $\pm$ 104 <sup>†</sup> | 103 $\pm$ 47    | 187 $\pm$ 58 <sup>†</sup> | 95 $\pm$ 44     |
| Ni                  | 0.99 $\pm$ 0.44            | 1.0 $\pm$ 0.3   | 0.9 $\pm$ 0.3              | 1.7 $\pm$ 0.6   | 0.8 $\pm$ 0.3             | 0.8 $\pm$ 0.2   |
| Pb                  | 54 $\pm$ 37                | 79 $\pm$ 46     | 25 $\pm$ 14 <sup>†</sup>   | 106 $\pm$ 65    | 197 $\pm$ 138             | 176 $\pm$ 170   |
| Zn                  | 66 $\pm$ 10                | 71 $\pm$ 6      | 78 $\pm$ 21                | 94 $\pm$ 13     | 73 $\pm$ 15               | 79 $\pm$ 18     |

\*No samples collected

<sup>†</sup>Significant difference ( $P < 0.05$ ) between species at indicated site.

is not an unreasonable assumption to make. Barber, et al., (1972) have shown that Hg does appear to increase with age in benthopelagic fish. However, we found only 2 out of 77 cases where metal concentration vs. length was significant and these were negative correlations (see Volume IV 10.4). In short, we do not know why Sebastes collected during winter from a relatively clean area (MIG) should have higher metal levels than a coastal area (PC). Because of this, we are not prepared to conclude that the winter differences are due to geographical consideration. Note that in the summer PC collections, Sebastes samples contained significantly higher Cu, Ni and Zn and COP contained significantly higher Cu compared to MIG. In both of these cases, there were no significant length or liver weight differences ( $P < 0.01$ ) and therefore, these two variables can be considered controlled. In this case, we may conclude (tentatively) that Sebastes collected from the coastal sites in summer contain more Cu (PC, COP) and Ni and Zn (COP) than their MIG counterparts. It is interesting that higher Cu values were also obtained for Mytilus samples collected from coastal sites than were found from any of the island collection areas (BLM Intertidal Year 11 Final Report 1977).

In the case of Lyopsetta, no significant differences were found for either length or liver weights for samples collected in the winter or summer. Here it is interesting to note that COP collections are the only samples which show significant metal differences. Thus, in winter, COP contains higher Cd, Pb and Zn than the "clean" MIG area and more Ni than PC. However, in the summer, COP contains more Pb than PC and no other differences were found. In view of the fact that we have no other variables with which to correlate the observed differences found in Lyopsetta, we can only conclude that the differences are geographical in nature. Certainly, this is not unreasonable. Lyopsetta is a bottom feeder (Frey, 1971) and the COP area contains significant amounts of sediment oil. It is, therefore, possible that the differences that were observed are somehow related to this oil-impacted area.

#### 10.4.2 Seasonal Comparisons

The seasonal comparison results indicate that large changes in mean trace metal levels occurred in both S. saxicola and L. exilis between winter and summer (Tables 11-10. 0-3 and 11-10. 0-4). These changes occur over a relatively short time span and approach each order of magnitude differences in some cases (e.g. Pb in Sebastes at MIG). As in the above discussion on geographical differences, it is difficult to identify the controlling variable(s). As already mentioned, investigators have often tried to correlate metal concentrations with age (length). Indeed, the MIG winter vs. summer samples show significant mean length differences with MIG comprising the longest group (126 vs. 111 mm,  $P < 0.001$ , Table 11-10. 0-3). It is also evident that the mean metal levels are higher for the MIG winter Sebastes collection. However, the exact reverse occurs when PC

winter vs summer Sebastes comparisons are made. The winter collections have a lower mean length relative to the summer (107 vs. 122 mm,  $P < 0.01$ ), yet the mean metal levels, although lower relative to MIG, are still higher in the winter, showing order of magnitude changes similar to those at MIG. For Lyopsetta samples collected from MIG, there are no significant length differences (Table 11-10.0-4), yet the mean levels for all levels are significantly higher during the winter period. All mean levels from COP samples are also significantly higher during the winter, but so is the length. No significant differences in mean metal levels (except Fe) or length were found for the PC collections.

It is obvious from the above discussion that length as a controlling variable cannot be considered important in terms of the data presented here. However, we do feel that these changes are truly seasonal and that they are related to seasonal fluctuations in liver weight. For example, Sebastes shows a significantly higher mean liver dry weight in summer for both MIG and PC collections: MIG winter vs. summer liver weights = 0.0846 and 0.3582 g, respectively,  $P < 0.01$ ; PC winter vs. summer 0.0704 and 0.2956 g, respectively,  $P < 0.01$ .

Similar conclusions can be reached for Lyopsetta liver data. Winter-summer liver weights for MIG, PC and COP are 0.2176 - 0.5414, 0.1889 - 0.2902 and 0.2085 - 0.3742 g, respectively. It seems reasonable to suggest that fluctuations in liver dry weights may be the overriding factor which contributes to the observed seasonal variations.

It is not difficult to explain these seasonal changes in liver weight. The length of Sebastes ranged from 98 - 162 mm standard length (SL), indicating that they are approximately 3 to 6 years old and most can therefore be considered mature fish (Phillips, 1964). The Lyopsetta collections ranged from 128 - 213 mm SL and are also probably mature (Hart, 1973). In support of the latter statement, many Lyopsetta were observed to be very ripe during the March 1977 collections. It is well known that the livers of teleosts undergo a reduction in size associated with gonadal maturation. We have observed this phenomenon in both Sebastes and Lyopsetta.

Figures 11-10.0-2 to 11-10.0-7 show liver dry weight plotted against length (age) for these two fish at all locations. It can be seen that, where good correlations are obtained (i.e. both Sebastes and Lyopsetta winter and summer collections from MIG), the slopes of the winter regressions are flatter than those of the summer collections (i.e. the winter liver samples are heavier than the summer samples). In contrast, this relationship is poor in almost every instance for the coastal sites.

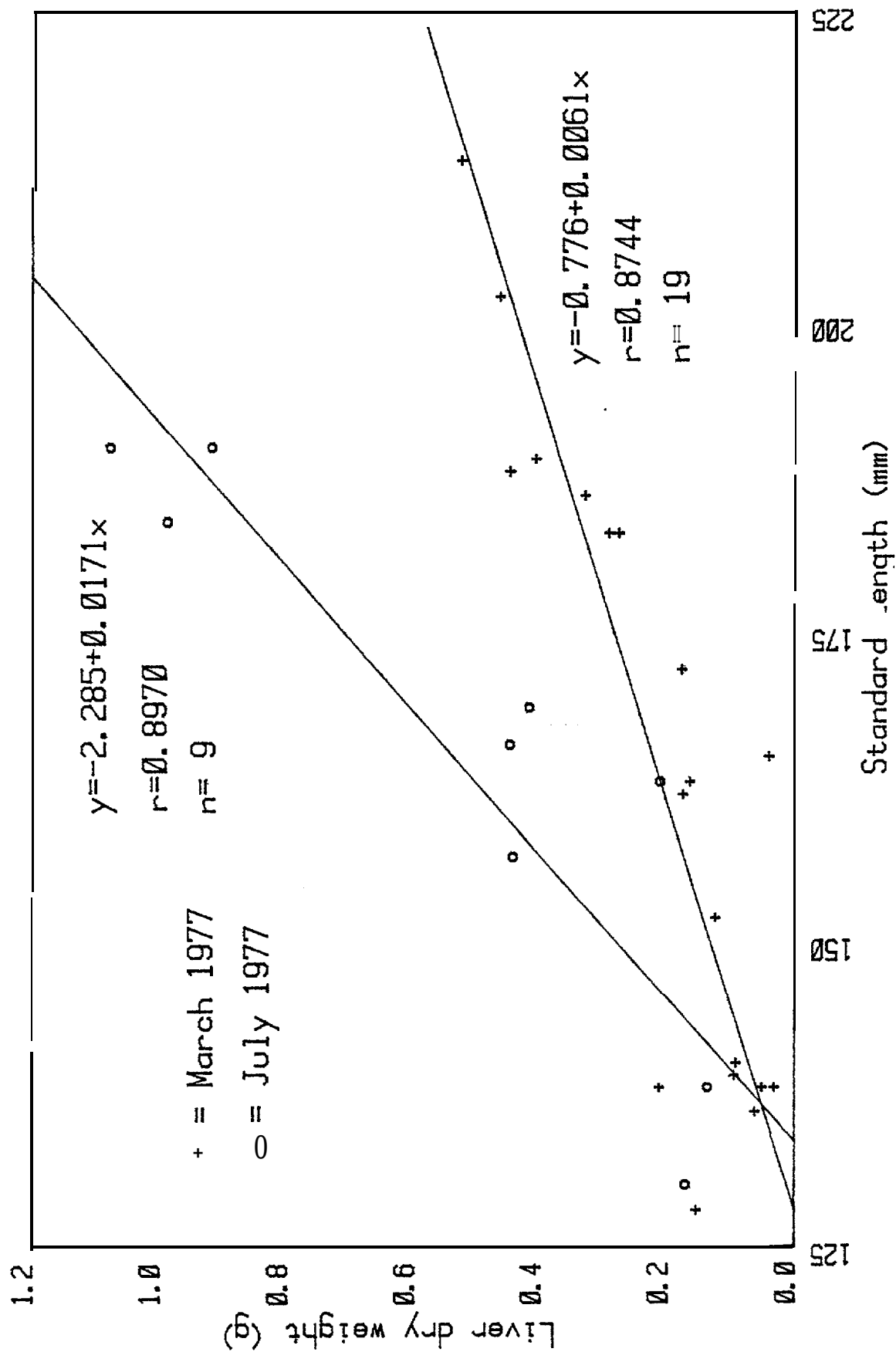


Figure II-10.0-2 Liver dry weight vs. length for Lyopsetta exilis from San Miguel Island

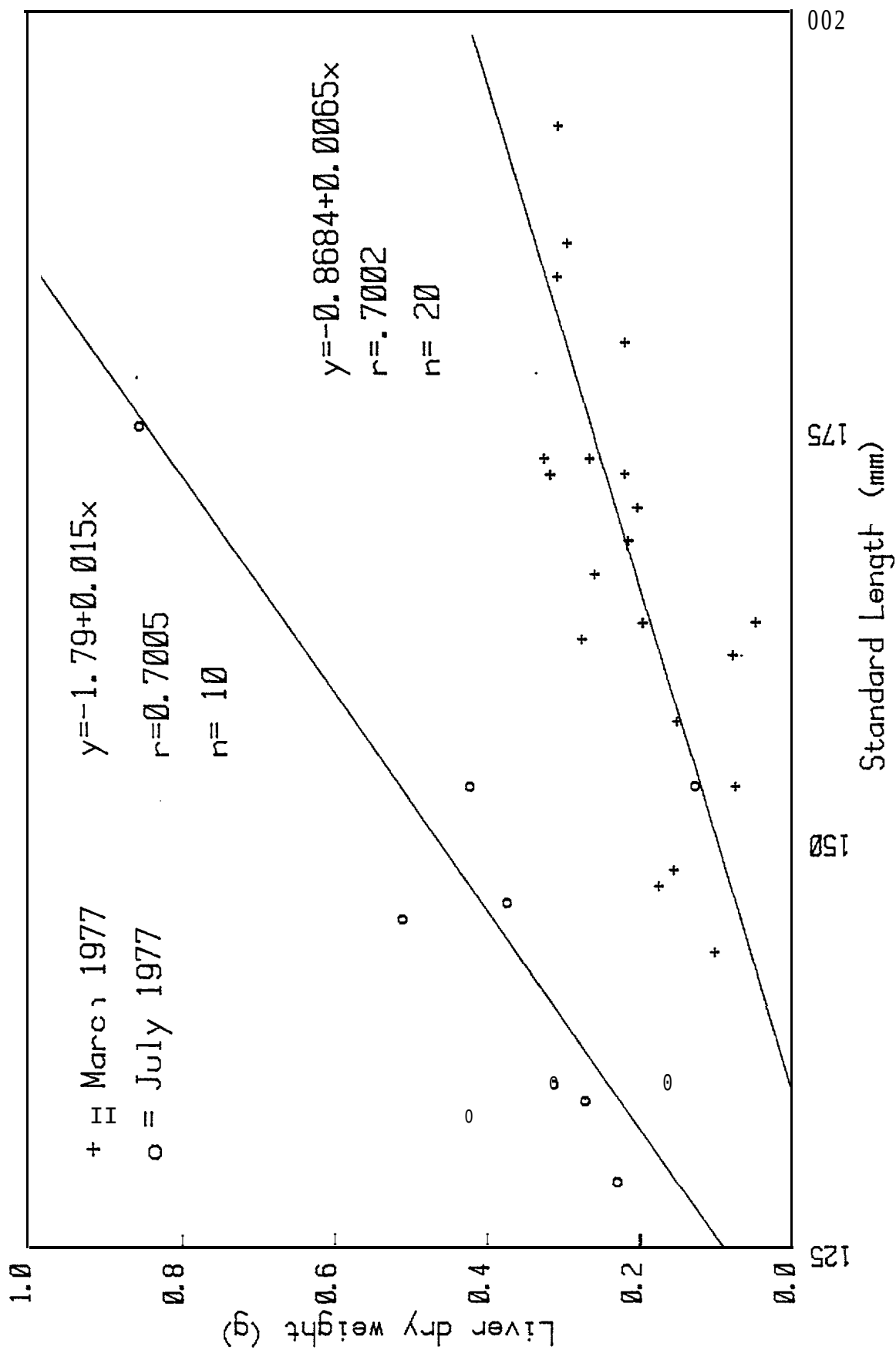


FIGURE II-10.0-3 Liver dry weight vs. length for Lyopsetta exilis from Coal Oil Point.

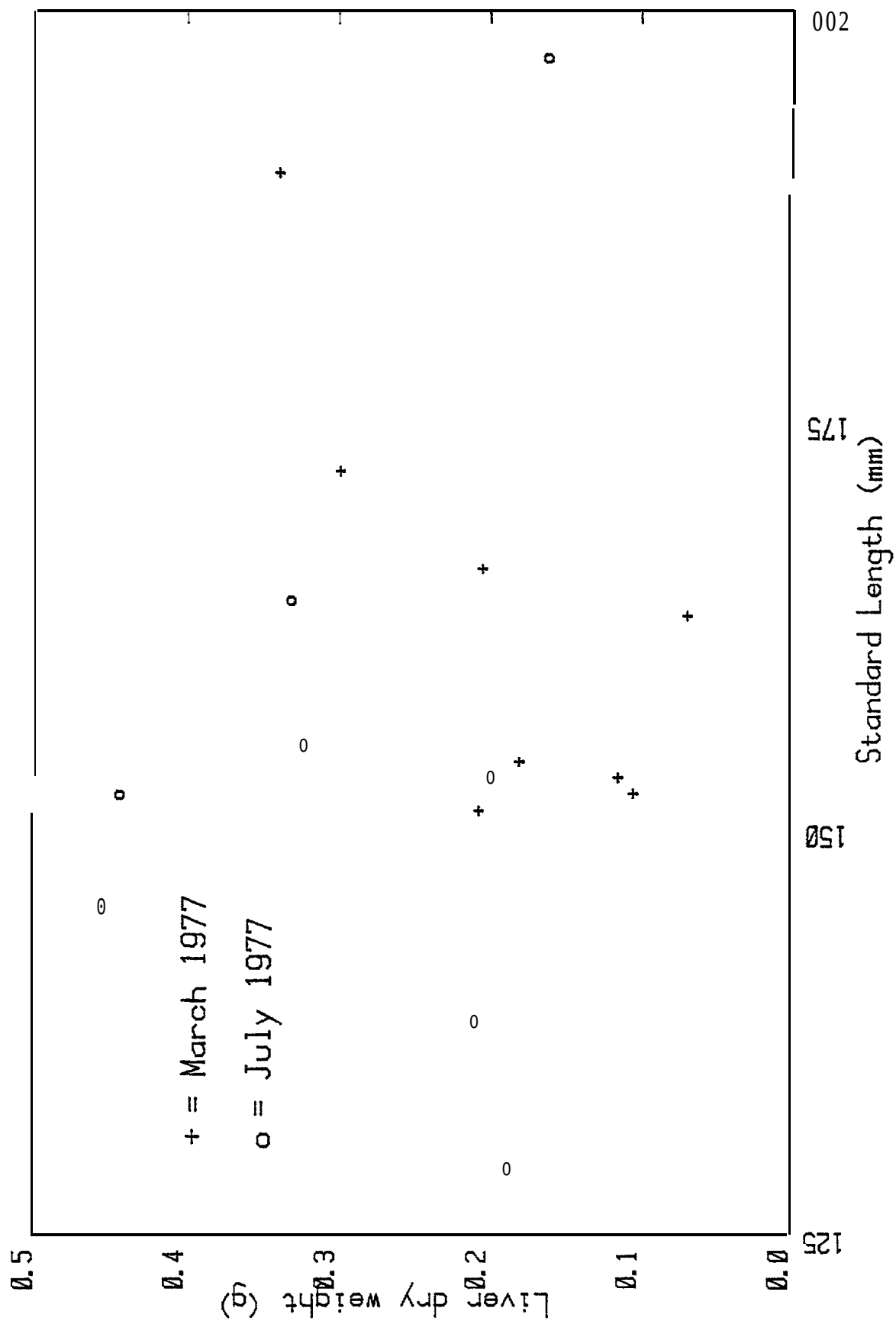


FIGURE 1-1-0-0 Liver dry weight vs. length for Lyopsetta exilis from Point Conception.

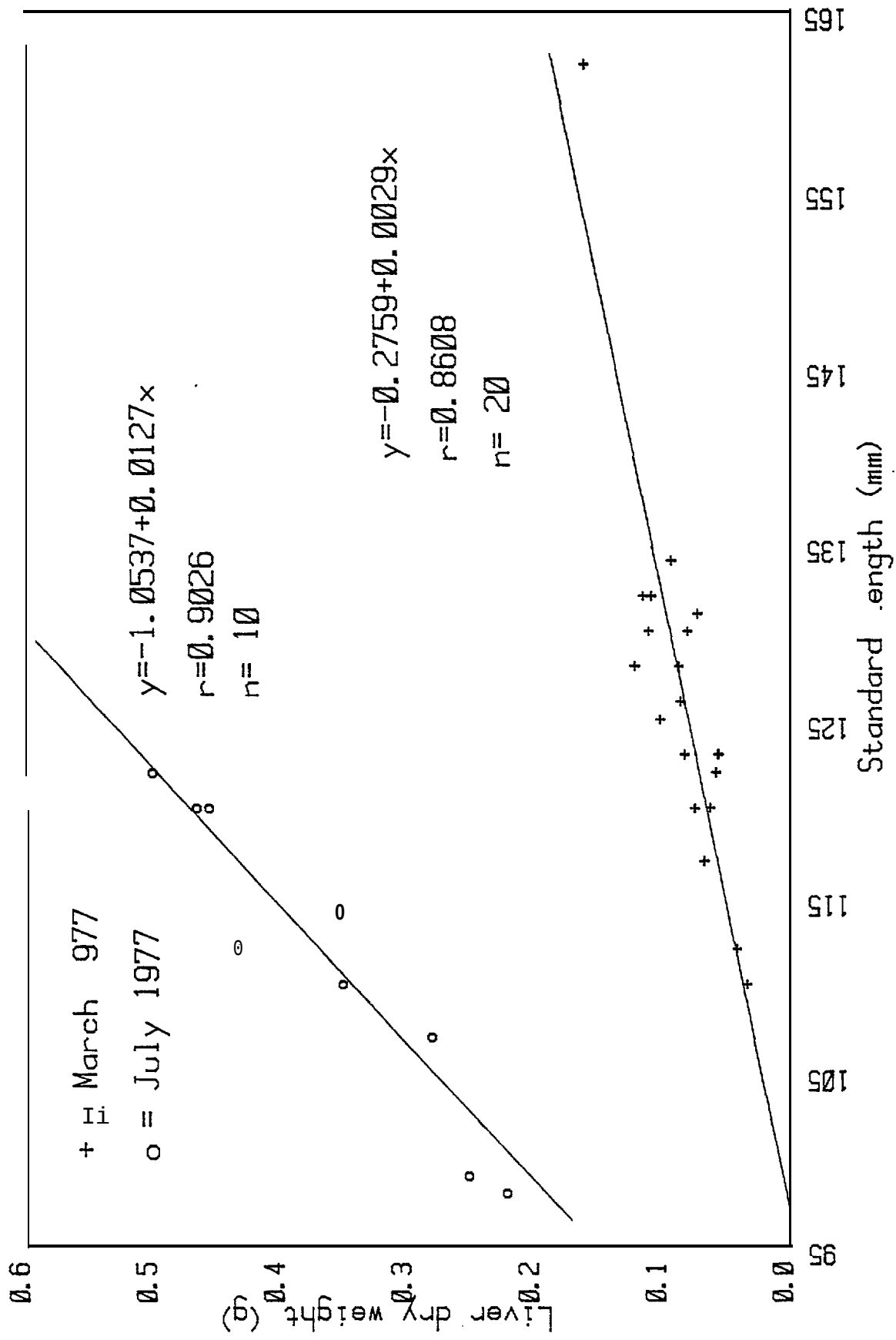


FIGURE II-10.0-5 Liver dry weight vs. length for Sebastes saxicola from San Miguel Island

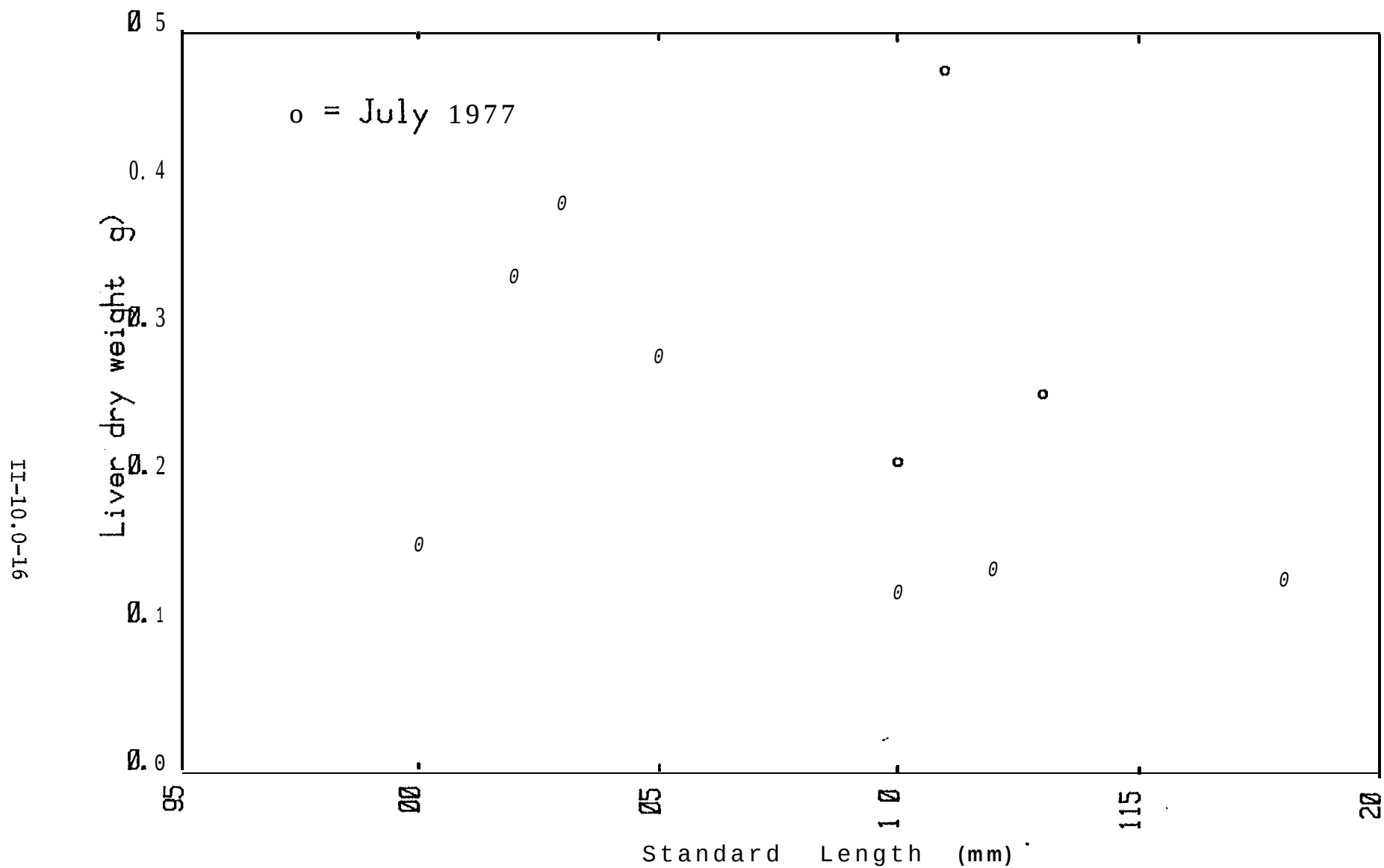


FIGURE 11-10.0-6 Liver dry weight vs. length for Sebastes saxicola from Coal Oil Point.

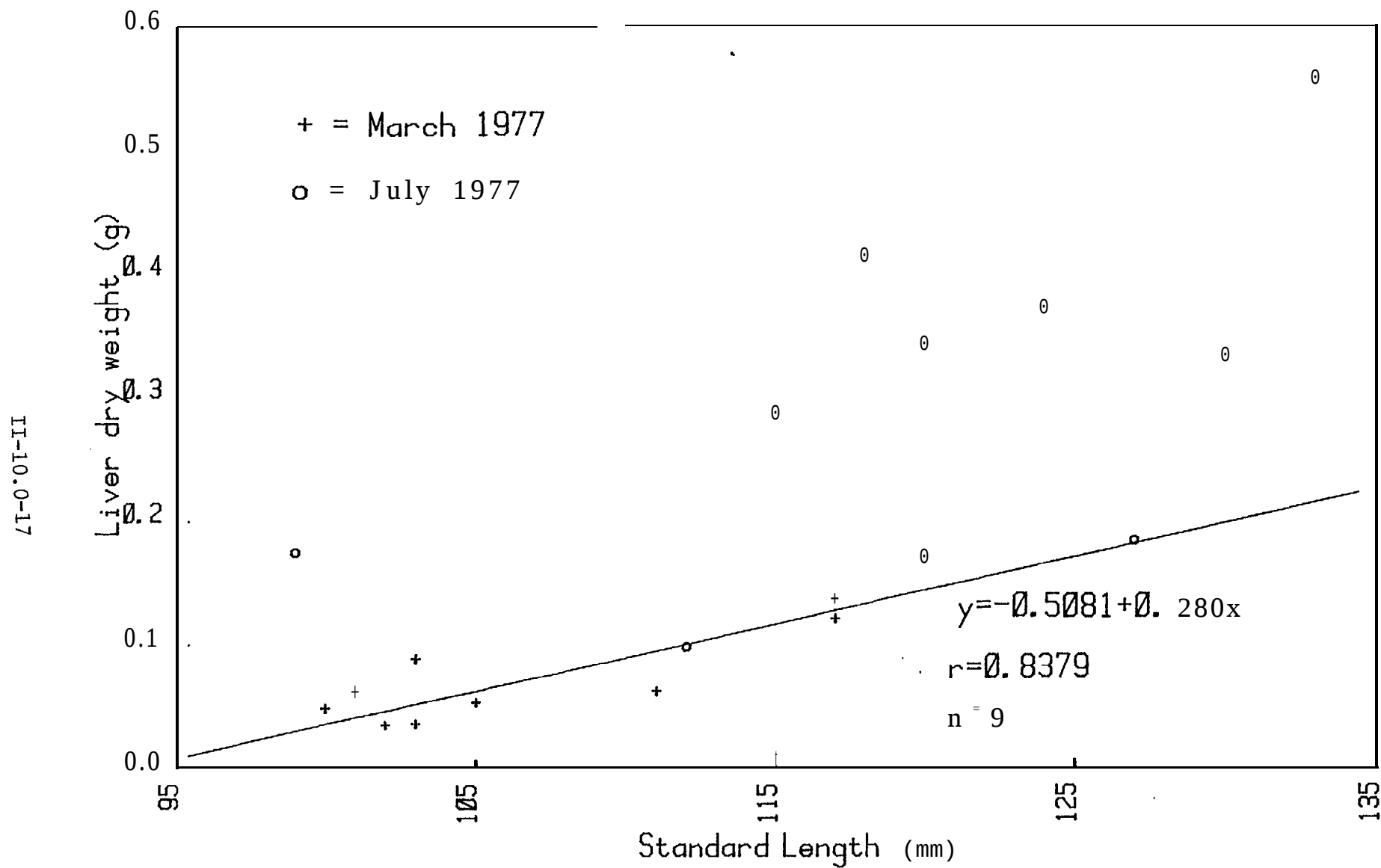


FIGURE 11-10.0-7 Liver dry weight vs. length for Sebastes saxicola from Point Conception.

Mearns and Harris (1975) have found increases in liver wet weight of Dover sole from polluted areas in the southern California bight. It is possible that pollutants in the coastal region are causing abnormalities in liver physiology resulting in a breakdown of the relationship between liver dry weight and length in the coastal collections.

The seasonal reduction in liver weight can be used to explain the seasonal differences in liver metal concentrations. For example, the liver of Fundulus is relatively large in the autumn containing abundant reserves of fats and glycogen. However, by spring, these reserves have been almost completely depleted as a direct response to gonadal maturation (Pickford, 1953). Obviously, if the stored liver deposits are used up in the winter by Sebastes and Lyopsetta and most of the trace metals were retained in the liver, then trace metal concentrations would be high in the winter and low in the summer, due to dilution. If the above mechanism is operating, then there should be no correlation of metal concentration with length, since the liver weight can fluctuate independently of length. This indeed is the case. Only 2 out of 77 significant metal concentrations vs. length were observed (see Volume IV 10.4). On the other hand, if metals are retained in the livers while energy stores are reduced, then total metals vs. length may be expected to be correlated. The results of these correlations may be found in Volume IV - 10.4. It can be seen that many more significant correlations were found and that most of the MIG total metals vs. length correlations were significant. The fact that few of the coastal sites showed such significance may be due to stress. For example, many Sebastes collected during March 1977 showed liver abnormalities (A. J. Mearns, pers. comm.)

#### 10.4.3 Species Comparison

Trace metal concentrations in various species of fish have been reported in the literature and, in many cases, apparent species differences have been observed (Windom, et al., 1973; Bebbington, et al., 1977). We present species comparisons between Lyopsetta and Sebastes on a site and season basis (Table 11-10.0-5). However, the results are conflicting depending on site and season. For example, Sebastes collected from MIG during winter have significantly higher Cd, Cr, Fe, Pb and Zn relative to Lyopsetta. In contrast, no significant differences were observed (except for Fe) between these two species during the MIG summer collections. In addition, only a few differences were found between the species for samples collected from PC in winter and PC and COP in summer.

There is no a priori reason to expect differences or no differences in trace metal concentrations between species of teleost fish. Sebastes is known to be a planktivore (Best, 1961), while Lyopsetta is a bottom feeder (Frey, 1971). Topping (1973) has suggested that

plankton feeding fish may contain much higher levels of some trace metals compared to bottom feeding species. This idea is generally borne out by the MIG Sebastes-Lyopsetta comparisons. The fact that only a few differences were found for the additional Table II-1 0.0-5 data may be due to the relatively high coefficients of variation (i.e. low precision) obtained from both the PC and COP samples. This implies that, perhaps, the near shore sites are more polluted, which is reflected in our relatively better precision at the "clean" MIG collection site.

In fact, however, we have no adequate explanation for the lack of consistency in the species comparisons from season to season or site to site. There may be many underlying factors such as species specific liver trace metal utilization during gonadal maturation or changes in food habits with season or site.

#### 10.5 CONCLUSIONS

A Until more data are collected to investigate and/or control the underlying variables affecting trace metal data in fish, we cannot accurately relate trace metal data to any present or future OCS petroleum activities. Geographical comparisons indicate that Sebastes and Lyopsetta from MIG tend to have lower levels of trace metals compared to PC or COP. Length is probably not a factor, but it cannot yet be ruled out.

Seasonal comparisons show order of magnitude decreases for some metals in both Sebastes and Lyopsetta from winter to summer. This is probably due primarily to changes in liver weight, which, in turn, relates to gonad maturation.

Species comparisons do not show a consistent trend. Underlying factors which may affect each species differently need to be defined and understood.

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## 10.7 RECOMMENDATION

It should be evident from the foregoing discussion that much more basic research will be required before any definitive conclusions regarding the use of fish as monitors for trace element contamination in the marine environment can be reached.