COOPERATIVE MARINE TECHNOLOGY PROGRAM FOR THE MIDDLE EAST

Fourth Annual Report
for the Period
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Technical Report

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COOPERATIVE MARINE TECHNOLOGY PROGRAM FOR THE MIDDLE EAST

Fourth Annual Report

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Cooperative Marine Technology Program

for the Middle East

Fourth Annual Report

FOREWORD

Considerable progress has been made during the third (and final) year of Phase II of the **Cooperative Marine Technology Program for the Middle East.** This is reflected in the numerous technical reports, articles in peer-reviewed journals, symposia proceedings, and presentations at international meetings and conferences. A list of these scientific contributions is provided in this report. As in last year's report, we have opted for succinct summary reports of the completed research activities instead of the technical and lengthy versions that characterized our first and second annual reports.

Missing from the Lake Management Section of this report is the Egyptian component. The late start-up date for that project, together with the shifting of the research activities from Lake Manzalah (Phase I) to the less studied Lake Burulus (Phase II), has prevented inclusion of that segment in this report.

The research activities carried out during Phase II, detailed here, point to the need for further data analysis to develop a predictive model for the **Coastal Management and Shore Processes Project.** They also underscore the need to expand research efforts in the **Biological Productivity of the Southeastern Mediterranean** to include assessment of the pelagic fish stocks using state-of-the-art technology. These and other research efforts in the fields of mariculture and fish nutrition are currently the subjects of a new proposal soon to be submitted to U.S./A.I.D.

We wish to acknowledge, with deep gratitude, the financial support received from A.I.D. during Phases I and II, which enabled scientists from Egypt, Israel, and the U.S. to make scientific advances in their fields while working in an atmosphere of mutual cooperation and friendship.

Sayed Z. El-Sayed
Chief Scientist

COOPERATIVE MARINE TECHNOLOGY PROGRAM FOR THE MIDDLE EAST
MANAGEMENT--PHASE II

Introduction

This was an unusual phase in the history of the Cooperative Marine Technology Program for the Middle East. For the first time, two phases were conducted simultaneously: Year 3 of Phase II and Year 1 of Phase III. Thus, projects in aquaculture, tilapia, coastal management and shore processes, seafood toxins, lake management, biological productivity of the Southeastern Mediterranean Sea, and uses of recycled wastewater proceeded apace. This report, however, will be confined to discussion of projects undertaken during Phase II: shore processes, biological productivity of the southeastern Mediterranean Sea, and tilapia culture.

A second feature of this year's program related to the diminished presence of the American partners, permitting the trend to continue toward closer partnerships between the Egyptians and Israelis. This, of course, is extremely salutary in terms of achievement of the program's basic goals; on the other hand, it strengthens the arguments of the program's proponents who want to continue with marine-oriented projects as the principal carrier of the program enterprises with fewer deviations into other technologies.

The third significant feature of overall program management concerned passage of part of the authority over the program from Agency for International Development (A.I.D.)-Washington D. C. to the American Embassy-Cairo. This is apparently intended to accrue to the benefit of the program, permitting more decisions to be made at the scene of major activity.

Narrative

As the year opened, Dr. Robert Abel made the first of the 1986 visits to the Middle East, spending January 4-6 in Cairo and Alexandria and January 7-9 in Tel Aviv and Haifa. During this time progress in all projects was reviewed.

A high point of the visit was Dr. Abel's discussions with Dr. Moshe Shachel, Israeli Minister of Energy and Infrastructure. The minister was primarily interested in bringing the program's achievements to the attention of Egypt's President Hosny Mobarek and Deputy Prime Minister Yousef Walli. He was also interested in the possibility of other nations joining the program.

Most of the discussions during that visit concerned disposition of funds and funding doctrine. The Hebrew University of Jerusalem questioned the program doctrine that had forbidden overhead up to that point. In Cairo also, the Egyptian government auditors insisted that a certain amount of the funding be withheld from the project operators to provide for indirect costs. Fortunately, Mr. Robert Rosseguie, the new A.I.D. Program Monitor, was on hand in Cairo to assist at the negotiations. When the problem was referred to A.I.D.-Washington, the final decision was that henceforth indirect costs could be allowed in both countries.

During the winter (January and February) 1986, the initial effects of the Gramm-Rudmann bill were felt as A.I.D. commenced reprogramming actions. Phase II was unaffected, however, since A.I.D. had previously programmed the funds and conveyed them on schedule.

During the spring, Washington became the scene of unusual activity when A.I.D. sponsored a symposium on Middle East regional cooperation, including all programs under its jurisdiction. All Principal Investigators in the health, agriculture, and marine programs convened in Washington on May 4-5 to review one another's projects including goals, activities, and general philosophy and to discuss various aspects of the doctrine and philosophy of regional cooperation. On May 6, the Committee on Foreign Affairs of the House of Representatives held a special hearing for the program in which the Principal Investigators met with interested members of the Congress.

In August, the program Steering Committee met in New York City with representatives of the Bigelow Laboratory for Ocean Sciences, Dr. Naim Dowidar of the University of Alexandria (representing the lakes management and productivity of the southeastern Mediterranean projects), Dr. T. Berman of the Israel Oceanographic and Limnological Research, Ltd., Dr. George Mellor of Princeton (who is interested in submitting a new project on the circulation of the Eastern Mediterranean), and Dr. George Assousa, consultant to the program. The purpose of the meeting was to review progress of ongoing projects and to refine the large number of projects submitted for inclusion in Phase IV to a workable number for further analysis.

Certainly the highlight of the year, and perhaps the highlight of the program to date, was Dr. Ahmed Khafagy's trip to Israel in September. As Egyptian Principal Investigator in the Coastal Management and Shore Processes Project, Dr. Khafagy has served prominently in Phases I and II of the program.

At the invitation of the Israeli Minister of Energy and

Infrastructure, Moshe Shachel, via the Egyptian Foreign Minister to the Minister of Irrigation, Dr. Khafagy, as Director of Egypt's Coastal Protection Institute, was assigned to tour the Israeli laboratories and projects under the jurisdiction of the Cooperative Marine Technology Program for the Middle East. His trip, described in detail elsewhere, is held up to the scientists in both countries as a model for cooperative endeavors for the future. In this particular case, the technological spin-off probably ranks equally with the sociological in that close cooperation of Egyptian and Israeli coastal engineers has developed an extraordinarily sophisticated technique for shoreside planning. This achievement will be exploited in the program package to be submitted to A.I.D. for Phase IV.

Minister Shachel was active in behalf of the program in other ways. As a native Iraqi, he has been a personal and principal agent of both Israeli Prime Ministers toward the advance of peace in the Middle East. During his trip to Egypt last fall, he discussed the Cooperative Marine Program with President Mobarek and Deputy Prime Minister Walli, with particular reference to social and technical progress.

Also during the fall of 1986, Dr. Mohammed Abdel Hady, previously Director of the Remote Sensing Center in the Egyptian Academy of Scientific Research and Technology, attained the presidency of the Academy. Dr. Abdel Hady was visited by Drs. Abel and El-Sayed during the October 1986 workshop. At that time, he expressed his admiration for the program and his intent to support it and encourage further Egyptian cooperation.

During late summer, the Honorable Frank Wisner became the new American Ambassador to Cairo. Ambassador Wisner expressed great interest in the Cooperative Marine Program early on and proceeded to encourage its continued progress. This turned out to be crucial to the program's continuation when, through a series of misunderstandings, the annual workshop scheduled for November was abrtuptly canceled.

Through Ambassador Wisner's good offices, the Deputy Prime Minister/Minister of Agriculture, assumed personal cognizance in the matter, arranging for the workshop to be reconvened under his personal sponsorship at the Ministry of Agriculture's International Conference Headquarters on December 1. Under these circumstances, the conference proved to be the best in the history of the program. The first day, a discussion of progress in all ongoing projects was co-chaired by Drs. Colette Serruya of the Israel Oceanographic & Limnological Research Ltd., and A. R. Bayoumi, of the Egyptian Academy.

On December 2, the meeting was devoted to discussion of the projects tentatively agreed upon at the New York meeting. After lengthy discussion, the package for Phase IV was fixed at "Trophodynamics of Marine Fisheries off the Egyptian and Israeli Coasts," A Study of the Circulation of the Eastern Levantine Basin," "Shoreside Model for Shoreline Changes along the Nile Littoral Cell," and "Fish Nutrition," and "Cooperative Development of Freshwater Prawn Culture in Egypt, Israel, and the United States." A cooperative program on mechanisms involved in coronary artery stenosis is also being considered. A final meeting of the Steering Committee was held the following day.

On December 4, the Israeli and American Coordinators met with Deputy Prime Minister Walli who affirmed his personal support for the program and pledged his cooperation in all phases. Thus, the program finished the year on a highly successful note.

Program Doctrine

A number of aspects of the program's philosophy came under considerable scrutiny throughout the year. As mentioned above, regional cooperation was afforded an opportunity to achieve strong external and internal coordination at the A.I.D. symposium in May. One of the meeting's products was a consensus of greater efficiency in the program's interest from projects of like nature submitted to A.I.D. in packages, rather than as individual projects or tasks.

Clearly evident in the program's component projects were improvements in communications and technical cooperation. Curiously, cooperation has proceeded along unique individual lines for each project, rather than in a uniform manner. For instance, joint operational planning and sharing of results have characterized the biological productivity project; the tilapia project has featured the trading of fish; and the coastal management and shore processes project has been marked by frequent interchanges of personnel and cooperative engineering development. It is proposed that this diversity of approach is in the best interests of regional cooperation overall and should be fostered and greatly encouraged during Phase IV.

Robert Abel
Program Manager

Papers/Abstracts/Technical Reports

resulting from

Cooperative Technology Programs for the Middle East (Phase II)

(1984/86)

I. Coastal Management and Shore Processes

Published Papers

Carmel, Z., D.L. Inman and A. Golik. 1984. Transport of Nile sand along the southeastern Mediterranean coast, pp. 1282-1290. In: Proc. 19th Coastal Engin. Conf., V. 2, Amer. Soc. Civil Engin., New York.

Carmel, Z., D.L. Inman and A. Golik. 1985a. Characteristics of storm waves off the Mediterranean coast of Israel. Coastal Engineering, 9:1-19.

Carmel, Z., D.L. Inman and A. Golik. 1985b. Directional wave measurement at Haifa, Israel, and sediment transport along the Nile Littoral Cell. Coastal Engineering, 9:21-36.

Inman, D.L. and S.A. Jenkins. 1984. THe Nile Littoral Cell and man's impact on the coast zone of the southeastern Mediterranean, pp. 1600-1617. In: Proc. 19th Coastal Engin. Conf., V. 2, Amer. Soc. Civil Engin., New York.

Papers in Press

Carmel, Z. in press. Haifa summer waves. Israel Journal of Earth Sciences.

Elwany, M.H.S., D.L. Inman and A.A. Khafgy. in preparation. Wave climate and sand transport along the Nile Delta.

Technical Reports

Boyd, W. and R.L. Lowe. 1985. A high density cassette data acquisition system: operation and applications, pp. 606-609. In: Oceans 85: Ocean Engineering and the Environment, Marine Technological Society and IEEE, V. 1, 674 pp.

Inman, D.L. and S.A. Jenkins. 1984. The Nile Littoral Cell and man's impact on the coastal zone of the southeastern Mediterranean, Univ. of California, Scripps Inst. of Oceanography, SIO Reference Series 84-31, 43 pp.

Lowe, R. and D.L. Inman. 1984. Wave parameters Abu Quir Array, Egypt. Univ. of California, Scripps Inst. of Oceanography, SIO Reference Series 84-32, 5pp + tbls. + figs.

II. Biological Productivity of the Southeastern Meditrranean

Published Papers

Azov, Y. 1986. Seasonal patterns of phytoplankton productivity and abundance in nearshore oligotrophic waters of the Levant Basin (Mediterranean). J. Plankton Research, 8: 41-53.

Berman, T., Y. Azov, A. Schneller, P. Walline, and D.W. Townsend. 1986. Extent, transparency and phytoplankton distribution of the neritic waters overlying the Israeli coastal shelf. Oceanol. Acta (in press).

Christensen, J.P., V. Goldsmith, P. Walline, A. Schneller, T. Berman, and S.Z. El-Sayed. 1986. Sedimentary nutrient regeneration on the oligotrophic eastern Mediterranean continental shelf. Oceanol. Acta (in press).

Dowidar, N.M. 1985. Epipelagic copepods of the southeastern Mediterranean, general remarks. Rapp. Comm. Int. Mer Medit., 29, 9:239-243.

Dowidar, N.M. and F. El-Nady. 1985. Distribution of some trace metals in the Mediterranean waters off the Nile Delta. Rapp. Comm. Int. Mer Medit., 29, 7:43.

Dowidar, N.M. and H. El-Rashidy. 1986. Ichthyoplankton of the Egyptian Mediterranean waters, 1. Eggs of Engraulis encrasicolus. Rapp. Comm. Int. Mer Medit., 30, 9: (in press).

Dowidar, N.M. and A. Abdel Moati. 1986. Distribution of nitrogen and phosphorus in the Mediterranean waters off the Nile Delta. Rapp. Comm. Int. Mer Medit., 30, 7: (in press).

Dowidar, N.M. and T.A. About Kassim. 1986. Levels of nutrient forms and chlorophyll a biomass in a highly polluted basin, the Eastern Harbour of Alexandria. Rapp. Comm. Int. Mer Medit., 30, 7: (in press).

Dowidar, N.M. and M.A. El-Sabroute, and A.A. El-Sammak. 1986. Distribution of organic carbon, nitrogen and phosphorus in the surficial sediments off the Nile Delta. Rapp. Comm. Int. Mer Medit., 30. (in press).

Dowidar, N.M. 1986. Effect of Aswan High Dam on the biological productivity of the southeastern Mediterranean. Proceedings: International Conference on Natural and Man-Made Hazards, Rimouski, Quebec, Canada, 3-9 August 1986.

Townsend, D.W., J.P. Christensen, T. Berman, P. Walline, A. Schneller, C.S. Yenstch. 1986. Near-bottom chlorophyll maxima in shelf waters of the southeastern Mediterranean Sea: upwelling and sediments as possible nutrient sources. Oceanol. Acta (in press).

Papers Submitted

Kimor, B., T. Berman, and A. Schneller. Phytoplankton assemblages in the deep chlorophyll maximum layers off the Mediterranean coast of Israel. J. Plankton Research.

Walline, P.D. Growth and ingestion rates of larval fish populations in the coastal waters of Israel. J. Plankton Research.

Technical Reports

Weber, L.H. and S.Z. El-Sayed. 1985. Biological productivity of southeast Mediterranean in post High Dam (Aswan) period: Phytoplankton studies during the April 1985 cruises of the NOOR YANABI and SHIKMONA. Technical Report, Texas A&M Research Foundation No. RF-5089-1, 23 pp.

Theses/Dissertations

The following theses registered at the Faculty of Science, Alexandria University, are wholly a result of the biological productivity project.

Hesham Mostafa. Phytoplankton production and biomass in the southeastern Mediterranean off the Egyptian coast. (M. Sc. awarded.)

Nabil Nasr El-Din. Hydrographic structure of the shelf area of the southeastern Mediterranean off the Egyptian coast. (M. Sc. awarded.)

Hoda El-Rashidi. Ichthyoplankton of the Mediterranean waters of Egypt. (M.Sc. in preparation.)

Howida Y. Zakaria. Zooplankton of the southeastern Mediterranean. (M. Sc. in preparation.)

Nehad M. Nour El-Din. Distribution and ecology of epipelagic copepods of the southeastern Mediterranean. (M. Sc. in preparation).

Fadia Aboul Magd. Budget of the nutrient salts in the Mediterranean waters of Egypt. (M. Sc. in preparation.)

Amre El-Sammak. Geochemistry of surficial sediments of the continental shelf of the Egyptian Mediterranean waters. (M. Sc. in preparation.)

Baher M. Aly. Trace metals in surficial sediments of the continental shelf of the Egyptian Mediterannean waters. (Ph. D. in preparation.)

IV. Lake Management

Papers Published

Gophen, M. (1984). The impact of zooplankton status on the management of Lake Kinneret (Israel). Hydrobiologia 113:249-258.

Gophen, M. (1985a). The management of Lake Kinneret and its drainage basin. Scientific Basis for Water Management (Proc. Jerusalem Symp. IAHS No. 153:127-38.

Gophen, M. (1985b) Effect of fish predation on size class distribution of cladocerans in Lake Kinneret. Verth. Intl. Verein. Limnol. 22:3104-8.

Gophen, M. (1985c). Zooplankton. In Lake Kinneret. Annual Report, ed. M. Gophen, pp. 82-83. Tabgha: Yigal Allon Kinneret Limnol. Lab.

Gophen, M. (1985d). The management of Lake Kinneret and its drainage basin. In Scientific Basis for Water Resources Management. Proceedings of the Jerusalem Symposium, IAHS Publ. No. 153, pp. 127-138.

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Gophen, M. (1986). Fisheries management in Lake Kinneret (Israel). Proceedings of the Annual Meeting of North American Lake Management Society, Lake Geneva, Wisconsin. 13-16 November 1985.

Gophen, M. and Pollingher, U. (1985). Relationships between food availability, fish predation and the abundance of the herbivorous zooplankton community in Lake Kinneret. Arch. Hydrobiol. Beih. Ergebn. Limnol. 21:397-405.

Spatura, P. and Gophen, M. (1985a). Feeding behaviour of silver carp Hypophthalmichthys molitrix Val. and its impact on the food web in Lake Kinneret (Israel). Hydrobiolog. 120:53-61.

Spatrua, P. and Gophen, M. (1985b). Food composition of the barbel Tor canis (Cyprinidae) and its role in the Lake Kinneret ecosystem. Environmental Biology of Fishes.

Spatura, P. and Gophen, M. (1985c). Food composition and feeding habits of Astatotilapia flaviikosephi (Lortet) in Lake Kinneret (Israel). J. Fish. Biolog. 26:503-7.

Spatura, P. and Gophen, M. (1986). The food and benthophagous feeding habits of Barbus longiceps (Cyprinidae) in Lake Kinneret (Israel). Archiv fur Hydrobiologie.

Papers in Press

Gophen, M. Fisheries management, water quality, and economic imparts: A case study of Lake Kinneret. International Conference on Great Lakes, Mackinac Island, Michigan, May 18-21, 1986.

Gophen, M. Fisheries management in Lake Kinneret (Israel), pp. 327-332. 5th Annual Meeting of North American Lake Management Society, proceedings.

Papers Submitted

Spatura, P. and Gophen, M. Food and feeding habits of Capoeta damascina (Cyprinidae) in Lake Kinneret, Israel. J. of Tropical Aquaculture

I. COASTAL MANAGEMENT AND SHORE PROCESSES IN THE SOUTHEAST MEDITERRANEAN

I.a. Coastal Management and Shore Processes in the Southeast Mediterranean

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INTRODUCTION

Coastal Management and Shore Processes in the Southeastern Mediterranean is a project of the Cooperative Marine Technology Program for the Middle East sponsored by the Agency for International Development, U.S. Department of State. This project is a cooperative trilateral study among the Coastal Research Institute, Alexandria, Egypt; Israel Oceanographic and Limnological Research, Haifa, Israel; and the Center for Coastal Studies, Scripps Institution of Oceanography, La Jolla, California. The scientific objectives of this project are: determine the wave and current "climate" in nearshore waters that provide the potential for sediment transport; understand the budget of sediments in the Nile Littoral Cell, and the sediment sources, transport paths and sinks; and to apply the principles of shore processes to the solution of erosion and other coastal engineering concerns. The administrative objective was to transfer technology necessary to operate and maintain sophisticated wave and current monitoring systems, and to transform this data into a form appropriate for assessing the sediment transport rates along the Egyptian and Israeli shores of the Nile Littoral Cell. The administrative objective was unequivocally met. Since waves and shoreline response varied from year to year, it was not possible to acquire a statistically reliable data base in the three-year time frame of the AID II project.

The essence of the AID I and II projects was to provide a data base for the driving functions (waves and currents) and the sediment response (beach changes) necessary for the formulation of a computer model for simulating shoreline changes along the Nile Delta and the coast of Israel. The principal components leading to this data base have been assembled as indicated by the attached list of publications and papers in preparation. The stage is now set for the final phase of this project, a predictive model for shoreline change as set forth in the proposal for AID IV (Appendix I). This report provides details of the scientific and administrative work undertaken during the report period.

RESEARCH RESULTS

The Center for Coastal Studies' (CCS) Engineering Support Group fabricated a fourth CAS system for the Israel Oceanographic and Limnological Research Ltd. The Coastal Research Institute (Alexandria, Egypt) decided that construction of a fourth station should wait until the existing stations were functioning in a routine manner. Additional pressure sensors, armored cable and recorder units were furnished in lieu of a fourth CAS system.

Data return from all CAS stations has been very good. Over 70% of the scheduled observations were obtained for the Ras El-Bar station and over 85% for Abu Quir. The stations at Ashkelon provided 88% returns, and the Haifa station 82%.

Statistical and spectra analysis of wave data was performed by the groups responsible for each station. The following conclusions were reported by the respective groups:

1. The wave action along the Nile Delta Coast is seasonal in nature and strongly related to the west to east traveling meteorological systems in the Mediterranean. These systems can be classified into three seasonal patterns:

summer season	June to September
winter season	October to March
spring season	April to May

2. Wave height at Abu Quir is higher than at Ras El-Bar, while the wave period is essentially the same.

3. Predominant wave direction is:

Ras El-Bar	wave height > 0.5m	NW
	wave height < 0.5m	NE to NW
Abu Quir	wave height > 0.5m	W to NW
	wave height < 0.5m	NE to NW

4. Wave period ranges between 4 and 11 seconds. Predominant wave period is 7 to 8 seconds.

5. At Ashkelon and Haifa two distinct cycles in wave height were recognized: a winter cycle and summer cycle.

6. At Askelon the winter cycle peaks at 0.98m average significant wave height with average peak wave period of 7.7 seconds; summer cycle peak height is 0.70m and wave period of 6.9 seconds.

7. At Haifa the winter cycle peaks at 1.07m average

significant wave height with average peak wave period of 7.9 seconds; summer cycle peak height is 0.65m, and wave period of 6.8 seconds.

The Coastal Research Institute undertook field surveys of the Burullus area to investigate the mechanisms causing shoaling of the estuary. It was determined that sediment moving in the breaker zone from west to east passed over the western jetty and caused siltation of the outlet.

Collection of field data from the northern coast of Sinai was also initiated. This area is an extension of the original study area and closes the data hiatus between the Nile delta shore and the shores of Israel.

ADMINISTRATIVE ACCOMPLISHMENTS

All parties in the project have acquired the technology to operate the CAS systems and routinely maintain them. All data analysis is now peformed at the respective institutions.

MEETINGS

Dr. Elwany visited Scripps Institution of Oceanography from September to December 1985. During this period he became conversant with the software for data analysis of the CAS system and he began a general wave refraction program for the Nile Delta.

The principle investigators of all three groups met in La Jolla, California in December 1985. The meetings included Dr. A. Khafagy and H. Elwany from Egypt, Drs. A. Golik and Z. Carmel from Israel and Professor D. L. Inman and Engineer R. Lowe from CCS. This meeting reviewed the achievements to date and agreed on future activities.

In June 1986 Dr. Ahmed Khafagy visited the National Institute of Oceanography at Haifa. This visit resulted in agreement on many important issues related to analysis of data collected along southeastern Mediterranean coasts and to the application of the project equipment.

SUMMARY

The project has been extremely successful. For the first time the Nile Littoral Cell was jointly studied by scientists from Egypt and Israel. Both groups have learned the technology required for successful wave monitoring and data analysis.

It has been established that the principal driving forces for coastal erosion in the Nile Littoral Cell are waves, currents and wind. Erosion is exacerbated by the loss to the coast of sediment now trapped behind the Aswan High Dam. Longshore sediment transport ranges from thousands to millions of cubic meters per year.

The information obtained during this project provides important input for future coastline management projects proposed for AID IV (Appendix I).

PUBLICATIONS

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Carmel, Z., D. L. Inman & A. Golik, 1985, "Transport of Nile sand along the southeastern Mediterranean coast," p. 1288-1290 in Proc., 19th Conf. Coastal Engineering, v. 2, Amer. Soc. Civil Engin.

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Coastal Research Institute, 1986, "Data collected in the coastal zone along El-Bardawil coast," Progress Report 1, March 1986.

Coastal Research Institute, 1986, "A study for the protection and dredging of El-Burullus Outlet," September 1986.

Coastal Research Institute, 1986, "Data collected in the coastal zone along El-Arish coast," Progress Report 1 (in press).

Elwany, M.H.S., A. A. Khafagy and D. L. Inman, 1986, "Probabilistic analysis of wave data recorded at Abu-Quir and Ras El-Bar arrays between June 1985 and May 1986," Coastal Research Inst., Internal report.

Elwany, M.H.S., A. A. Khafagy and A. M. Fanos, 1986, "Evaluation of the hydraulis of tidal inlets mathematic computer model, 1986," Coastal Research Inst., Internal report.

El-Fishawi, N. M., 1984, "Roundness and sphericity of the delta coastal sands," Acta Mineralogica-Petrographica, Szeged, v. 26, n. 12, p. 235-245.

El-Fishawi, N. M. and B. Molnar, 1984, "Distinction of the Nile delta coastal environments by scanning electron microscopy, a statistical evaluation," Acta Mineralogica-Petrographica, Szeged, v. 26, n. 12, p. 247-259.

El-Fishawi, N. M., 1985, "Textural characteristics of the Nile delta coastal sands, an application in reconstructing the depositioal environments," Acta Mineralogica-Petrographica, Szeged, v. 27, p. 71-88.

El-Fishawi, N. M. and B. Molnard, 1985, "Mineralogical relationships between the Nile delta coastal sands," Acta Mineralogica-Petrographica, Szeged, v. 27, p. 89-100.

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IN PREPARATION

Elwany, M. H. S. & D. L. Inman, in preparation, "Wave climate and sand transport along the Nile Delta,"

Elwany, M. H. S., A. A. Khafagy & D. L. Inman, in preparation, "Abu Quir and Ras El-Bar Wave Arrays: Probabilistic analysis of wave data recorded between June 1985 and May 1986," 41 pp. + appendix.

I.b. Coastal Management and Shore Processes in the Southeast Mediterranean

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1. INTRODUCTION

The project of Coastal Management and Shore Processes in the southeast Mediterranean is one of the activities of the Cooperative Marine Program for the Middle East, which began in January 1981. Four reports have been submitted to date covering the previous periods.

This report describes in brief the scientific and cooperative accomplishments achieved during 1985/1986. It includes the following:

a. Research undertaken

b. Summary of results

c. Major accomplishments

d. Future research plans

e. List of publications.

2. RESEARCH WORK UNDERTAKEN

The work carried out consists of the following activities:

a. Continuing full monitoring of marine and coastal phenomena; i.e., waves, currents, beach profile evolutions, etc., and studying the distribution of sediment transport.

b. Maintainance of CAS I at Abu Quir and CAS II at Ras El-Bar. A sizable amount of wave data has been recorded which gives reasonable accurate information about the wave climate along the Delta Coast.

c. Complete analysis of the wave records carried out at the Institute in Alexandria.

d. Detailed hydrographic survey for the coastal zone at Ras El-Bar from shoreline to 10m water depth.

e. Field data collection of Burullus area, studying the shoaling problems of its estuary and working out the solution to keep its outlet free from heavy siltation.

f. Monitoring and collecting of field data of the northern coast of Sinai. This work is actually an extension of our original study area, which was limited to the delta shores from Abu-Quir to Port Said. The extension was meant to close to gap in the information between the delta shore and the shores of Israel and to understand the causes of the shore's instability at El-Arish and El-Bardawil.

g. Analysis of wind data collected at Abu-Quir to establish a model for wind climate.

h. Analysis of samples collected from the surface of sea bottom of the whole nearshore zone and determining the spatial and temporal variation.

i. Carrying out the studies, planning and designing protective works for the marine outlet of Western Nobaria Drain. The studies were held during and after implementation of the protection works to evaluate any side effects on the neighboring area.

j. Investigation to calculate the budget of medium and coarse sand near El-Burullus to evaluate possibilities of using it as artificial nourishing material.

3. SUMMARY OF RESULTS

3.1 Wave Data

The measured wave data of Abu Quir and Ras El-Bar CAS stations have been subjected to statistical and spectra analysis from which the following conclusions were drawn:

a. The wave action along the Nile Delta coast is seasonal in nature and is strongly related to the air pressure systems which can be classififed into three various patterns, as follows:

- Summer seasons occurs June to September
- Winter season occurs October to March
- Spring season occurs April to May

b. The wave height at Abur Quir is higher than that at Ras El-Bar for the same recording period while the wave period is more or less the same.

c. At Ras El-Bar, the predominant wave direction for waves higher than 0.5m is from the NW while it varies from NE to NW for waves less than 0.5 m.

d. At Abu Quir the predominant wave direction is in the sector from W to NW for waves greater than 0.5 m, and NE to

NW for waves less than 0.5 m.

e. The wve periods range from 4 to 11 seconds. The predominant wave period is 7 to 8 seconds.

3.2 Burullus Outlet

The data collected in this area was analyzed with the following results:

- The predominant direction of the littoral current is from west to east. Its average vlocity is 0.40 m/sec.

- the average discharge through the outlet is 40 m3/sec during the flood and 45 m3/sec during the ebb.

- the tidal range is about 15 cm.

- the cross-sectioal area (wetted area) of the gorge changed from 275 m2 at the beginning of the study period to 175 m2 at the end of the study.

- the sediments are moving in the breaker zone from west to east overpassing the western jetty on the outlet and causing the siltation of this outlet.

It is suggested the following recommendations be carried out to reduce the rate of siltation of the outlet:

a. Extension of the existing western jetty to contour 3.25m

b. Construction of a new eastern jetty, in the outlet itself, almost parallel to the western one but shorter, creating a modified channel of the outlet.

c. Protection of both sides of the Said channel by using geotextile filters and stones.

d. Smoothing the gorge channel leading to the lake and protecting its embankment slopes by revetment on filter layer.

e. The shore between the Said new jetty and the old eastern one is to be protected by flexible basalt embankment laid on geotextile filter layer.

3.3 Sediment Distribution Along the Nile Delta Coast

Mechanical and pipette tube analysis of the surface samples of the sea bottom have been carried out. It is found that:

a. The grain size of coastal sediments in general is fine at both promontories, i.e. Rosetta and Ras El-Bar, while it is coarser at Burullus headland.

b. The mean diameter of the bed material decreases from the shoreline towards the sea hwere D_{50} decreases from 0.25 mm to 0.063 mm, except for some patches of coarser sediments in front of Maadia and Burullus where D_{50} u is about 0.5 mm.

c. Comparing the changes of the grain size with time, it is noticed that the sediments became finer by time.

4. MAJOR ACCOMPLISHMENTS

4.1 Transferring the Know-How Technology

The project has acquired the know-how technology of the CAS system, originally developed at Scripps Institution of Oceanography, Shore Processes Laboratory. Now the Institute technicians, scientists and engineers are well acquainted with the hardware and software of the system. The analysis of the system data is being carried out as a routine operation via computer. All the records since 1985 from Abu Quir and Ras El-Bar stations were analyzed in Alexandria.

The electronic maintenance section has become familiar with the components and circuits of the CAS system, and is capable of maintaining it and carrying out minor repairs that may arise.

4.2 Exchange of Information and Views between the Contributing Groups

a. Under this effect, Dr. Hany Elwany made a visit to Scripps from September to December 1985. During his visit he successfully acquired knowledge of CAS software and the methodology of data analysis. He also conveyed this highly advanced technology to the concerned members of the Institute staff.

b. The principal investigators of the three contributing parties have convened in La Jolla in December 1985 and have reviewed their achievements, agreed on activities, work plan and budgets for AID IV.

c. During June 1986, a working visit to Haifa's National Institute of Oceanography was made by the Egyptian principal investigator to organize, coordinate and strengthen ongoing research under the auspices of this project. This visit resulted in agreement on several important issues relating to the analysis of data collection along the southeastern Mediterranean coasts and to the application of project equipment. Cooperation between the consequent parties to upgrade project achievements and services were also organized.

5. FUTURE RESEARCH PLAN

a. Install an array of deep current meter recorders to measure and analyze the current circulation in the southeastern Mediterranean.

b. Survey the sea bottom to explore and evaluate coarse and medium sand budget in the nearshore zone which may be suitable for artificial nourishment.

c. Modify and apply mathematic computer model techniques to study the stability of tidal inlets.

d. Continue wave data collection by CAS system and analyze its records for wave climate information. Set up a new CAS station near El-Arish.

e. Develop a sophisticated mathematical computer model for sediment transport along the southeastern Mediterrean shoreline which would predict shore evolution and side effects of man-made coastal and marine structures.

f. Continue data collection of waves, hydrographic profiles, currents, etc.

I.c. Coastal Management and Shore Processes in the Southeast Mediterranean

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Coastal Management and Shore Processes in the Southeast Mediterranean

INTRODUCTION

This report describes the developments in the AID project (Phase II) in Israel from June 1985 through September 1986. During this period, the two CAS stations continued for the third year to measure waves off the beaches of Haifa and Ashkelon. Most recent effort was directed at analyzing and reducing the data which were collected during this three-year period. The highlights of an extensive scientific report, which is now in preparation, are presented here. The report consists of two parts: administrative activities and scientific activities.

ADMINISTRATIVE ACTIVITIES

In June 1985, Dr. Abraham Golik visited the Institute of Coastal Research in Alexandria, Egypt, where he met with Drs. Ahmed Khafagy, Alfy Morcos, and Hani Elwani as well as members of the technical staff. During this visit, preliminary ideas were raised concerning the future proposal for the AID project (Phase IV). It was decided that the emphasis of the future project will be aimed at preparing numerical models which will permit forecasting of coastal developments along the Nile Littoral Cell, whether under natural conditions or as a result of engineering activity in the coastline.

In December 1985, Drs. Abraham Golik and Zev Carmel participated in a meeting in the Center for Coastal Studies (CCS) at Scripps Institution of Oceanography with Dr. Douglas Inman and Mr. Robert Lowe of CCS and Drs. Khafagy and Elwani from Egypt. During this meeting, the proposal for AID IV research was prepared and submitted to AID. In June 1986, Dr. Ahmed Khafagy visited Israel Oceanographic and Limnological Research (IOLR) and met with Dr. Abraham Golik as well as other participants in the project. Dr. Khafagy conducted a field trip along the Israeli coastline, reviewed the results of the AID study in Israel, and discussed technical aspects of deployment of a new CAS system in El Arish, Egypt. Dr. Khafagy's visit is described in detail in a report that was issued after the visit.

SCIENTIFIC ACTIVITIES

Between July 1983 and June 1986, a total of 3,894 measurements for Ashkelon and 3,517 measurements for Haifa were recorded and analyzed. This number of measurements is 88.5 percent of the maximum possible (if the system had not malfunctioned even once) for Ashkelon and 82.1 percent for Haifa.

Two distinct cycles in wave height may be recognized: a winter cycle and a summer cycle. At Ashkelon the winter cycle peaks at 0.98m average significant wave height, whereas in Haifa it is 1.07m. For the summer cycle, the values are 0.70 and 0.65m for Ashkelon and Haifa, respectively. The highest significant wave height during the reported period was on 15 February 1985 with Hs = 4.26m for Ashkelon and Hs = 4.45m for Haifa. Comparison of the wave period between Ashkelon and Haifa shows behavior similar to that of the wave height. During winter, the average peak period was 7.7 and 7.9 sec for Ashkelon and Haifa, respectively, and during summer the values were 6.9 sec for Ashkelon and 6.8 sec for Haifa. This trend of higher and longer waves in Haifa during winter and vice versa in Ashkelon during summer was further supported when waves were compared on a daily basis.

There are two possible explanations for the difference in wave dimensions between Haifa and Ashkelon: (1) difference in wind fetch for the two locations; (2) difference in shoaling of deep water waves when entering shallow water due to differences in bathymetric conditions between Haifa and Ashkelon.

Computations of longshore sediment transport (LST) rates, based on the wave energy flux, show that the annual LST in Ashkelon is $267 \pm 174 \times 10^2 \ m^3/y$. This compares well with previous estimates of LST by various investigators. The results of the LST in Haifa are not yet available.

II. BIOLOGICAL PRODUCTIVITY OF THE SOUTHEASTERN MEDITERANNEAN IN THE POST-HIGH DAM (ASWAN) PERIOD

II.a. Biological Productivity of the Eastern Mediterranean in the Post-Aswan Period

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Biological Productivity of the Eastern Mediterranean in the Post-Aswan Period

INTRODUCTION

During the past year (February 1985 to February 1986), we made six short cruises aboard the R.V. Shikmona, bringing to 13 the number of ichthyoplankton collections at the two sampling stations (Station N at 30m depth and Station P at 250m depth) near the Israel Oceanographic Institute. We now have more than two full years of data for some components of the ecosystem, including chlorophyll *a*; salinity and temperature; nutrient concentrations; and numbers, sizes, growth rates, and species composition of the fish larvae. Here we present the major findings of the past year, primarily in the form of figures.

ABUNDANCE

Fish larvae are most abundant in spring and fall. As in 1984, the anchovy, *Engraulis encrasiacolus*, was the most abundant larvae in the samples taken in 1985. Anchovies and sardines composed approximately 30 percent of the larvae at both stations in both years. The abundance of anchovy declined in 1985 (Figure 1), but the large numbers of *Sardinella aurita* in the samples from June 1985 more than compensated for the decrease.

Seasonal abundance of the anchovy followed the same pattern in 1984 and 1985. At Station P two peaks of abundance were observed in each year, one in the late spring-early summer and one in fall. The pattern was slightly different at Station N where the spring maximum in the abundance of clupeoid larvae was not observed in 1985. In 1984 the periods of maximum abundance occurred in different phases at each of the two stations, while in 1985, they coincided (Figure 1).

Average annual ingestion rates were nearly the same in 1985 as in 1984 (Table 1). In both years, ingestion at Station P was approximately three times that at Station N. The 1985 results confirm those of 1984, especially with regard to the conclusion that either primary production supporting the food chain must be greater than the 40-50mg C $m^{-2}d^{-1}$ currently estimated from ^{14}C uptake data or food consumption by the populations of larval fish must be overestimated by the techniques used in this study.

The results indicate that the periods of greatest abundance, and, therefore, demand on the food resources of larval fish, are late spring and fall. The main spawning occurs at the end of the winter, just before stratification sets up. The situation appears on the surface to be similar to the classical one in temperate waters where in the spring phytoplankton standing stocks increase rapidly when the mixed layer depth shallows to less than the compensation depth. However, in our shelf waters nutrients in the mixed layer are generally at extremely low levels even during winter, so onset of stabilization has little effect. However, Azov (1985) reported occasional periods of high nutrient concentrations and associated high phytoplankton biomass in the late winter at the two stations discussed in this report. Since time is necessary for the effect to pass up the food chain to the level of larval fish food, the spring spawning could be timed to take advantage of this delayed increase in the density of zooplankton. The spawning observed in the fall may be associated with periods of upwelling. Winds with N and NE components occur frequently at this transitional period of the year, so upwelling of waters relatively rich in nutrients should occur and eventually result in increased abundances of zooplankton suitable as food for larval fish.

NUTRIENT SOURCES

Upwelling and sediments are important nutrient sources. Cores were taken on the April 1985 cruise, and porewater nutrient concentrations and nutrient fluxes were determined. From this data it was calculated that severe storms could resuspend enough sediments to supply nutrients for two weeks of phytoplankton production (Christensen et al., 1986).

Using these estimates of the rate of supply of nutrients from the sediment together with STD data from the February 1985 cruise, we made calculations estimating the possible importance of upwelling in these waters. With reasonable values assumed for C:N ratios, the rate at which N is regenerated by grazing, the depth of origin for upwelled water, and so on, it was calculated that the rate of upwelling needed to explain the low levels of production observed is only 2.1 cm s^{-1}. Thus, even weak, episodic upwelling is significant and should be taken into account in nutrient budgets (Townsend et al., 1986).

BACTERIAL NUMBERS

Bacterial numbers were below grazing threshold. Since primary production measured by ^{14}C uptake seems insufficient to account for production at higher trophic levels in coastal waters of the SE Mediterranean, bacterial production was evaluated as a potential source of additional organic matter for the food chains leading to larval fish. Counts of free-living bacteria in 83 samples taken from 22 stations and 8 cruises ranged from 0.3 to 6.8 x 10^5 ml^{-1}. Concentrations never reached the $10^6 ml^{-1}$ thought to be necessary to support grazing by ciliates and remained far below the 10^5 ml^{-1} suggested as the lower limit which can be grazed directly by copepods. Bacterial numbers did not show great variation with depth or season (Figure 3). In experiments in which predators were excluded by filtration, bacterial daily production was estimated to be about 25 percent of standing stock and was just balanced by grazing. The concentration of dissolved organic matter, the substrate for bacterial production, was measured in a few samples and was found to be lower than that reported from other surface waters of the world ocean and near the limit of detection by routine methods.

PICOPLANKTON

Euterpina grazing on picoplankton have low survival rates. In his master's thesis, "Ecology of the Marine Copepod _Euterpina acutifrons_," Schneller found that although _E. acutifrons_ is apparently capable of grazing on picoplankton (cells <3nm), mortality rates and generation times are greatly increased in comparison to those obtained with larger algae as food. _E. acutifrons_ seems to be adapted to extreme patchiness in its food supply. If these characteristics hold for most of the copepods in these waters, it seems that the dominance of the phytoplankton biomass by picoplankton does lengthen food chains as expected. However, the reduction in food available for larval fish may be less than expected if, in general, the zooplankters are able to make efficient use of food resources characterized by extreme patchiness.

COOPERATION WITH EGYPTIAN AND U.S. PARTICIPANTS

In April 1985, Professor C. Serruya and Dr. Paul Walline attended and AID meeting in Cairo and met with Bob Abel, Dr. Sayed El-Sayed, and Dr. Naim Dowidar. Previous research was reviewed, and plans for the coming year were discussed.

Drs. John Christensen, El-Sayed, and Larry Weber participated in the AID cruise of the RV Shikmona in April 1985.

Dr. David Townsend from Bigelow and Dr. Larry Weber from Texas A&M took part in AID Cruise 15 (July 1986).

In August 1986, at the meeting of the International Association for Ecology held in Syracuse, NY, Prof. T. Berman organized a workshop on the role of microorganisms in aquatic food webs. At this meeting he also met with Drs. Yentsch, Abel, Dowidar, Townsend, and El-Sayed to discuss the AID project and to consider ways to make the best use of the results obtained during the past three years.

PUBLICATIONS

Azov, Y. 1986. Seasonal patterns of phytoplankton productivity and abundance in nearshore oligotrophic waters of the Levant Basin (Mediterranean). J. Plankton Research, 8: 41-53.

Berman, T., Y. Azov, A. Schneller, P. Walline, and D.W. Townsend. 1986. Extent, transparency and phytoplankton distribution of the neritic waters overlying the Israeli coastal shelf. Oceanol. Acta (in press).

Christensen, J.P., V. Goldsmith, P. Walline, A. Schneller, T. Berman, and S.Z. El-Sayed. 1986. Sedimentary nutrient regeneration on the oligotrophic eastern Mediterranean continental shelf. Oceanol. Acta (in press).

Townsend, D.W., J.P. Christensen, T. Berman, P. Walline, A. Schneller, C.S. Yentsch. 1986. Near-bottom chlorophyll maxima in shelf waters of the southeastern Mediterranean Sea: upwelling and sediments as possible nutrient sources. Oceanol. Acta (in press).

SUBMITTED

Kimor, B., T. Berman, and A. Schneller. Phytoplankton assemblages in the deep chlorophyll maximum layers off the Mediterranean coast of Israel. J. Plankton Research.

Walline, P.D. Growth and ingestion rates of larval fish populations in the coastal waters of Israel. J. Plankton Research.

Table 1. Average annual ingestion in mgC per sq m per year.

Larval group	Station	Ing ('84)	Ing ('85)	Ing (Average)
E. encrasicolus	N	0.19	0.21	0.20
	P	0.54	0.31	0.42
All clupeoids	N	0.33	0.29	0.31
	P	0.62	0.95	0.79
All fish larvae	N	0.99	0.95	0.97
	P	2.34	3.07	2.70

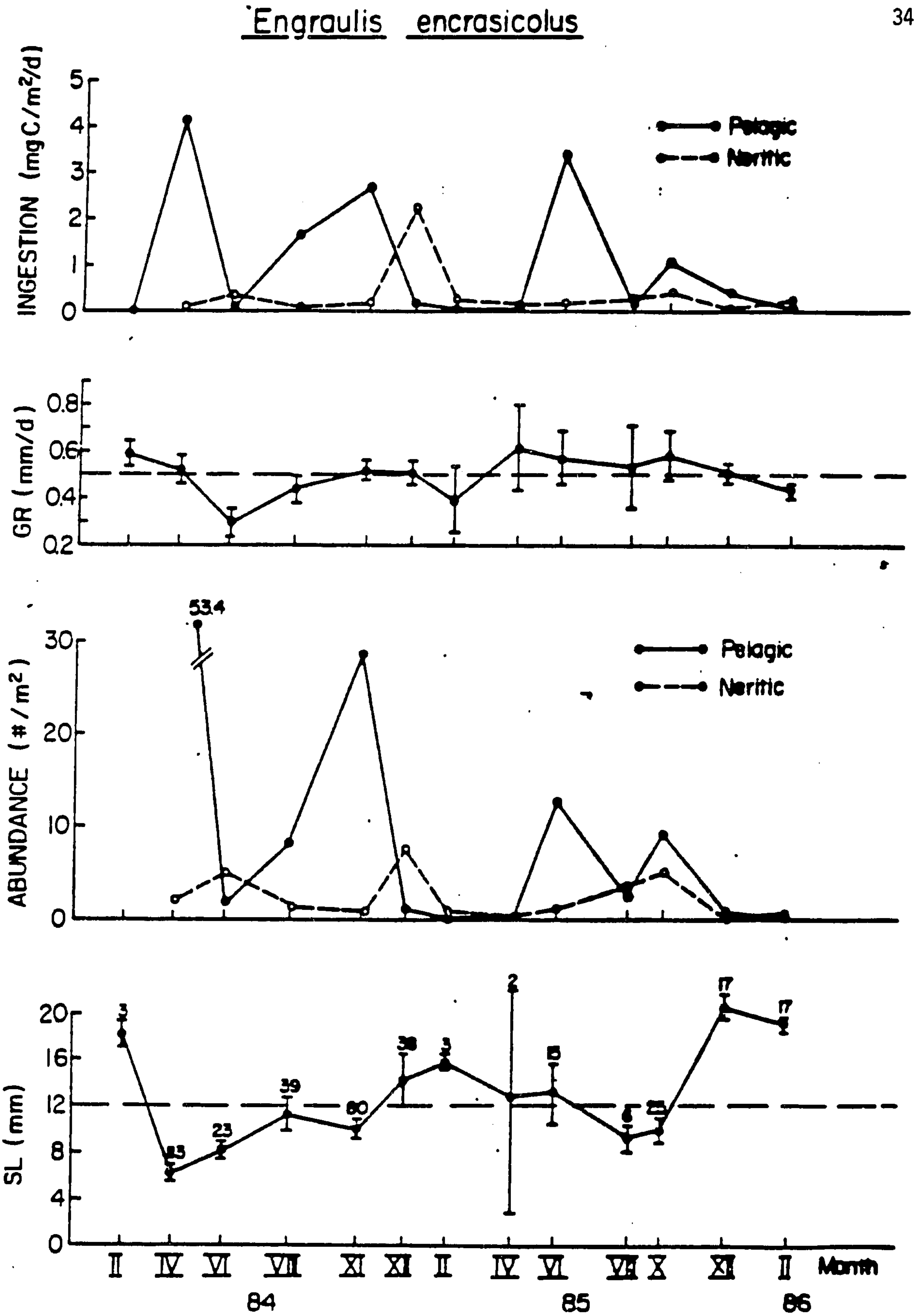

Figure 1. Population ingestion rate, average growth rate (GR), abundance, and average length (SL) for E. encrasicolus on 13 sampling dates. Data from all stations and nets were combined to calculate GR and SL for each sampling date. Numbers above the error bars (± 2 S.D.) indicate the number of larvae measured on the corresponding data for SL and GR.

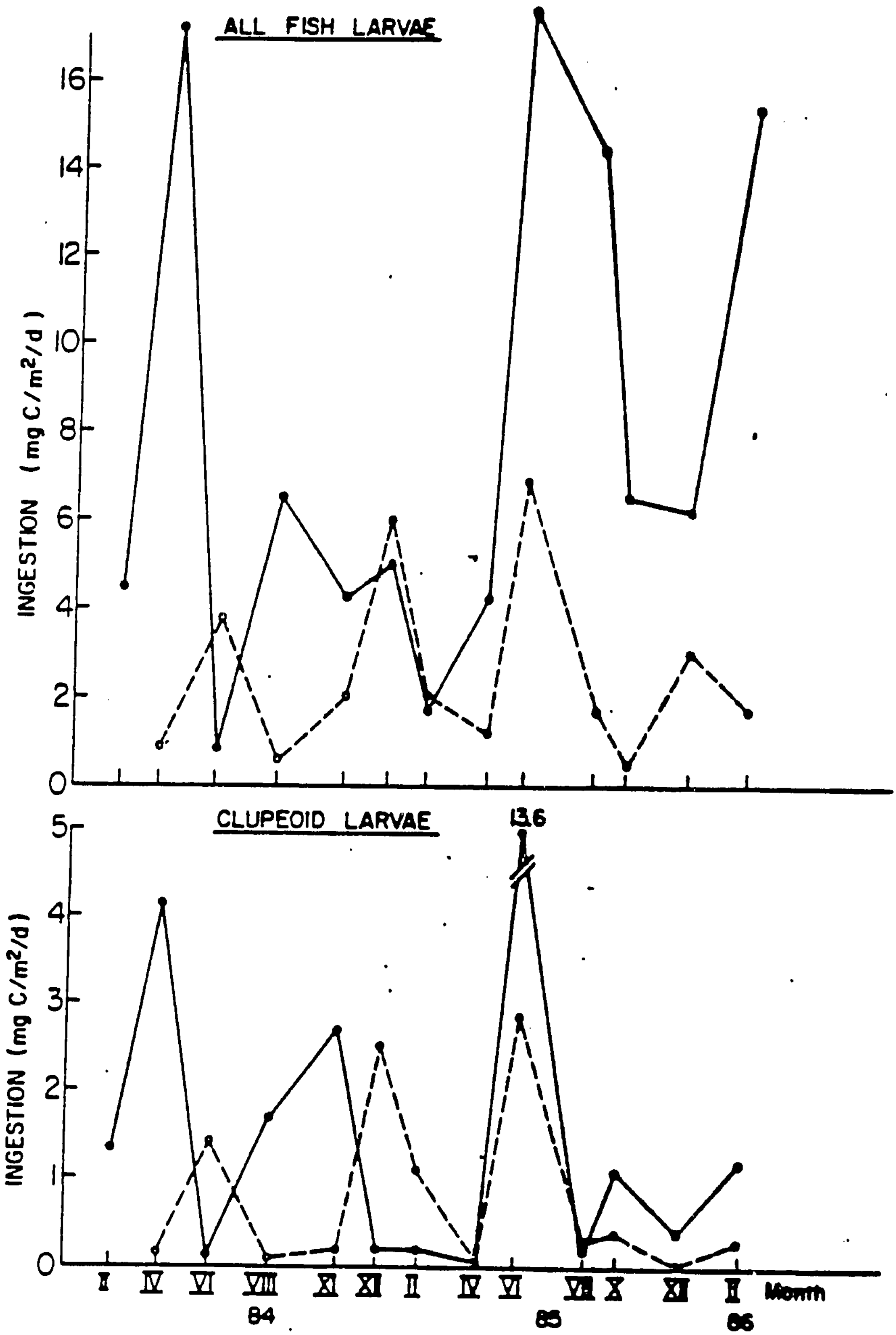

Figure 2. Ingestion rate on each of 13 sampling dates for populations of larval clupeoids and for populations of all fish larvae combined, dotted line for Station N and solid line for Station P.

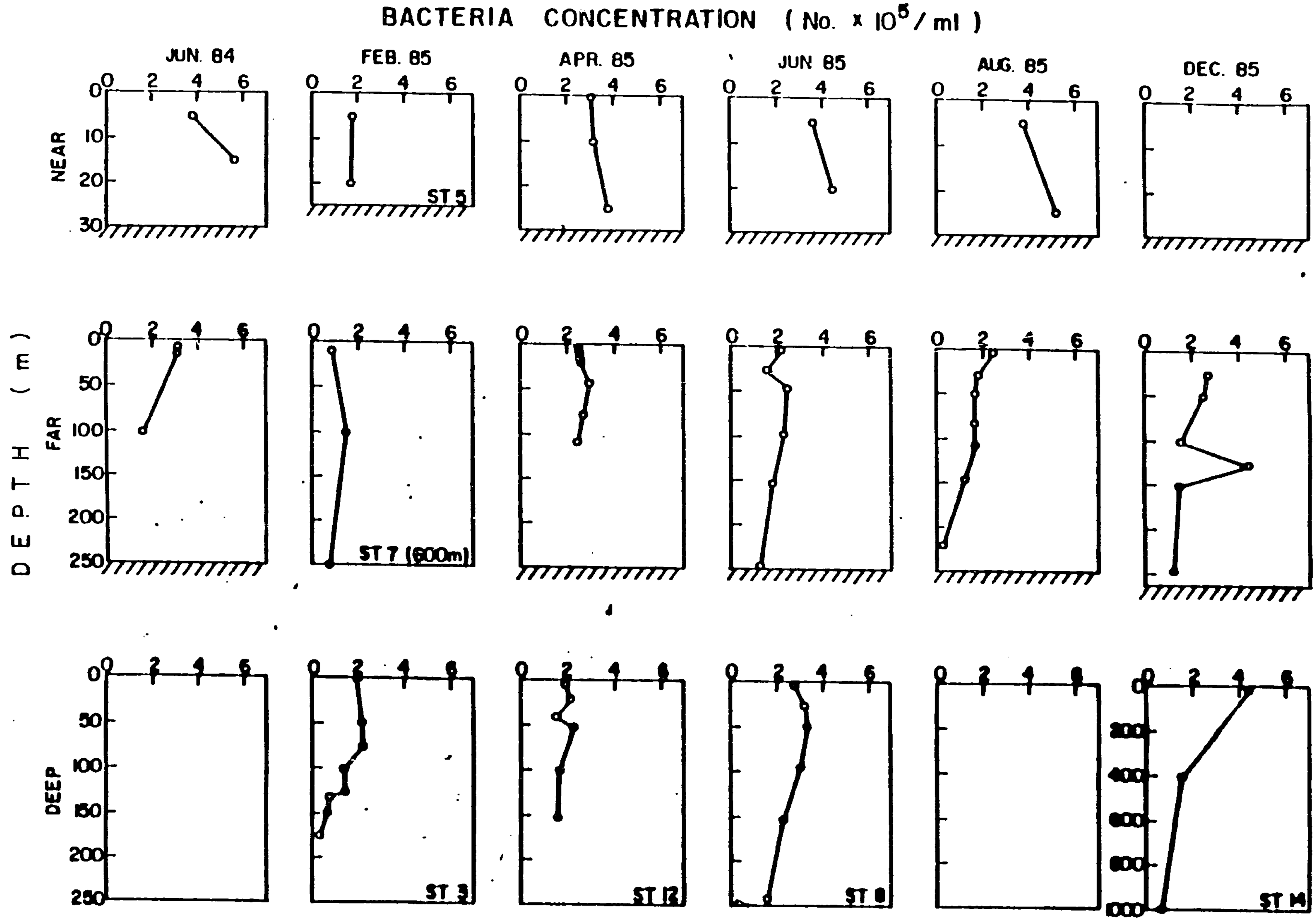

Figure 3. Vertical distribution of bacteria on six sampling dates at Station N (Near), Station P (Far), and at stations in water deeper than 500m (Deep).

II.b. Biological Productivity of the Southeastern Mediterranean (January 1985-September 1986)

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Biological Productivity of the Southeastern Mediterranean (January 1985-September 1986)

INTRODUCTION

During the period covered by this report four cruises were conducted off the Egyptian Mediterranean coast. The dates of the cruises were as follows:

Spring 1985, 11-25 April;

Summer 1985, 26 July-8 August;

Winter 1986, 16-28 February;

Summer 1986, 16-29 June and 13-18 July.

SUMMARY OF ACTIVITIES

During each cruise, the following activities were carried out.

Ichthyoplankton Studies

The ichthyoplankton was sampled at each station using ichthyoplankton net, 500um mesh and 1 meter in diameter, fitted with a Rigosha flow meter. Both surface (neuston) oblique tows were taken. Samples were preserved in 4 percent buffered formalin. In each catch, fish eggs were quantified, larval and postlarval stages were identified, and length frequency was studied. Additionally, the stomach and intestinal contents of the larval/postlarval stages were analyzed. Distribution charts for the most common larval forms were made.

Zooplankton Investigations

Zooplankton samples were collected by the following types of hauls:

1. Surface hauls using 65um and 200um mesh nets. Samples collected in these hauls were used for studying the species composition of the zooplankton population.
2. Vertical hauls from 200m (in shallow stations from near the bottom) to the surface.
3. Stratified vertical hauls from depth horizons of 200-150m, 150-100m, 100-75m, 75-50m, 50-25m, and 25-0m.

The net used in vertical tows was 50cm in diameter with 200um mesh size. Samples collected in these hauls were used to study the standing stock, vertical distribution, and species composition of the zooplankton population.

Phytoplankton Investigations

Studies on the phytoplankton community were continued during this period. Both vertical and horizontal fine net (65um) hauls were taken at each station. In addition, water samples (1 liter) were collected at discrete depths for assessing the species composition and numerical abundance of the phytoplankton populations. Phytoplankton standing stocks were determined fluorometically using water collected by Niskin samplers from several discrete depths within the upper 200m water column. Primary productivity was measured during April 1985 and February 1986 by the ^{14}C method using an on-deck simulated in situ incubator.

Physiochemical Studies

The following physical and chemical parameters were routinely assessed at each of the hydrographic stations: salinity, temperature, dissolved oxygen, pH, alkalinity, and dissolved nutrient salts (phosphate, nitrate, nitrite, ammonia, and silicate).

Total suspended matter at the surface and at mid-depths were also studied.

Concentrations of organic carbon, nitrogen, phosphorus, and some trace metals in surface sediments were measured.

Optical Parameters

The available incident light energy was measured with a LICOR quantum meter. Light penetration and the depth of the euphotic zone were determined using both the quantum meter and secchi disc.

PUBLICATIONS

The following papers have been published or accepted for publication during 1985-86:

Dowidar, N.M. 1985. Epipelagic copepods of the southeastern Mediterranean, general remarks. Rapp. Comm. Int. Mer Medit., 29, 9:239-243.

Dowidar, N.M. and F. El-Nady. 1985. Distribution of some trace metals in the Mediterranean waters off the Nile Delta. Rapp. Comm. Int. Mer Medit., 29, 7:43.

Dowidar, N.M. and H. El-Rashidy. 1986. Ichthyoplankton of the Egyptian Mediterranean waters, 1. Eggs of *Engraulis encrasicolus*. Rapp. Comm. Int. Mer Medit., 30, 9: (in press).

Dowidar, N.M. and A. Abdel Moati. 1986. Distribution of nitrogen and phosphorus in the Mediterranean waters off the Nile Delta. Rapp. Comm. Int. Mer Medit., 30, 7: (in press).

Dowidar, N.M. and T.A. About Kassim. 1986. Levels of nutrient forms and chlorophyll a biomass in a highly polluted basin, the Eastern Harbour of Alexandria. Rapp. Comm. Int. Mer Medit., 30, 7: (in press).

Dowidar, N.M. and M.A. El-Sabroute, and A.A. El-Sammak. 1986. Distribution of organic carbon, nitrogen and phosphorus in the surficial sediments off the Nile Delta. Rapp. Comm. Int. Mer Medit., 30. (in press).

Dowidar, N.M. 1986. Effect of Aswan High Dam on the biological productivity of the southeastern Mediterranean. Proceedings: International Conference on Natural and Man-Made Hazards, Rimouski, Quebec, Canada, 3-9 August 1986.

THESES/DISSERTATIONS

The following theses registered at the Faculty of Science, Alexandria University, are wholly a result of the biological productivity project.

Hesham Mostafa. Phytoplankton production and biomass in the southeastern Mediterranean off the Egyptian coast. (M. Sc. awarded.)

Nabil Nasr El-Din. Hydrographic structure of the shelf area of the southeastern Mediterranean off the Egyptian coast. (M. Sc. awarded.)

Hoda El-Rashidi. Ichthyoplankton of the Mediterranean waters of Egypt. (M.Sc. in preparation.)

Howida Y. Zakaria. Zooplankton of the southeastern Mediterranean. (M. Sc. in preparation.)

Nehad M. Nour El-Din. Distribution and ecology of epipelagic copepods of the southeastern Mediterranean. (M. Sc. in preparation).

Fadia Aboul Magd. Budget of the nutrient salts in the Mediterranean waters of Egypt. (M. Sc. in preparation.)

Amre El-Sammak. Geochemistry of surficial sediments of the continental shelf of the Egyptian Mediterranean waters. (M. Sc. in preparation.)

Baher M. Aly. Trace metals in surficial sediments of the continental shelf of the Egyptian Mediterannean waters. (Ph. D. in preparation.)

II.c. Biological Productivity of the Southeastern Mediterranean in the Post-High Dam (Aswan Period)

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Biological Productivity of the Southeastern Mediterranean in the Post High Dam (Aswan) Period

Sayed Z. El-Sayed

As part of the Biological Productivity of the Southeastern Mediterranean Project, Dr. Larry H. Weber participated in the research efforts aboard the Egyptian vessel Noor Yanabi (19-26 June 1986) and the Israeli vessel Shikmona (1-3 July 1986). These were the final Phase II cruises for the project. Our research objectives were to quantify the phytoplankton biomass and productivity and to determine the relative contribution of different phytoplankton size fractions to those parameters in the areas investigated. Unfortunately, equipment failed to arrive in time for the Egyptian cruise, so we were unable to process samples aboard the Noor Yanabi. Samples were collected from several depths at stations located along inshore-offshore transects of Haifa and Hadera, Israel, in order to characterize the variability in phytoplankton biomass, productivity, and size distribution as a function of distance from shore.

Analysis of the samples collected is now complete and will soon be published. Size fractionated analyses of chlorophyll *a* concentration and ^{14}C uptake revealed that most of the phytoplankton standing stock and metabolic activity is attributable to very small cells. The average size distribution was nearly identical to that observed during the April 1985 cruise of the Shikmona with 6, 51, and 43 percent of the chlorophyll *a* in the net ($>$20 um), nano- (1-20 um), and picoplankton ($<$1 um), respectively.

During the period covered by this report, a study of the phytoplankton samples (species composition and quantitative estimates) collected during cruises in April 1985 was completed and will be published as a technical report. Additional equipment was procured for our Egyptian colleagues, and ^{14}C samples from the Egyptian cruises were radioassayed at Texas A&M.

Also during this report period, Dr. S. Z. El-Sayed participated in the meeting of the Steering Committee to discuss plans and proposals for Phase IV. The meeting was held in Paris 4-7 March 1986.

On 9 July, Dr. S. Z. El-Sayed met in New York with other Principal Investigators of the Biological Productivity Project (Drs. T. Berman, N. Dowidar, D. Townsend, and C. S. Yentsch) to discuss with Dr. R. B. Abel plans for continuation of their studies during Phase IV.

On 11 October, Dr. S. Z. El-Sayed met in Alexandria (Egypt) with Dr. Naim Dowidar, Dr. Talaat Hashem (Director, Alexandria Institute of Oceanography and Fisheries), Dr. Ali Beltagi (Director of the Institute's Data Center), and other fisheries biologists and discussed details of the Egyptian component to the proposal "Trophodynamics of Marine Fisheries off the Egyptian and Israeli Coasts" which will be submitted as part of the Phase IV proposal.

II.d. Biological Productivity of the Southeastern Mediterranean Sea

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and

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Biological Productivity of the Southeastern Mediterranean Sea

SUMMARY OF ACTIVITIES

The following is a summary of the activities (September 1, 1985 to August 31, 1986) of the Bigelow Laboratory for Ocean Sciences under its portion of the grant from the U.S. Agency for International Development, "Cooperative Technology Program for the Middle East."

This report year represents the final, wind-down year of our program on the biological productivity of the southeastern Mediterranean Sea, and as such our goals were to synthesize, in the form of scientific publications, our results up to this time and to push forward our plans to seek outside funding to follow up on important new leads in the broad area of the biological oceanography of the eastern Mediterranean. These efforts began with the presentation of papers by D.W. Townsend and J.P. Christensen at the international colloquium "Oceanography of the Mediterranean Sea: Interdisciplinary Aspects of the Pelagic Environment," held at Villefranche Sur Mer, France, 16-20 September 1985. These papers are presently in revision for publication in Oceanolog. Acta. D.W. Townsend is also a co-author with T. Berman (IOLR et al.) on a paper in press at Oceanolog. Acta. Each of these papers is appended.

Our efforts to continue the investigation of the biological oceanography of the eastern Mediterranean produced two versions of a National Science Foundation research proposal entitled "An Interdisciplinary Oceanographic Investigation of the Oligotrophic

Eastern Mediterranean Sea." Though our initial efforts were unsuccessful, our ideas and plans were met with favorable reviews, and we have been encouraged by NSF to resubmit for a 1988 expedition to the Black Sea and Eastern Mediterranean.

D.W. Townsend joined L. Weber (TAMU) in Israel to participate on a short research cruise in July, but because of short notice was unable to participate on the Egyptian leg which concluded prior to the Israeli leg. Funds for this trip were provided by TAMU.

Finally, we attended a workshop in New York this past August with our Israeli and Egyptian colleagues in an effort to finalize our plans for continued participation in AID sponsored research in the Eastern Mediterranean. Future plans were made at that meeting, and each of us is presently writing his portion of a new AID proposal.

III. FISH CULTURE AND FISH NUTRITION

III.a. Controlled Reproduction of Commercially Important Fishes

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Controlled Reproduction of Commercially Important Fishes

SUMMARY REPORT

The main objectives of the project are to increase our knowledge and understanding of the reproductive processes of the grey mullet, *Mugil cephalus*, with emphasis on control of the reproductive processes, gonadal maturation, and the inducement, by administering hormones, of this fish to breed. This consists of:

1. Study of the reproductive cycle through year-round morphometric and histological study of the cycle of gonadal recrudescence.
2. Establishment of a broodstock well-acclimated in captivity to be suitable for inducement of artificial spawning.
3. Inducement of spawning through the injection of gonadotrophic hormones, followed by incubating the artificially fertilized eggs till hatching, nursing and feeding the hatchlings with cultured plankton till the fry stage.

During Phase I of this project, the first two objectives have already been successfully accomplished. The third objective, which will complete the project, remains to be achieved.

Undertakings covered during Phase I are summarized as follows:

1. From the monthly samples of adult fish, collected year-round for two consecutive years, the morphometric data were obtained. From age at first maturity, gonadosomatic and hepatosomatic indices were calculated.

2. From these data (see no. 1), the prospective breeding season and the critical time for hormone injection before resorption of the eggs sets in were obtained.
3. The gonads of the morphometrically studied specimens were collected monthly. Examinations of fish, their fixation, processing, sectioning, staining, and histological studies of the ovaries were conducted to more accurately substantiate the results obtained morphometrically.
4. It was found that the gonadal recrudescence of Mugil cephalus ovaries in Lake Quarun does not proceed beyond stage three of Kuo et al. (1974). Resorption of the ova sets in at this stage. This occurs during November or December according to the climate prevailing a particular year. Thus, the months of October and November in Lake Quarum are the most suitable for inducing spawning in Mugil cephalus.
5. Further samples procured during 1984 confirmed that male maturity occurs slightly earlier than female and extends to cover the time of ovarian maturity.
6. Fishery data on the production of Mugil cephalus in Lake Quarun have been recorded. Seasonal occurrence and distribution of mullet fry off the Mediterranean coast of Egypt have also been recorded.
7. Procurement and acclimatization on of a broodstock of Mugil cephalus in captivity, (in a large enclosed net offshore of the

research station at Lake Quarun). There are in stock five large broodstock fishes out of 21 being acclimated in the large enclosure net. The work is still in progress to accumulate a large number of this broodstock.

OTHER ACCOMPLISHMENTS

1. Insulating the brackish water reservoirs supplying the wet laboratory by lining it with glazed tiles.
2. Establishing a filtering well to supply filtered lake water to the reservoirs.
3. Fitting the filtering well with a suction pump to raise the filtered lake water to the reservoirs.
4. Establishing a new wet laboratory for the spawning of grey mullet and rearing of its larvae, in conjunction with other projects at Lake Quarun.

The above mentioned work continued up to 31 March 1985.

III.b. Production of Monosex Tilapia

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Production of Monosex Tilapia

INTRODUCTION

Tilapias are a major protein source in many developing countries. In Egypt, Tilapia contribute the highest production among the few species which can be cultured in fish farms.

Previous experiments carried out under the A.I.D. project showed the following results:

- Rearing male Tilapia nilotica in eathern ponds at stocking rates of 2, 2.5, and 3 fish/m^2 resulted in net production of 4415, 5434, and 5276 Kgm/ha respectively (Report No. 2).
- Rearing male T. nilotica fingerlings for two crops in a rearing season (6 months) showed a net production of 3281 Kgm/ha for the first crop and ?193 Kgm/ha for the second crop (Report No. 3).
- Experiments on sex reversal of T. nilotica fry fed on methyltestosterone at a rate ranging from 15-60 ugm/gm food showed that the best results were obtained (i.e., 90 percent males) when using 20 ugm/gm food (Report Nos. 2 and 3).
- Experiments on hybridization of female T. nilotica with male T. aurea (Egyptian strain) resulted in 81.5 percent males, and using male T. aurea Israel strain 82.7 percent males were produced (Report Nos. 2 and 3).
- Experimental comparisons of growth rate of T. nilotica, T. aurea, and their hybrids showed that the hybrids maintained better growth rates than parents (Report No. 3).

The main objectives of the present study are:

1. The production of male Tilapia through hybridization by crossing

   a. Female T. nilotica x male T. aurea

   b. Female T. aurea x male T. nilotica;

2. The study of suitable methods for mass production of hybrid fry which could be used for commercial culture;

3. Comparison between the growth rates of fingerlings of male T. nilotica, male T. aurea, and their male hybrids.

MATERIALS AND METHODS

The experimental work was conducted at the Barrage Fish Farm.

Experimental Fish

Mothers of T. nilotica from the River Nile and of T. aurea from Lake Manzalah were collected from March 21 till April 15, 1985. These mothers were kept in cement ponds. Males and females of each species and from each locality were kept in a separate cement pond ($40m^2$).

Hybridization Procedure

1. On April 6, 1985, twenty-seven T. aurea males, ranging in length from 18-20.5cm and in weight from 125-185gm, were put together with 42 female T. nilotica, ranging in length from 18.5-21.5 and in weight from 130-190gm, in three ponds at a ratio of 9 males: 14 females in each pond. On May 22, 1985 12 crosses were carried out. The mothers with their fry were collected and, the fry were reared for four months, after which they were examined for male percentage. Each of the 12 mothers was put together with one male for successive spawning. Some females spawned twice, while

others spawned three times during six months (from April to October). The fry of the second and third spawnings were counted without sexing.

2. On May 15, 1985, 6 males of *T. nilotica* were put together with 11 females of *T. aurea*: four crosses were carried out. After hatchng, the fry of each were collected and reared separately in one cement pond (40m^2) for four months and were examined for male percentage.

Male fingerlings of *T. nilotica*, *T. aurea*, and their male hybrids (from crosses between male *T. aurea* and female *T. nilotica*) obtained during the rearing season 1984 and ranging in length from 10-13cm were collected and stocked in three cement ponds.

Preparation of Ponds

Three cement ponds (each 40m^2) were cleaned, and each was subdivided into two compartments with nylon nets of fine mesh (1cm), each compartment an area of 20m^2. On June 17, 1985, each pond was filled to the level of one meter with water from an irrigation canal.

Male *T. nilotica*, male *T. aurea*, and their male hybrids were each stocked in separate cement ponds. In each cement pond 80 fish were stocked, 40 fish in each compartment at a stocking rate of two fish per m^2.

From July 17 till October 17, 1985, the experimental fish in the three ponds were fed with supplementary food of locally available ingredients mainly of plant origin containing 30 percent protein.

Imported Fish

In April 1985, 46 fingerlings of *T. aurea* and 26 fingerlings of *T. nilotica* Ghana strain were received from Israel. All *T. nilotica* Ghana strain died last January, while all *T. aurea* are still alive at the Barrage Fish Farm.

RESULTS

Hybridization

1. Hybridization of female *T. nilotica* x male *T. aurea*. The hybridization of female *T. nilotica* with male *T. aurea* showed that from 12 females, four spawned once, two spawned twice, and 6 spawned three times during the spawning season (6 months from April till September), and the number of fry of female is shown in Table 1.

   A great number of fry from each mother of the first spawning was collected then reared for four months. At the end, the fish were examined for male percentage, which is represented in Table 2.

2. Hybridization of female *T. aurea* with male *T. nilotica* produced the following results.

Cross No.	No. of fry Examined	Progency Female	Progency Male	Percent Males
1	171	40	131	76.6
2	154	42	112	72.7
3	78	19	59	75.6
4	117	31	86	73.5
Total	520	132	388	74.6

The results showed an average of 74.6 percent males.

Growth rates

The results indicated that the growth rate of male *T. nilotica* was lower than that of male *T. aurea* and their male hybrids (Table 3). Male *T. nilotica* increased in weight from 24-151 grams within four months, while male *T. aurea* increased from 22.5-182 grams and their male hybrids from 32.5-234 grams within the same period.

Table 4 shows that male *T. nilotica* gained an average weight of 127 grams in four months, with a mean daily gain in weight of 1.1 grams and food conversion of 3; while *T. aurea* gained 159.5 grams in weight with an average daily gain in weight of 1.3 grams and food conversion 2.3. The male hybrids of the two species gained 201.5 grams in weight during the same period and a daily gain of 1.7 grams and food conversion of 2.7.

Table 1. Number of fry from the first, second, and third spawning of hybridization of male *T. aurea* and female *T. nilotica*.

Fish Number	Number of Fry			
	1st spawning	2nd spawning	3rd spawning	Total
1	236	198	172	606
2	188	146	-	334
3	244	-	-	244
4	354	268	189	811
5	269	218	176	663
6	168	-	-	168
7	342	246	210	798
8	226	-	-	226
9	264	-	-	264
10	312	272	223	807
11	288	236	198	722
12	218	178	-	396
Total	3,109	1,762	1,168	6,039

Table 2. Number of examined fingerlings, number of males, females, and percentage of males.

Cross No.	No. of fingerlings examined	Progeny		Percent of males
		females	males	
1	198	37	161	81.3
2	177	31	146	82.5
3	161	29	132	82.0
4	206	38	168	81.5
5	216	48	168	77.7
6	141	24	117	83.0
7	247	45	202	81.8
8	132	25	107	81.1
9	154	32	122	79.2
10	281	51	230	81.9
11	233	47	186	79.8
12	148	28	120	81.1
Total	2,294	435	1,859	81.03

Table 3. Growth in length and weight of fingerlings of *T. nilotica*, *T. aurea*, and their hybrids from June 17 till October 17, 1985.

	Composition I		Composition II	
	Length (cm)	Wt (gm)	length (cm)	Wt (gm)
T. nilotica				
June 17	12.1	28	10.7	20
July 17	15.6	68.4	14.8	65
August 17	17.8	96	17.5	88
September 17	18.5	128	18.3	119
October 17	20.1	154	19.6	148
Average	L=19.85	wt=151		
T. aurea				
June 17	11.5	24	11	21
July 17	16.1	77	15.2	69
August 17	18.5	118	17.8	97
September 17	19.6	146	19.0	139
October 17	21.4	176	21.0	188
Average	L=21.2	wt=182		
Hybrid				
June 17	11.4	29	12	36
July 17	16.5	86	16.7	91
August 17	19.4	136	19.8	141
September 17	20.8	178	20.9	186
October 17	22.2	224	22.9	244
Average	L=22.5	wt=234		

Table 4: Summary of results of experiments of growth of *T. nilotica*, *T. aurea*, and their hybrids from June 17 till October 17, 1985 (four months).

Items	*T. nilotica*	*T. aurea*	Hybrids
Initial no. of fish	80	80	80
Av. wt. of fish (gm)	24	22.5	32.5
Total wt. of fish (gm)	1920	1800	2600
Final no. of fish	78	78	79
Percentage of mortality	2.5	2.5	1
Av. final wt. of fish (gm)	151	182	234
Total final wt. of fish (gm)	11778	14196	18486
Gain in total wt. (gm)	9858	12396	15886
Growth/day (gm)	1.06	1.33	1.6
Wt of food consumed (Kgm)	29.3	33.2	42.4
Food efficiency	33.6	37.4	37.5
Rate of increase	6.3	8.1	7.2
Conversion ratio	3.0	2.7	2.7
Calculated product per/ feddan (Kgm)	1178	1420	1849

DISCUSSION

Tilapia (Oreochromis) nilotica and Tilapia (Oreochromis) aurea are common in Egyptian waters and seem to be fast growing species which can be easily crossed.

In order to develop aquaculture and to meet the needs for increasing fish production as a source of animal protein, the introduction of male Tilapia culture in Egypt is of high significance. Hence, the production of male tilapia is essential for fish culture.

In the present study, for mass production of hybrid seeds, 12 females spawned: four spawned once; two spawned twice; six spawned three times; and the 12 produced a total of 6,039 fry during the spawning season. Each female produced an average of 500 fry hybrid in one spawning season (6 months).

The present results are in accordance with the findings of Mires (1977), who found that Tilapia spawning within the same species such as T. aurea x T. aurea can easily produce 3,000 fingerlings per female per spawning season, whereas for hybrids only 500-1000 fingerlings are obtained per female. Mires (1977) concluded that this fact makes the number of available Tilapia mothers one of the key factors in the course of mass production of all male progeny. Tal and Ziv (1978) stated that the production of T. nilotica x T. aurea hybrids is much lower than in pure species lines. Wohlforth et. al, (1983) however, showed fry production ranging from 1800-1900 from interspecific cross of female T. nilotica Ivory coast strain and male T. aurea. Lee (1979) mentioned that there is no difference in the number of fry of T. aurea x T. nilotica hybrids and the purebreds when mated in aquaria.

During the present work it was observed that only three spawnings occurred during the 6-month spawning season. Mires (1983) found that most females of Tilapia used for intraspecific crosses spawned not more than six or seven times in a 6-month season. This author points out that interspecific crosses of Tilapia result in reduced spawning for four or five times.

So, fingerling hybrid production needs at least two years before revealing any definite information for the production of hybrids and for the hybrid fingerlings to reach a suitable size for rearing.

The present study indicated that interspecific crosses between female _T. nilotica_ and male _T. aurea_ for the production of hybrid fry resulted in 77.7-82.9 percent males with an average of 81 percent males. The reciprocal cross produced 72.7-76.6 percent males with an average of 74.5 percent males. Similar results were shown by Chervinski (1967) who obtained 82.6 percent males from crossing female _T. nilotica_ with male _T. aurea_, and the reverse cross produced 63.5 percent males. Prugnin _et. al_ (1975) pointed out that the progeny on crossing female _T. nilotica_ with male _T. aurea_ produced only males, and the reverse produced 77.2 percent males (i.e., a ratio of 3:1). Mires (1977) reported that cross of female _T. nilotica_ with male _T. aurea_ resulted in 80-90 percent males. Majumder and McAndrew (1983) showed that cross of female _T. nilotica_ with male _T. aurea_ (Egyptian strain) gave a male percentage between 65.5 to 85 percent males with an average of 79.1 percent males. Labib (1985) found that crossing of female _T. nilotica_ with male _T. aurea_ resulted in 81.5 percent males and in crossing female _T. nilotica_ with male _T. aurea_ Israelei strain resulted in 82.7 percent males.

The present results indicate that male hybrid fingerlings grow faster than either parent species and the growth rate of male T. aurea fingerlings was better than that of T. nilotica. The present results support the previous findings of Chervinski (1967) who while working with the same species found that the growth rate of hybrids of crosses T. nilotica with T. aurea (from 2-297 gm) was better than that of T. aurea (from 2-211 gm). Prugnin et. al (1975) and Lovshin et. al (1974) found no significant difference in the growth rate of Tilapia species and their male hybrids.

Prugnin et. al (1975) found that the growth rates of male T. nilotica, male T. aurea, and their male hybrid were from 8.3-200 gm, 8.5-235, and 9.2-225 gm respectively.

On the basis of the previous results it is suggested that the future plan include:

1. Study of the mass production of hybrid fry by increasing the frequency of spawning.
2. Study of the purity of strains of T. nilotica and T. aurea by electrophoretic analysis.
3. Experimental studies on the feeding of newly hatched fry hybrid to attain a suitable size for rearing, using food that produces a high growth rate within a short time.

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III.c. Production of Monosex Tilapia

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Since 1984 we have been investigating the variation among experimental and commercial hybrid progenies of different stocks of *T. nilotica* and *T. aurea*. The first results were reported in the Third Annual Report submitted in June 1985. The present report covers the research carried out in 1985 and 1986. In the first year two tests were carried out, one on adult fish spawned in the previous year and the other on young of the fish spawned during that year. In the second year only an adult fish test was carried out.

1. 1985, adult fish test.

Four groups of tilapia hybrids were tested:

a. F_1 hybrids, *T. nilotica* x *T. aurea*, sampled from the Nir David commercial stock;

b. F_1 hybrids, *T. nilotica* x *T. aurea*, from the Dor station stock;

c. F_2 sex inverted (*T. nilotica* x *T. aurea*)^2 sampled from the Gan Shmuel stock;

d. A sample of the wild type segregants of the cross red tilapias (of Taiwanese origin) x *T. aurea*.

These fish were overwintered males from the groups tested in 1984 (see previous report), except the Nir David F_1 group which was purchased from that farm. Prior to stocking, all fish were examined and any females discarded, such that only males were stocked into the experimental ponds. The mean weight of these fish varied, according to their growth in the previous year. Each group of tilapias was stocked separately into three 400 m^2 ponds. The test thus consisted of 12 ponds. Tilapias were stocked at 3000/ha. In addition, all ponds were stocked with common carp (2000/ha x 500g and silver carp (500/ha x 144g). The tilapias were stocked on May 5, and the test terminated on October 23, resulting in a growth period of 136 days. Nutrients were applied daily, six days per week. These consisted of a constant amount of dry poultry manure (50 kg dry matter/ha) and 25% protein feed pellets, computed as 4% carp biomass plus 2% tilapia biomass. Amounts of feed were adjusted every two weeks according to the results of sample weight. At the termination of the test, all fish were sorted, counted, and weighed. In addition, all tilapias from two of the ponds, one stocked with Dor F_1 fish and the oher with sex inverted F_2 fish were weighed individually. The results, shown in Table 1 and Figures 1 and 2, are summarized below:

a. Survival of all tilapia groups was high, between 95-99%;

b. Growth of the Nir David F_1 hybrid was faster than that of all other groups;

c. The F_2 sex inverted tilapias showed a slower growth than either F_1 group. However, calculation of a specific growth rate (SGR, defined as = 100 $(\ln W_1 - \ln W_0)/(t_1 - t_0)$ reveals that the F_2 sex inverted group does not differ in growth from the Dor F_1. The difference in mean daily growth may reflect effects of differences in stocking size on growth rates;

d. The coefficient of variation of the F_2 was larger than that of F_1.

These results accord with our previous conclusions that genetic variation exists among T. nilotica and T. aurea stocks from different experimental and commercial farms in Israel. Progress can be made by selecting the best growing hybrids available from the different sources. The Nir David hatchery is presently supplying about 75% of the Israeli tilapia fingerling trade (not including production of fingerlings for its own use).

2. 1985, young of the year test

The test involved isolates of the two most important tilapia species, T. nilotica and T. aurea, see Table 2 and a single isolate of T. hornorum. These fish were used to obtain purebred progenies within isolates, interspecific hybrid progenies of T. nilotica females and T. hornorum males. Samples of these fry were taken directly from the spawning ponds and stocked into 21 (400 m^2) experimental ponds. Stocking took place on July 23, and the test was terminated after 90 days.

Ponds were stocked with 360 tilapias per pond (9000 per ha). In addition each pond was stocked with 100 common carp of 52 g, 20 silver carp of 230 g, 20 grass carp of 105 g, and 800 freshwater prawns of 1 g. The ponds were fertilized 6 days a week with dry poultry manure. The initial amount of dry matter of manure was 50 kg/ha/day, rising every two weeks by 25 kg/ha/day to a final amount of 175 kg/ha/day. Food pellets (25% protein) were applied at one-third of the standard ration, calculated as 4% of common carp biomass and 2% of tilapia biomass.

The 14 groups of tilapias to be tested were divided into two sets, purebred stocks and crossbreeds. Each set was tested in a separate series of ponds. Each pond was stocked with two groups of tilapia:

a. *T. nilotica* or interspecific hybrids mothered by *T. nilotica*;

b. *T. aurea*.

These groups are distinguishable by the vertical striation on the caudel fin, present in *T. nilotica* and its interspecific hybrids, but absent in *T. aurea.* Each group was tested in at least three replicated ponds. In order to avoid biasing the results by interactions between groups, each *T. aurea* group was stocked together with each *T. nilotica,* or *T. nilotica* x *T. aurea* group. This scheme presented in Table 4. Each combination was stocked into one pond.

At the termination of the experiment all the ponds were drained, the fish recovered, sorted, and weighed. Problems were encountered in four ponds: In one pond, stocked with *T. aurea* (LM), we found several hundred fingerlings that were spawned by the experimental fish. Some of these could not be distinguished from the experimental fish. In the three ponds stocked with *T. nilotica* (G) x *T. aurea* (EH) crossbreeds, we could not identify the *T. nilotica* x *T.* aurea by the stripes on their tail. Thence there was no way to separate the two groups. In other ponds sorting the tilapias into the two groups stocked together was easy.

The most outstanding phenomenon in the data was large variation in survival rate (Table 5). This was more pronounced in the pure strains. Weight gains are listed in Table 6. Here again there is large variation among replicates within groups, presumably caused by the variable mortalities (and hence effective densities). Comparisons (ANOVA) among both T. nilotica and T. aurea groups did not show any significant differences among strains within species. Similarly, differences between the two intraspecific hybrids or the three intraspecific T. aureaua crossbreeds were not significant.

Table 7 presents yields (kg/ha) for each of the two groups stocked in each pond. Differences are smaller than those in weight gains for T. nilotica, but larger for T. aurea. None of these differences was significant.

No conclusions can be drawn from this experiment, due to the large variation among replicates within treatments. High and variable mortalities, as in this study, were experienced in the past with purebred T. nilotica populations in a selection experiment (Hulata et al. 1986). In contrast survival rates were high in our previous tests with hybrid tilapias, carried out in the same ponds and with a similar management. The low and inconsistent survival is unexplained and was not experienced by Hanson et al. (1983), who ran somewhat similar tests with pure T. nilotica in tanks and cages.

At the termination of the experiment the females were discarded. Males of all tested groups were transferred into a greenhouse facility, consisting of 2x2x1m concrete tanks. These fish were further tested in their second year in the spring of 1986.

3. 1986, adult fish test

After overwintering, the adult fish from the test carried out in 1985 were tested during their second year. This experiment included all but two of the groups previously tested (in 1985) as young of the first year fish. The missing groups of fish were: 1. The hybrid *T. nilotica* (G) x *T. aurea* (EH) due to difficulties in identification at the end of the previous test. 2. The hybrid *T. nilotica* (G) x *T. aurea* (M) which suffered a heavy mortality during overwintering. Experimental ponds were stocked on May 4 with tilapias at 2500/ha and on May 5 with common carp (3000/ha x 86g), silver carp (200/ha x 716g), and grass carp (450/ha x 130g). Before stocking, all tilapias were marked with colored Floy tags (Dell, 1986). Identification of a given genetic group was based on the color of its tag and presence or absence of *T. nilotica* type tail striation.

A common growth test of these tilapia groups was carried out in 8 ($1000m^2$) ponds. Four ponds were stocked with purebred isolates of *T. aurea* or *T. nilotica.* The other four ponds were stocked with intraspecific crossbreeds of *T. aurea* and with two interspecific hybrids (*T. nilotica* x *T. aurea* and *T. nilotica* x *T. hornorm*). In addition 6 ($400m^2$) ponds were stocked separately with either *T. nilotica* x *T. aurea* or *T. nilotica* x *T. hornorum*, in order to compare relative growth in communal and separate testing. These stocking schemes are shown in Table 8. Nutrients applied daily for 6 days per week, consisted of a constant amount of dry chicken manure (5 kg dry matter/ha) plus 25% protein fish pellets. The amount of feed applied was equivalent to 4% of the carp biomass plus 2% of the tilapia biomass, adjusted every two weeks according to the results of sample weighings. Growth of fish was rapid, resulting in high fish biomass and large amounts of applied feed. In July mortalities of common, silver, and grass carp occurred in some of the $1000m^2$ ponds. In order to reduce fish biomass, the $1000m^2$ ponds were drained sequentially between August 7-12. Tilapias, silver carp, and grass carp from each pond were transferred to neighboring $1000m^2$ ponds. Common carp, which by this time weighed over 700g, were removed, and the ponds were restocked with fingerlings of 35g. Tilapias were sorted according to their identifying marks, and each group was counted and weighed separately. The results of these comparisons are shown in Table 9 and summarized in Table 10. The test in both $1000m^2$ and $400m^2$ ponds was terminated in October. Analysis of these results is not yet finished, and they will be reported at a later date.

The results of this test, for the period May to August 1986, are summarized below:

1. Growth of the T. nilotica isolates was considerably faster than that of T. aurea isolates, with no overlap between the species.
2. In T. aurea, purebred isolates and crossbreeds between isolates showed similar growth rates.
3. The interspecific tilapia hybrid in commercial use in Israel, T. nilotica x T. aurea, showed a growth similar to that of different T. aurea groups, but considerably slower than that of T. nilotica) isolates. Survival of this hybrid was much higher than that of all other groups tested.

4. The other interspecific hybrid, T. nilotica x T. hornorum, showed the slowest growth of all tested groups.

These results require confirmation by statistical analysis, by analysis of the total growth period, May to October, and by repeated observations. They may lead to far-reaching conclusions about choice of species and lack of heterosis for growth in tilapias.

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Fig.1. GROWTH CURVES OF THE FOUR GROUPS

(Stocking:5-Jun-85, Harvest:23-Oct-85)

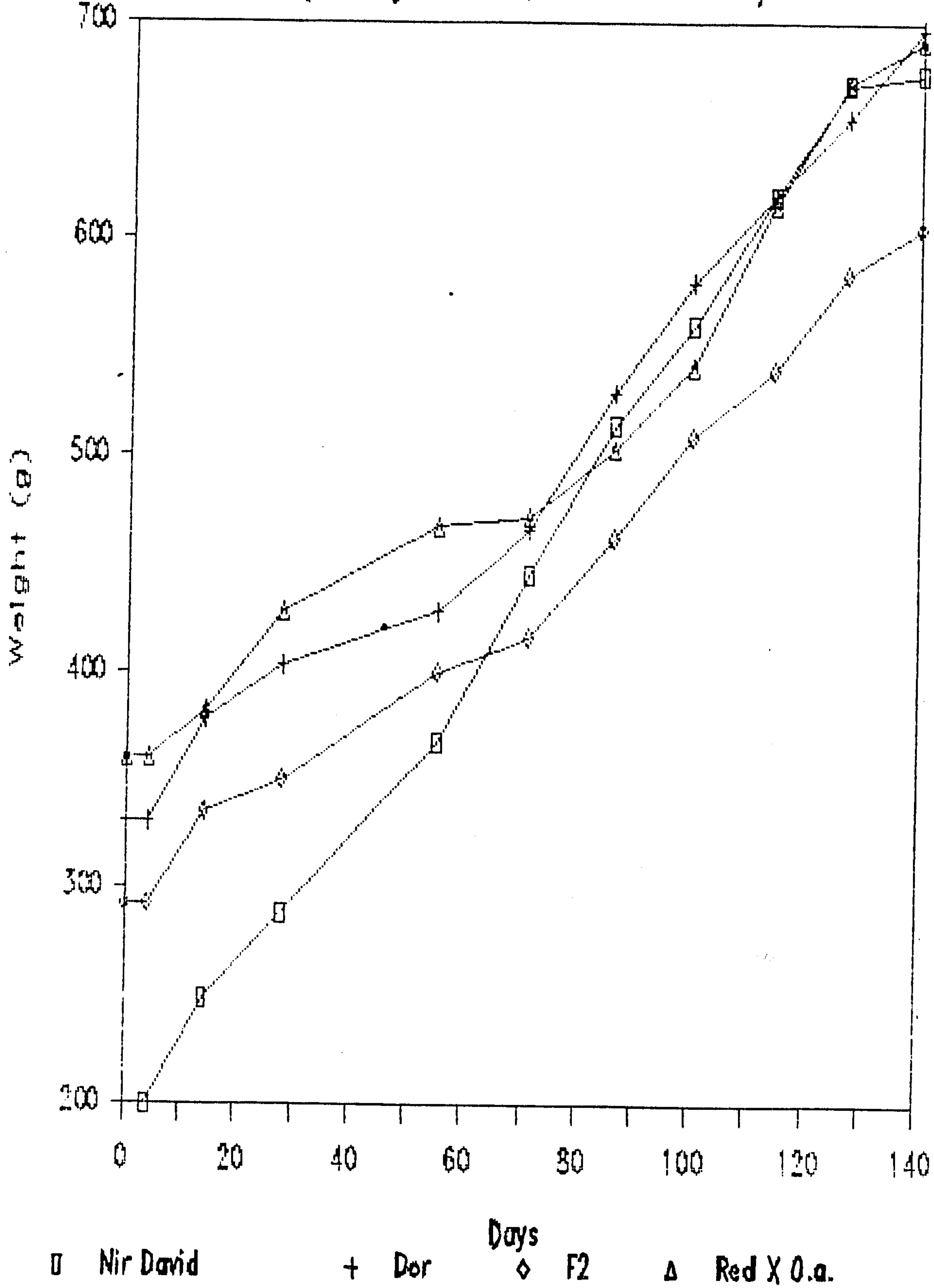


Fig. 2. SIZE FREQUENCY DISTRIBUTIONS

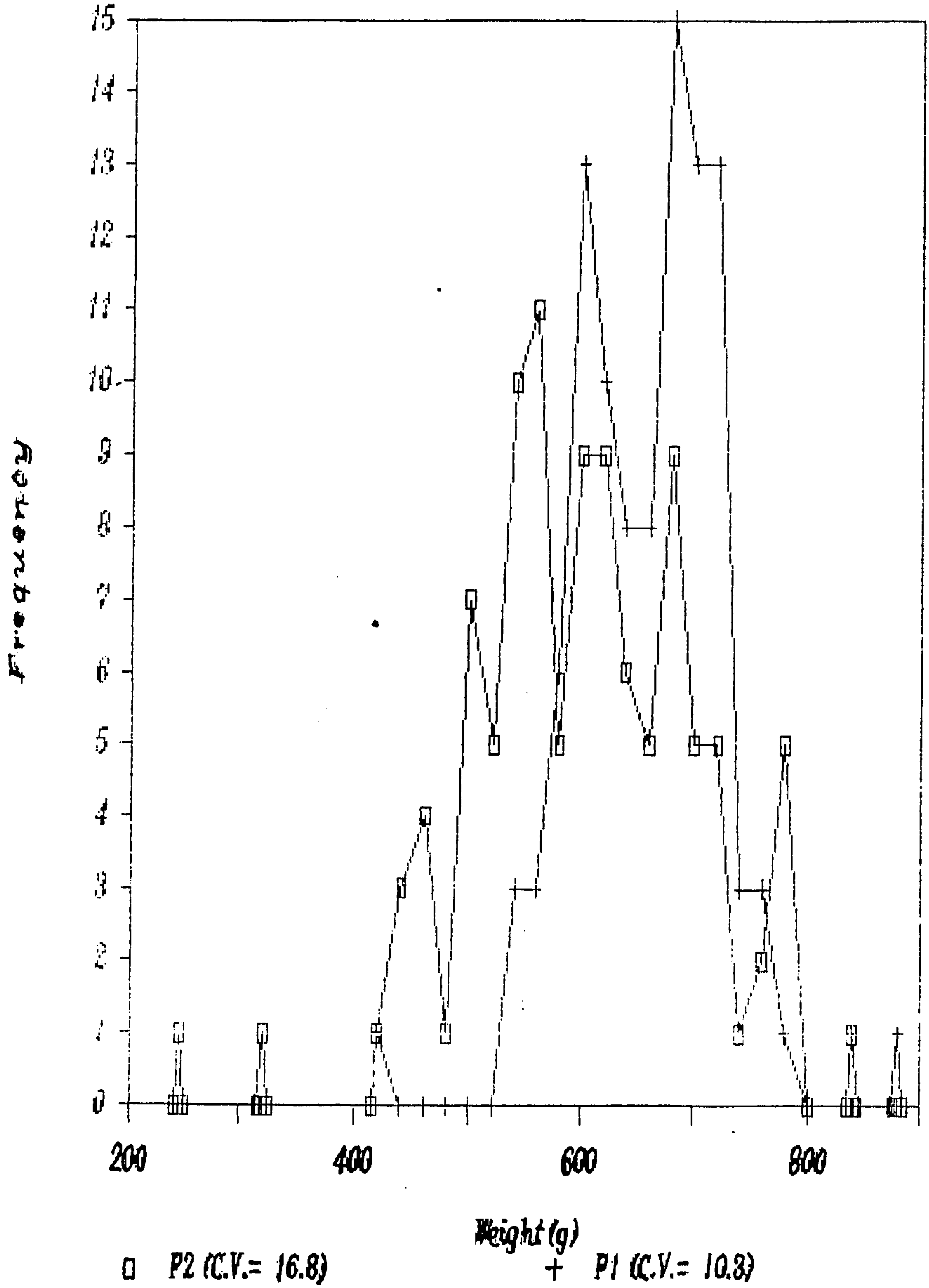


Table 1. Survival, growth and variation of adult tilapias tested in 1995

Hybrid	Mean weight (g)			SGR**	Survival	Coefficient
	Initial (W_0)	Final (W_1)	Mean daily gain		(%)	of variation
T. nilotica x *T. aurea** F_1 (Nir David)	199	677	3.64	0.93	99	
T. nilotica x *T. aurea* F_1 (Dor)	330	699	2.70	0.55	95	10.3
T. nilotica x *T. aurea* F_2 (sex inverted)	292	606	2.30	0.54	95	16.8
Red tilapia x *T. aurea*	359	692	2.45	0.48	98	

* Stocked five days later than the other tilapia groups.

** $$SGR = \frac{\ln W_1 - \ln W_0}{t_1 - t_0}$$

Table 2. Description of isolates of tilapias tested in 1985 and 1986

Species	Isolats	Designation	Comments
Tilapia aurea	Ein Hamifrats	EH	Developed at Ein Hamifrats hatchery
	Dor	D	Closely related to EH
	Menhadrin	M	Progenies of sample collected in isolated irrigation reservoir
	Lake Manzala	LM	Progenies of sample collected in Lake Manzala, Egypt (Majumdar and McAndrew, 1983)
T. nilotica	Ghana	G	Progenies of sample collected in Ghana, used as commercial brood stock for hybridization with *T. aurea* (Mires, 1977)
	Nile	N	Progenies of sample collected in the Nile River (courtesy of Ali Khater)
	Lake Manzala	LM	Progenies of sample collected in Lake Manzala (Majumdar and McAndrew, 1983)
	Bangkok	B	Progenies of sample from the Bangkok strain (courtesy of B. McAndrew)

Table 8. Spawnings arranged in spring 1985

No	Type of spawn	species	Isolates
1	Pure bred	*T. aurea*	EH x EH
2			M x M
3			LM x LM
4		*T. nilotica*	N x N
5			LM x LM
6			G x G
7			B x B
8	Intra-specific crossbreds	*T. aurea*	EH x M
9			EH x LM
10			M x LM
11	Inerspecific hybrid	*T. nilotica* x *T. aurea*	G x EH
12			G x LM
13			G x M
14			G x D
15		*T. nilotica* x *T. hornorum*	G x *T. hornorum*

* Failed to spawn

Table 4. Scheme for co-stocking different isolates of *T. nilotica* and *T. aurea* or *T. nilotica* x *T. aurea* and *T. aurea* (i) *T. aurea* (j).

Isolates are identified by abbreviation as listed in Table 2. Those for *T. aurea* or *T. aurea* crossbreds are given in the lower left corner of each cell, and those of *T. nilotica* or *T. nilotica* hybrids in the upper right corner.

	T. nilotica				*T. nilotica* x *T. aurea*		
T. aurea	G + EH	B + EH	LM + EH	N + EH	Gx(H)* + EHxM	GXD + EHxM	GXEH + EHxM
	G + LM	B + LM	LM + LM	N + LM	Gx(H)* + EHXLM	GxD + EHxM	GxEH + EHxM
	G + M	B + M	LM + M	N + M	Gx(H)* + MxLM	GxD + MxLM	GxEH + MxLM

* *T. hornorum*

Table 5. Survival rates (%) of experimental groups.
(Each cell contains the survival of the group listed above at the upper right corner, and that of the group listed aside at the lower left corner).

A. PURE STRAINS.

T. aurea	*Tilapia nilotica*				Mean
	Ghana	Bangkok	L. Manzalah	Nile	
E. Hamifratz	59 33	68 47	55 8	78 68	39
L. Manzalah	100 44	60 45	*	90 95	61
Mehadrin	86 63	89 84	99 68	90 86	75
Mean	82	72	77	86	58 79

B. HYBRIDS.

T. aurea crossbreds	*T. nilotica*(G) hybrids with:			Mean
	T. aurea (EH)	*T. aurea* (D)	*T. hornorum*	
EH x M	46**	103 92	98 82	87
EH x LM	73**	91 88	100 82	85
M x LM	74**	99 93	91 5	49
Mean		96	96	74 57

* not included due to very low survival
** Sorting impossible, due to lack of tail stripes on any of these fish.

Table 6. Average weight gain (g) of experimental groups.
(Each cell contains the weight of the group listed above at the upper right corner, and that of the group listed aside at the lower left corner).

A. PURE STRAINS.

T. aurea	*Tilapia nilotica*				Mean
	Ghana	Bangkok	L. Manzalah	Nile	
E. Hamifratz	195 138	162 127	198 (134)*	130 91	119
L. Manzalah	186 194	141 143	- -	133 126	154
Mehadrin	124 123	153 129	124 79	140 111	110
Mean	169	152	161	135	

B. HYBRIDS.

T. aurea crossbreds	*T. nilotica*(G) hybrids with:			Mean
	T. aurea (EH)	*T. aurea* (D)	*T. hornorum*	
EH x M	- - **	143 124	139 120	122
EH x LM	- - **	134 123	135 108	116
M x LM	- - **	130 140	195 (153)*	--
Mean		135	157	

* Not included due to very low survival

** Sorting impossible, due to lack of tail stripes on any of these fish.

Table 7. Production (kg/ha) of experimental groups.
(Each cell contains the survival of the group listed above at the upper right corner, and that of the group listed aside at the lower left corner).

A. PURE STRAINS.

T. aurea	*Tilapia nilotica*				Mean
	Ghana	Bangkok	L. Manzalah	Nile	
E. Hamifratz	512 / 176	478 / 246	466 / *	443 / 266	230
L. Manzalah	450 / 364	355 / 286	- / -	534 / 538	390
Mehadrin	478 / 333	602 / 482	542 / 234	564 / 424	368
Mean	480	478	504	514	

B. HYBRIDS.

T. aurea crossbreds	*T. nilotica*(G) hybrids with:			Mean
	T. aurea (EH)	*T. aurea* (D)	*T. hornorum*	
EH x M	- / - **	664 / 504	614 / 426	465
EH x LM	- / - **	543 / 471	615 / 178	424
M x LM	- / - **	581 / 585	794 / *	
Mean		596	674	

* not included due to very low survival
** Sorting impossible, due to lack of tail stripes on any of these fish.

Table 8. Stocking scheme for testing adult fish in 1986

Testing Method	No. of ponds (area)	Breeding system	Species	Isolate	No. stocked per pond
Communal testing	4 (1000m^2)	Pure-breds	*T. aurea*	EH	31
				M	36
				LM	36
			T. nilotica	N	36
				LM	31
				G	40
				B	37
		Hybrid*	*T. nilotica* x *T. aurea*	G X D	3
	4 (1000m^2)	Cross-breds	*T. aurea* x *T. aurea*	EH X M	58
				EH X LM	56
				M X LM	19
		Hybrid	*T. nilotica* x *T. hornorum*	G X H	32
			T. nilotica x *T. aurea*	G X D	38
				G X D*	58
Separate testing	3 (400m^2)	Hybrid	*T. nilotica* x *T. hornorm*	G X H	100
	3 (400m^2)	Hybrid	*T. nilotica* x *T. aurea*	G X D	100

* Unmarked fish, added in order to reach a stocking rate of 250 per pond.

Table 9. Results of adult fish test, May to August, 1986

Tested group		Mean Weight (g)		Mean daily weight gain (g)	Survival (%)
Species	Isolate	Initial	Final		
T. aurea	EH	173	406	2.75	63
	M	128	435	3.15	71
	LM	156	413	2.66	78
T. nilotica	N	180	522	3.77	57
	LM	171	549	3.95	74
	G	156	478	3.43	56
	B	190	503	3.27	76
T. nilotica x *T. aurea**	G X D	134	445	3.25	264
T. aurea x *T. aurea*	EH X M	147	477	3.41	71
	EH X LM	134	430	2.96	69
	M X LM	176	431	2.60	88
T. nilotica x *T. hornorum*	G X H	171	388	2.22	78
T. nilotica x *T. aurea*	G X D	132	432	3.07	91
		142*	393*	2.54*	86*

* Unmarked fish. Apparent surplus due to tag loss in other groups

Table 10. <u>Summary of adult fish test, May to August, 1986</u>

Breeding system	species	Mean daily weight gain (g)	Mean Survival (%)
Purebreds	*T. nilotica*	3.61	66
Purebreds	*T. aurea*	2.85	71
Crossbreds	*T. aurea*	2.99	76
Hybrids	*T. nilotica* x *T. aurea*	3.07	91
Hybrids	*T. nilotica* x *T. hornorum*	2.22	78

IV. LAKE MANAGEMENT (KINNERET)

IV. Lake Kinneret Management

IV.a. Gut content analysis

IV.b. Bleak feeding behavior

IV.c. Sarotherodon galilaeus populations in Lake Kinneret

IV.d. Littoral fingerling communities

IV.e. Echo survey: preliminary results

IV.f. International cooperation

Dr. M. Gophen and Dr. P. Walline with

Dr. P. Spataru, Ms. Z. Katz, and Mrs. B. Azoulay

Israel Oceanographic & Limnological Research Ltd.

Kinneret Limnological Laboratory

Tiberias, Israel

IV.a. Gut Content Analysis

Dr. P. Spataru and Dr. M. Gophen

1. *Tristramella sacra*
2. *Tristramella simonis simonis*
3. *Capoeta damascina*

MATERIALS AND METHODS (GENERAL)

Fish from various parts and depths of the lake were sampled monthly with purse-seine and trammel nets. Several additional samples were collected with a cast net. The total of 126 T. sacra, 367 T. simonis simonis, and 210 Capoeta damascina included a wide range of lengths and weights (Table 1).

Fish were weighed and measured immediately after being caught. Intestines were then removed and placed in 6% formaldehyde solution. Quantitative estimations of food components were carried out on a plate chamber (530.66 mm^2) using an M40 Wild inverted microscope equipped with an Utermohl eyepiece. Phytoplankton and zooplankton biomass assessments were based on data previously published (Pollingher and Berman, 1974; Pollingher, 1981; Bourrelly, 1968; Dor, 1974; Kimor and Pollingher, 1965; Gophen, 1973; Pollingher, 1978) and on data obtained by weighing freshly collected benthic animals. Intestine indices (II) were calculated by the following formula:

$$II = L_i/L_s$$

where L_i = intestine length and L_s = fish standard length. To estimate the degree of satiation (F_i = index of fullness) the following formula was used:

$$F_i = 100(w/W)$$

where w = weight of the gut content and W = fish weight. The digestibility of ingested organisms was studied by comparing their degree of integrity and structure in various parts along the fish intestine.

In the case of T. simonis simonis, detritus in the intestines was examined microscopically and its weight taken as the remainder after

Table 1. Ranges of weights and total lengths (TL) of sampled fish

Species	Weight (g)	TL (mm)
T. sacra	2.5 - 242.3	45 - 202
T. simonis simonis	17.7 - 239.1	80 - 191
C. damascina	18.9 - 740	98 - 353

subtracting the weight of organisms present from total gut content weight.

For C. damascina mud quantities in the intestines were high. Therefore, the gut content of each fish was diluted (1:150-1:300) with 6% formaldehyde to allow counting and identification of ingested organisms. Ten subsamples were taken from the diluted gut contents for microscopical analysis. Ingested diatoms were measured, and their volume was calculated using different geometrical shape formulae (Pollingher, 1981).

RESULTS AND DISCUSSION

Each species will be discussed separately. In each case the discussion is divided into two parts: (1) the main food items in the diet and (2) seasonal changes in the diet.

1. Tristramella sacra (Gunther, 1864)

The most common algal species in the fish intestines was Peridinium cinctum fa. westii, the dominant phytoplankter in Lake Kinneret during March-June every year. The relative biomass of Peridinium in the gut contents during April was as high as 99% of ingested material, and the frequency of this alga among analyzed fish was 90.5% (Table 2, Fig. 1).

Planktonic chlorophytes were frequently (73.8%) present in the gut contents, but their relative biomass in each fish was low (Table 1). The most frequent chlorophytes were Scenedesmus spp., Pediastrum spp., and Lagerheimia spp. (73.8%, 71.4%, and 57.7% respectively). Two major planktonic diatom species were observed: Melosira granulata (64.3%) and Cyclotella spp. (59.5%) (Table 2).

Table 2. Frequencies (% of analyzed fish in which mentioned food component was found) and abundance (% of gut content biomass) of food components analyzed in the gut contents of T. sacra from Lake Kinneret.

Food Components	Frequency	Abundance
ALGAE		
Cyanophyta		
Microcystis spp.	80.9	0 - 10
Oscillatoria sp.	19.1	0 - 1
Bacillariophyta		
Melosira granulata	64.3	1 - 5
Cyclotella spp.	59.5	1 - 5
Chlorophyta		
Botryococcus braunii	47.6	0 - 1
Coelastrum microporum	45.2	0 - 1
Cosmarium laeve	7.1	0 - 1
Golenkinia radiata	50.0	0 - 1
Lagerheimia spp.	57.1	0 - 1
Volvocales	64.3	0 - 1
Oocystis spp.	45.2	0 - 1
Scenedesmus spp.	73.8	1 - 5
Pediastrum spp.	71.4	0 - 1
Tetraedron spp.	53.4	0 - 1
Pyrrhophyta		
Peridinium cinctum fa. *westii*	90.5	5 - 99
Euglenophyta		
Phacus sp.	4.8	0 - 1
ANIMALS		
Oligochaeta	2.4	0 - 1
Cladocera		
Bosmina longirostris	73.8	10 - 35
Cyclopoida	10.1	1 - 5
Rotatoria		
Keratella sp.	66.7	5 - 10
Tintinnidae	40.5	1 - 5
Chironomidae larvae	9.5	0 - 1
ORGANIC DETRITUS	76.2	1 - 70

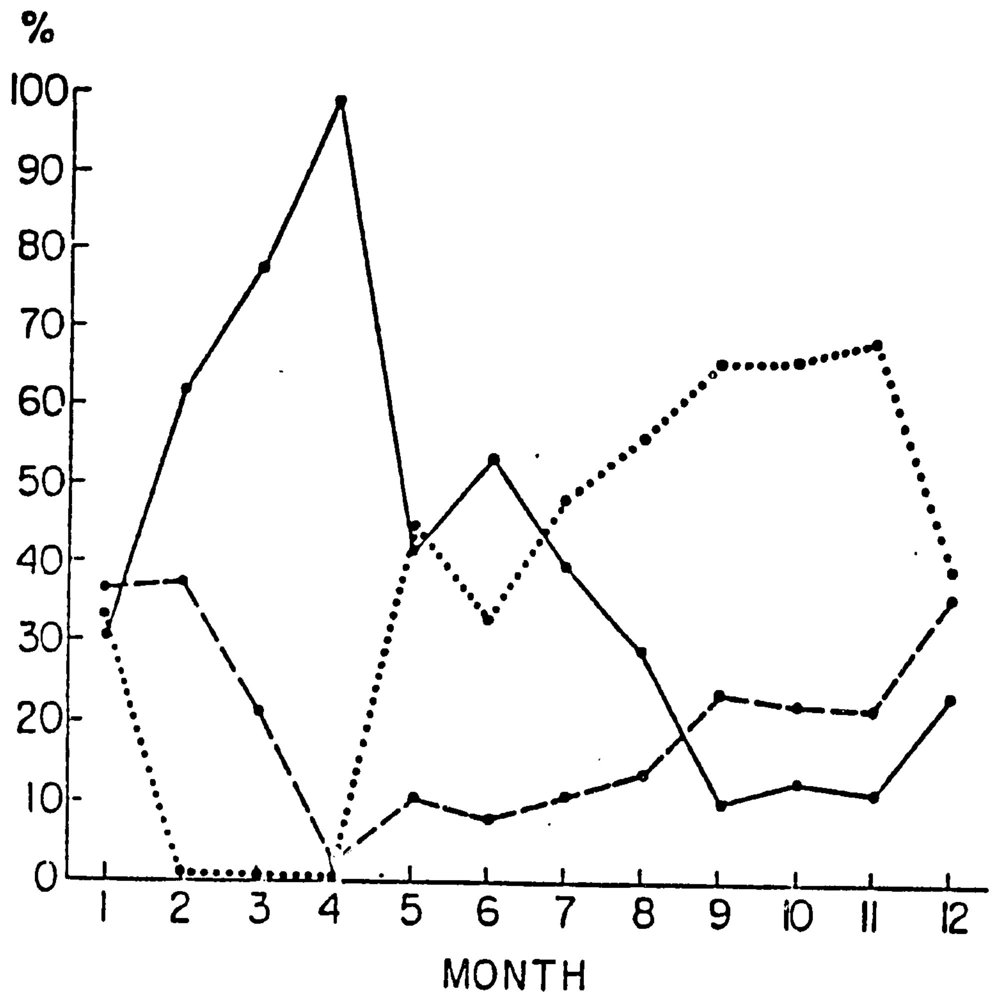


Fig. 1. Seasonal changes of biomass compositions (%) of T. sacra gut contents sampled in Lake Kinneret; phytoplankton |——| zooplankton - - - -; detritus ●●●●●●●●.

Frequencies of unidentifiable zooplankton fragments in the gut contents were relatively high. Identifiable zooplankton including Bosmina longirostris, tintinnids and Keratella spp. showed high values of both frequency and abundance. Zoobenthic organisms (oligochaetes, chironomid larvae) were found in low frequencies. Because the first stage of chironomid larvae is a pelagic form, it is more intensively grazed than are the benthic forms. Results presented here indicate that major food sources of T. sacra in Lake Kinneret are suspended organic particles, i.e. detritus (including macrophyte fragments), phytoplankton, and zooplankton. The contribution of benthic organisms or sediment particles to the fish diet is negligible. The ingested detrital matter was characterized by low percentages of mud and/or other inorganic particles.

Seasonal changes in biomass composition of the fish food components were noted (Fig. 1). The relative biomass (%) of ingested detrital particles was 32.5%, 45.8%, 68.4%, and 39.8% in January, May, November, and December respectively. During February-April only small quantities of detritus were found in the gut contents. Therefore, in February-April the major food source is phytoplankton. Algal species composed 52.1-71.4% of the natural assemblage and 62.5-99.2% of the gut content compositions, while zooplankton contributed only 6-37% of the food biomass during this period. During May-June organic detritus is common in lake water, originating from decomposing Peridinium blooms. Consequently, organic detritus and phytoplankton were consumed in high quantities. From September through January, in contrast to previous months, zooplankton made up a larger proportion of the fish diet than did phytoplankton. However, it is likely that detritus, rather than phytoplankton or zooplankton, is the preferred food source.

In the summer and fall months, when natural detritus and phytoplankton densities are lower than during springtime, the total plankton biomass is much lower than in winter periods, due mostly to this reduction in algal biomass. During this period T. sacra increase the predation pressure on zooplankton. It is also probable that other fish species compete with T. sacra for zooplankton resources in the summer-fall season. In winter periods (December) the intestinal biomass of detritus and zooplankton are similar (39.8%, 36.4% respectively) while that of phytoplankton is much lower. In January the three food components are present in nearly equal quantities.

We conclude that for T. sacra detritus is the primary food source, with phytoplankton second most important and zooplankton third. As far as we know, this is the only Kinneret fish which consumes suspended organic detritus as one of its major food components. These particles are very abundant during the late bloom season of Peridinium. It is suggested that T. sacra has adapted to utilize the large biomass of decomposing Peridinium cells in the lake. The efficient utilization of this abundant food source is probably one of the reasons for the endemism of T. sacra in Lake Kinneret. The ability of this fish to graze Peridinium-detrital particles should be considered in management schemes for Lake Kinneret.

2. Tristramella simmonis simonis (Cichlidae)

The gut contents of this species were dominated by organic detritus (Fig. 2, Table 3). Mud particles, small fragments of macrophytes, algae, and animals were also represented. These fragments were highly macerated and partly unidentifiable. Significant seasonal changes of relative quantities of the major food components were observed. During March-April when Peridinium dominated lake phytoplankton, this algae contributed the highest part of gut content biomass (45-62% of the total). From May through December, January, and February, detritus appeared to be the major food of T. simonis simonis in Lake Kinneret (46-67% of total wet weight). During February-June the ingested phytoplankton biomass was higher than that of zooplankton, but in other months more zooplankton than phytoplankton was consumed (Fig. 2).

The most frequent (86%) and abundant (10-50%) phytoplankter in the gut contents was Peridinium cinctum fa. westii, while other species composed less than 1% of the algal biomass in each fish (Table 3). This species consumes a wide variety of plants and animals: three species of Cyanophyta; 12 benthic Bacillariophyta; 10 Chlorophyta; 3 Pyrrhophyta; 1 Euglenophyta; 2 Copepoda (one a benthic harpacticoid); 2 Cladocera (Bosmina longirostris and the small benthic Illyocryptus sordidus); 1 species of Rotifera (Keratella cochlearis); fragments of zoobenthic organisms (oligochaetes, chironomid larvae); and fish scales and bones. Cosmarium laeve was the dominant chlorophyte in the gut contents (71% of the Chlorophyta biomass). This alga is commonly found in deep water layers and in the sediments. Cladocera, the most common zooplankter, represented up to 95%

Table 3. Frequency (% of analyzed fish in which mentioned species was found) and abundances (% of individual gut content volume) averaged for all specimens of Tristramella simonis simonis.

Food components	Frequency	Abundance
ALGAE		
CYANOPHYTA		
Microcystis aeruginosa	64.3	5 - 10
Merismopedia punctata	28.6	0 - 1
Oscillatoria spp.	32.1	0 - 1
BACILLARIOPHYTA		
Amphora ovalis	39.3	0 - 1
Cymatopleura solae	41.1	0 - 1
Cymatopleura sp.	21.4	0 - 1
Cymbella sp.	42.9	0 - 1
Epithemia zebra	46.4	0 - 1
Gyrosigma sp.	19.6	0 - 1
Navicula spp.	48.2	0 - 1
Nitzschia spp.	46.7	0 - 1
Pinularia sp.	55.4	0 - 1
Stauroneis sp.	23.2	0 - 1
Surirella sp.	32.1	0 - 1
Synedra sp.	28.6	0 - 1
CHLOROPHYTA		
Botryococcus braunii	39.3	0 - 1
Chlamydomonas	14.3	0 - 1
Coelastrum spp.	44.6	0 - 1
Cosmarium laeve	87.5	1 - 5

Table 3 (continued)

Pediastrutrum sturmi	69.6	0 - 1
Scenedesmus arcuatus	12.5	0 - 1
CHLOROPHYTA		
Scenedesmus bijuga	32.1	0 - 1
Scenedesmus quadricauda	82.1	0 - 1
Tetraedron caudatum	17.9	0 - 1
Tretraedron trigonum	66.1	0 - 1
PYRRHOPHYTA		
Peridinium cinctum fa. *westii*	85.7	10 - 50
Peridinium cunnigtonii	31.2	0 - 1
Ceratium hirudinella	12.5	0 - 1
EUGLENOPHYTA		
Phacus sp.	8.9	0 - 11
ANIMALS		
Nauplius	5.4	0 - 1
Cyclopoidae + Harpothicoidae	25.0	5 - 10
Cladocera	94.6	10 - 50
Rotatoria	41.0	0 - 1
Tintinidae	25.0	0 - 1
Zoobenthos fragments	42.9	0 - 1
DETRITUS + MUD PARTICLES	98.2	>50

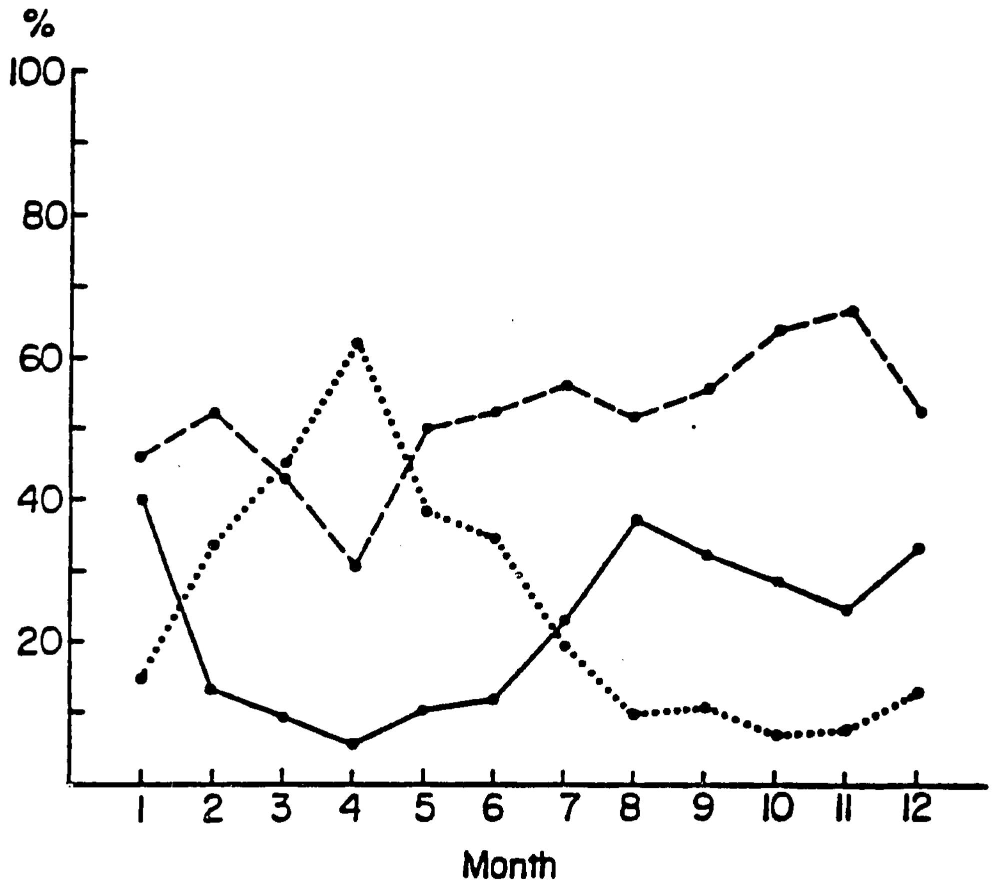


Fig. 1. Monthly changes of the wet weights (%) of three major food components in the gut contents of *Tristramella simonis simonis* in Lake Kinneret: detirtus (•— — —•), zooplankton (•——•) and phytoplankton (•••••).

frequency and 10-50% abundance. Our results indicate that detritus is the major component of the food of T. simonis simonis in Lake Kinneret. We assume that detrital particles are collected by the fish in deep layers. The deep layer origin of this detritus was indicated by the predominance of mud particles and the benthic alga Cosmarium. Due to the relatively high resistance of Cosmarium cell walls, empty cells are abundant in deep water layers and consequently in fish intestines. We did not, however, find high quantities of benthic organisms in the fish food. Therefore, we think that the major part of the food is sinking detritus and resuspended bottom particles. The food composition of T. simonis simonis in Lake Kinneret reflects the plankton assemblages that exist in the lake throughout the year. Nevertheless, the fish feed in deep water layers, and therefore, disintegrated organisms such as detritus are the most common components of the diet.

We suggest that the role of T. simonis simonis in the food web of the Kinneret ecosystem is as follows. During winter-spring the dinoflagellate Peridinium produces a heavy bloom, contributing approximately 50-60% of assimilated carbon (standing stock). A major part of this organic matter is present in the form of degradation products of Peridinium decomposition. T. simonis simonis as an organic detrital consumer converts part of this decomposing Peridinium material into fish biomass. Moreover, during summer and fall months, T. simonis simonis utilizes detrital particles orginating from organisms other than Peridinium. Thus, in addition to its value as a commercial fish, T. simonis simonis plays a beneficial role in the lake ecosystem by diminishing the organic matter load in the lake.

3. Capoeta damascina (Cyprinidae).

The most abundant organism in the gut contents of C. damascina were diatoms (Table 4), especially those that belong to epipelon algal communities (Round, 1978). Several algal species classified by Round (1978) as epiphyton, epipsammon, and epilithon components were also present in the fish intestines. Some other diatoms and chlorophytes, commonly found in the phytobenthos and phytoplankton of Lake Kinneret (Dor, 1974; Pollingher, 1978), were also identified as food components.

The major component of the gut contents was mud composed of particles of 150-250 u diameter. Some of the mud particles found in the anterior parts of the intestines were covered with algae and/or organic substance. Among these attached and free algae, diatoms were most abundant. Many diatom cells were found as an empty half or complete frustulae. We observed a gradual increase in the degree of digestion of the diatoms along the intestines. Empty frustulae were abundant in the posterior part of the intestines and rare at the beginning of the digestive tracts. Zoobenthic organisms were present in only 5-20% of analyzed fish and only in low quantities.

Seasonal fluctuations of relative quantities of benthic algae and mud particles in gut contents followed water level changes. During periods of relatively low water level (Oct.-Feb.), diatom biomass varied between 54-56% of the total gut content and that of mud particles 37-42%. When the water level was high (March-Sept.), percentages were 33-41% and 48-53% for diatoms and mud particles respectively (Fig. 3). During periods of low water level the sediment strip, which is a suitable substrate for benthic diatoms, may be wider

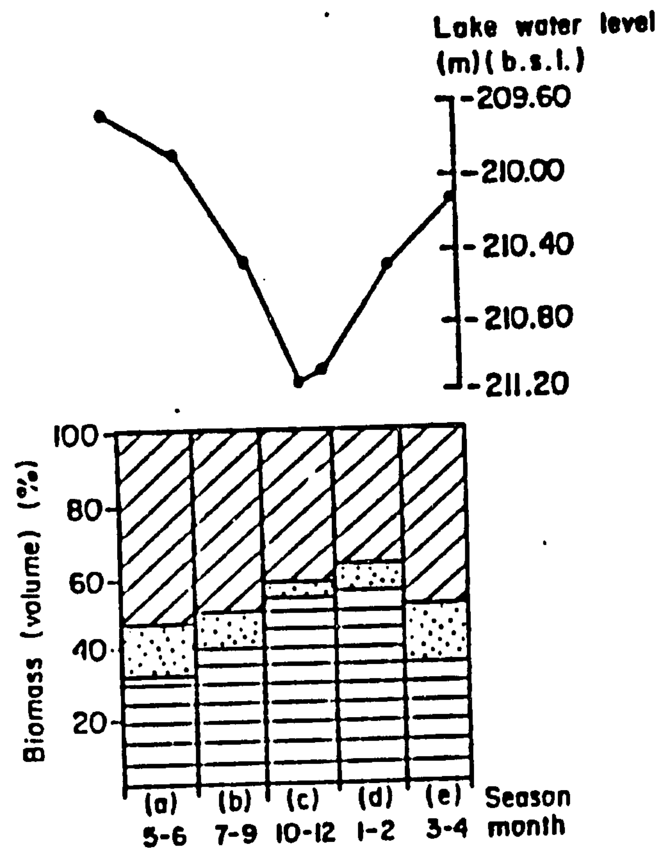
Table 4. Frequency (% of analyzed fish (Capoeta damascina) in which mentioned species was found) and abundance (% of gut content volume) averaged for all specimens.

Food components	Frequency	Abundance
Algae		
Cyanophyta		
Microcystis spp.	4.8	0 - 1
Merismopedia punctata	33.3	1 - 5
Oscillatoria sp.	42.9	5 - 10
Bacillariophyta (diatoms)		
Cyclotella spp.	38.1	1 - 5
Melosira arenaria	42.9	5 - 10
Melosira granulata	9.5	0 - 1
Fragillaria sp.	21.4	5 - 10
Synedra ulna	26.2	10 - 50
Synedra affinis	9.5	0 - 1
Cocconeis placentula	23.8	5 - 10
Achantes sp.	2.4	5 - 10
Rhoicosphenia curvata	7.1	10 - 50
Gyrosigma spp.	14.3	5 - 10
Caloneis spp.	2.4	10 - 50
Stauroneis sp.	40.5	10 - 50
Navicula spp.	90.5	10 - 50
Pinnularia spp.	83.3	10 - 50
Amphora ovalis	66.7	10 - 50
Cymbella spp.	57.1	5 - 10
Gomphonema intricatum	30.9	5 - 10

Table 4. (continued)

Epithemia zebra	54.8	5 - 10
Bacillaria sp.	11.9	5 - 10
Cylotella (diatoms)		
Nitzschia spp.	57.1	10 -
Cymatopleura solea	40.5	5 - 10
Cymatopleura eliptica	26.2	5 - 10
Surirella capronii	23.8	5 - 10
Surirella spiralis	4.8	1 - 5
Chlorophyta		
Chlamydomonas spp.	28.6	1 - 5
Golenkinia sp.	7.1	0 - 1
Pediastrum sp.	16.7	0 - 1
Coelastrum microporum	19.0	0 - 1
Oocystis sp.	7.1	0 - 1
Chodatella spp.	7.1	0 - 1
Tetraedron trigonum	11.9	0 - 1
Scenedesmus sp.	28.6	0 - 1
Cosmarium laeve	66.7	.5 - 10
Pyrrhophyta		
Peridinium cinctum fa. *westii*	73.8	1 - 5
Peridinium spp.	11.9	0 - 1
Animals		
Cladocera	19.0	0 - 1
Copepoda	19.0	0 - 1
Rotatoria	7.1	0 - 1
Tintinnidae	4.8	0 - 1

Fig. 3. Biomass (volume) composition (%) of major food components ([horizontal lines] - diatoms; [dots] - other algae; [hatching] - mud particles) of gut contents, averaged for all analyzed <u>C. damascina,</u> and water level fluctuations (meters below sea lecel) (m) (b.s.l.) in Lake Kinneret during four seasons: early (a) and late (b) - summer; (c) - fall-winter; (d) - winter and (e) - spring.



than during higher water level conditions. Therefore, at low water levels, food collection by the fish is more efficient, and mud content in the intestines is low in comparison with high water level conditions.

Capoeta damascina in Lake Kinneret can be classified as a phytobenthophagous fish which collects food from bottom sediments. The index of intestine fullness is high (up to 12.7), compared with values of 5.3, 5.5, and 5.6 found for S. galilaeus, T. zillii and H. molitrix, respectively. The high quantities of ingested material observed in the guts are probably a result of the low nutritional value of the mud.

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IV.b. Bleak Feeding Behavior

Dr. M. Gophen and Mrs. B. Azoulay

Mirogrex terraesanctae terraesanctae (Kinneret sardine, Kinneret bleak), endemic to Lake Kinneret, dominates the fish biomass. Gut content analyses of fingerlings and adults indicate its zooplanktivorous feeding habit (Gophen and Landau, 1977; Gophen and Scharf, 1981). The bleak is therefore implicated in the clear decrease of zooplankton biomass and consequent enhancement of nanoplanktonic algae observed in recent years in Lake Kinneret. For this reason, knowledge of feeding rates of the Kinneret bleak is needed to formulate management plans for the lake.

MATERIALS AND METHODS

Adult fish were collected alive from purse-seiners and introduced into 3 glass aquaria, each containing 65 l of lake water. Number of sardines in each tank was 19, 10, and 15. A control aquarium was maintained without fish. Experiments were carried out during the winter with fish acclimated for 10 days prior to each experiment and fed with fresh lake plankton collected daily. Water in the tanks was slightly aerated. During an experiment water samples were collected from the tanks immediately after introduction of the fish and after 24 hours. Samples were collected with a 5-cm diameter plastic pipe blocked with a rubber stopper. Each sample was filtered (63 u mesh) after sample volume was measured. Food consumption was estimated from the decrease in zooplankton abundance after 24 h, correcting for changes in the control aquarium.

At the end of the experiments all fish were weighed. Conversion of zooplankton organism numbers to biomass was based on data published by Gophen (1973). The feces in each tank were daily collected and weighed after drying for 24 hours at 85^{o}C.

RESULTS

Zooplankton biomass ingested by sardines in the experimental aquaria ranged from 0.36 to 0.81g wet wt/fish/day (Table 5).

The overall average was 0.56g wet wt./fish/day (+0.17). The average weight of the fish was 12.3 g ($\mp$2.3 g), so the average consumption in mg wet wt./ body wt./day was 46.

Defecation rates averaged 7.6 mg dry wt./fish/day, or 0.62 mg dry wt./g body wt.day (Table 6).

Indices of electivities (E) for Copepoda (adult copepods and IV-V copepodites), *Bosmina* sp. (*B. longirostris*), *Ceriodaphnia* sp. (*C. reticulata*), and *Diaphanosoma* sp. (*D. brachyureum*), were daily calculated using formulae presented by Ivlev (1961). Positive values greater than 0.50 were found for all categories of zooplankton examined (Table 7).

CONCLUSIONS

It can be concluded that the Kinneret sardines are efficient consumers of large zooplankters in Lake Kinneret. According to data presented here, the Kinneret bleaks consume a daily ration of 4.6% of their body weight in zooplankton at 21-25^{o}C. It should be taken into account that plankton was given to the fish only once per day, so grazing rates declined as food concentrations were reduced over the 24 h of an experiment. Fish can probably consume higher quantities if food concentrations are maintained at a constant level.

Table 5. Averages (∓SD) of ingested zooplankton biomass by bleaks in g wet. wt./fish/day.

Tank	Replication	Consumed zooplankton
A	1	0.81 (0.46)
	2	0.39 (0.29)
B	1	0.64 (0.40)
	2	0.55 (0.33)
C	1	0.36 (0.22)
	2	0.61 (0.43)

Table 6. Averages (±SD) of feces dry weights (85°C, 24 h) for each tank.

Tank	Feces (mg dry wt./fish/day)
A	6 (±3)
B	8 (±4)
C	9 (±4)

Table 7. Averages of indices of electivities (E) (∓ S.D.) in two experiments (tanks).

Tank	Copepoda	*Bosmina*	*Ceriodaphnia*	*Diaphanosoma*
A	+0.58 (0.30)	+0.56 (0.33)	+0.61 (0.31)	+0.73 (0.32)
B	+0.61 (0.34)	+0.53 (0.35)	+0.51 (0.33)	+0.67 (0.38)

References

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IV.c. Sarotherodon populations in Lake Kinneret

INTRODUCTION

New procedures of stocking *Sarotherodon galilaeus* fingerlings have been instituted in Lake Kinneret. The new stocking program is based mainly on the results of the US-AID Lake Management Project, Phase I (1980-83). One of the aims of Phase II is to document the results of the new operations as implemented by the Kinneret Authority (Water Commission-Ministry of Agriculture). For this purpose we are monitoring the appearance of the stocked fish in commercial catches.

MATERIALS AND METHODS

Fish from the Tiberias fishmarket were sampled. The total catch of one boat in one night of fishing was weighed, and small fish (18 cm TL) were sampled for measurements. In the laboratory weight, TL and SL were measured, and scales were taken from each fish for age determination. Sampling started in February 1986, one and a half years after the start of the new stocking program in the summer of 1984.

Results presented in Table 8 indicate that 28-40% of the fish in the catches are smaller than the legally permitted size (19-20 cm). Most of the small fish were those stocked in summer 1984 when the new stocking program started. Can these fish grow to the legal size in only a few months? A detailed analysis of this question will be presented in the next report.

Table 8. Sarotheron galilaeus market samples of small fish (18 cm). Total catch (kg); weight (g), SL (cm) (range-upper numbers, average-lower numbers); and ages (years) are presented.

Date	Total catch (kg)	Small fish catch (%)	Weight (g)	SL (cm)	TL (cm)	Age (y)
8.2.86	27	37%	80.5-137.1	12-15.5	15-19	0+: 0
			(105.3)	(13.7)	(16.8)	1+:34
						2+: 9
4.3.86	30	40%	81.8-139	12-15.5	15.5-19	0+: 0
			(114.3)	(13.8)	(17.2)	1+:42
						2+: 0
10.4.86	11	36%	90.1-133.9	12.5-15	16-19	0+: 1
			(113.7)	(13.9)	(17.3)	1+:17
						2+: 8
15.5.86	40	28%	95.2-139.2	12.5-15.5	16.5-19	0+: 0
			(123.3)	(14.2)	(17.6)	1+: 5
						2+: 8
						3+: 1
2.7.86	40	35%	109-145.8	13-15.5	16.5-19	0+: } Not yet analyzed
			(123.3)	(14 2)	(17.6)	1+:
						2+:

IV.d. Littoral Fingerling Communities

M. Gophen and Z. Katz

We started a survey of the fingerling population structure in the littoral of Lake Kinneret. Fingerlings were fished by cast net. Between February and April 1986, 4 samples were collected utilizing similar effort (3 throws of a 6-ft. diameter cast net in each case).

Results indicate differences in densities and composition of fingerling populations in shallow waters (Table 9). The data will be analyzed in the next report when more samples will be presented and results correlated with water level conditions.

IV.e. Echo Survey: Preliminary Results

P. Walline

The main goal of the acoustic work is to assess the size of the sardine stock and relate changes in stock size to environmental and biological features of the lake. The first steps in attaining this objective are to get the acoustic system fully operational, to establish routine procedures for making surveys, and to obtain and adapt a system for analyzing the acoustic data on a personal computer (IBM-PC compatible).

We made trial surveys in July and September to test the equipment and to obtain an idea of fish distribution in these months. Preliminary results are reported here.

MATERIALS AND METHODS

The echo-sounder system used is a SIMRAD EY-M scientific echosounder operating at 70 kHz. The entire system is portable and

Table 9. Catch by species in cast net samples from Lake Kinneret.

Species	20.2.86	18.3.86	22.4.86	
	Tabgha	Tabgha	Tabgha	Ginnosar
S. galilaeus	2	0	0	2
O. aureus	13	0	0	5
T. zillii	149	484	8	33
T. canis	134	97	13	0
A. flaviijosephi	23	23	20	0
H. nanus	44	75	0	0
M. terraesanctae	0	22	0	0
A. lissneri	0	0	31	24
Total	365	701	72	64

power is supplied from a 12-v car battery. This makes it possible to use the system on a small boat (R.V. Hermona) without a generator.

For recording purposes, the frequency of the echo returns is downshifted from 70 kHz to 10 kHz at the calibrated output, so the analog signed can be recorded directly using an ordinary high-quality audio tape recorder, in our case a Sony TC-DSM. The echo sounder has two switch-selectable time-varied-gain (TVG) functions, "40 log R" and "20 log R," which compensate for spreading and absorption of the echo signal. In our surveys all data were recorded using the 40 log R TVG, making the strength of received echo returns independent of range.

The transducer used is a multi-element ceramic narrow-beam transducer developed by SIMRAD. The transducer is mounted to a V-fin and is towed at a depth of 0.5-1m, giving good stability in the water. However, because the TVG function starts only after 1.5m, fish located in the upper 2m are not sampled.

At the present time, analysis of the sonic tapes is being done in cooperation with Torfin Lindem of the Physics Institute at the University of Oslo. Briefly, analysis involves reproducing the recorded 10-kHz analog signal in an AC/DC converter, sampling the envelope every 0.1ms using an 8-bit analog-to-digital converter, and storing the digital records on floppy disks. A computer is used to select returns from single targets for analysis of target strength using a modification of the algorithm of Craig and Forbes (1969). By this means, the effect of position of the target in the beam can be removed from the received echo distribution, and the echo distribution statistically transformed to a target strength (TS) distribution. The mean target strength obtained in this way is used to scale the returns from multiple targets to estimate total fish density in depth intervals along transects. These densities can be integrated to produce a population estimate for the lake.

Surveys were made at night because preliminary work and results from other lakes indicate that fish are more uniformly distributed at night. A uniform distribution is desirable to minimize the number of multiple targets in the acoustic samples.

RESULTS AND DISCUSSION

Our first cruise was made during the night of 7-8 July. A N-S transect was made from Tsemah to Amnon Bay. The cruise track continued from Amnon Bay to Tiberias following the shoreline at a distance of approximately 1 km.

The TVG of the echo sounder failed to operate properly, so the sonic tapes could not be analyzed. However, several useful qualitative observations were made. The boundary between the anoxic layer and the epilimnion was clearly visible on the chart records. Fish were frequently observed to be concentrated just above the anoxic layer. The fish appear to be distributed singly rather than in dense aggregation, confirming previous observations that fish are more uniformly distributed at night. Finally, targets appearing within the anoxic layer were tentatively identified as bubbles.

After repairs to the echo sounder, a second survey was made on the night of 10-11 September. The cruise track ran from Migdal to Amnon Bay to Kursi to Tiberias and ended at Tsemach.

Fish densities were in general quite high, especially near shore (Fig. 1). Dense schools were often observed, making analysis of the records difficult, because analysis is based on single targets. In deeper waters near the center of the lake, densities were lower, and single targets dominated the echo return (Fig. 2).

Unfortunately, the TVG function once again malfunctioned on this cruise. As a result, TS strength distributions were skewed toward large targets. The tapes cannot be analyzed to give correct TS results at the present time, but in the future, when we have the analysis system adapted to an IBM-PC, we may be able to adjust for the incorrect TVG computationally. In any case, it is still possible to estimate total numbers of fish along the transects. Two sections of the survey, corresponding to the sections of the chart record presented in the figures were analyzed (see examples of output from computer analysis in Appendix). The results emphasize the patchiness observed during this cruise with numbers in the 5-15m depth layer ranging from 4496 to 15386 fish per hectare.

A complete survey using identical equipment was made by Torfin Lindem and Moshe Gophen in March 1981. At that time fish were distributed very evenly with up to 98% of the return in the form of single fish (Fig. 3).

The data were recently evaluated, and the results are the first known record of fish stock-assessment in Lake Kinneret based on echo-survey methodology. Echo-sounding transects are shown in Fig. 4, and the fish biomass distribution is presented in Table 1. Results

<u>Table 1</u>: Lake Kinneret Echo-survey: distribution of three averaged size groups (I: <10 cm TL, 25g II: 10-20 cm TL, 125g; III: 20 TL< 350 g) in two zones (inshore = < 10 m depth, and offshore = > 10 m depth) in m-tons. Data evaluation: Dr. T. Lindem, University of Oslo, Norway.
Relative % of inshore and offshore numbers are given in parenthesis.

Lake Area	I	II	III
Inshore	1225	3558	368
	(79%)	(85%)	(83%)
Offshore	322	615	73
	(21%)	(15%)	(17%)
Sub-total	1547	4173	441
Total		- 6161 -	

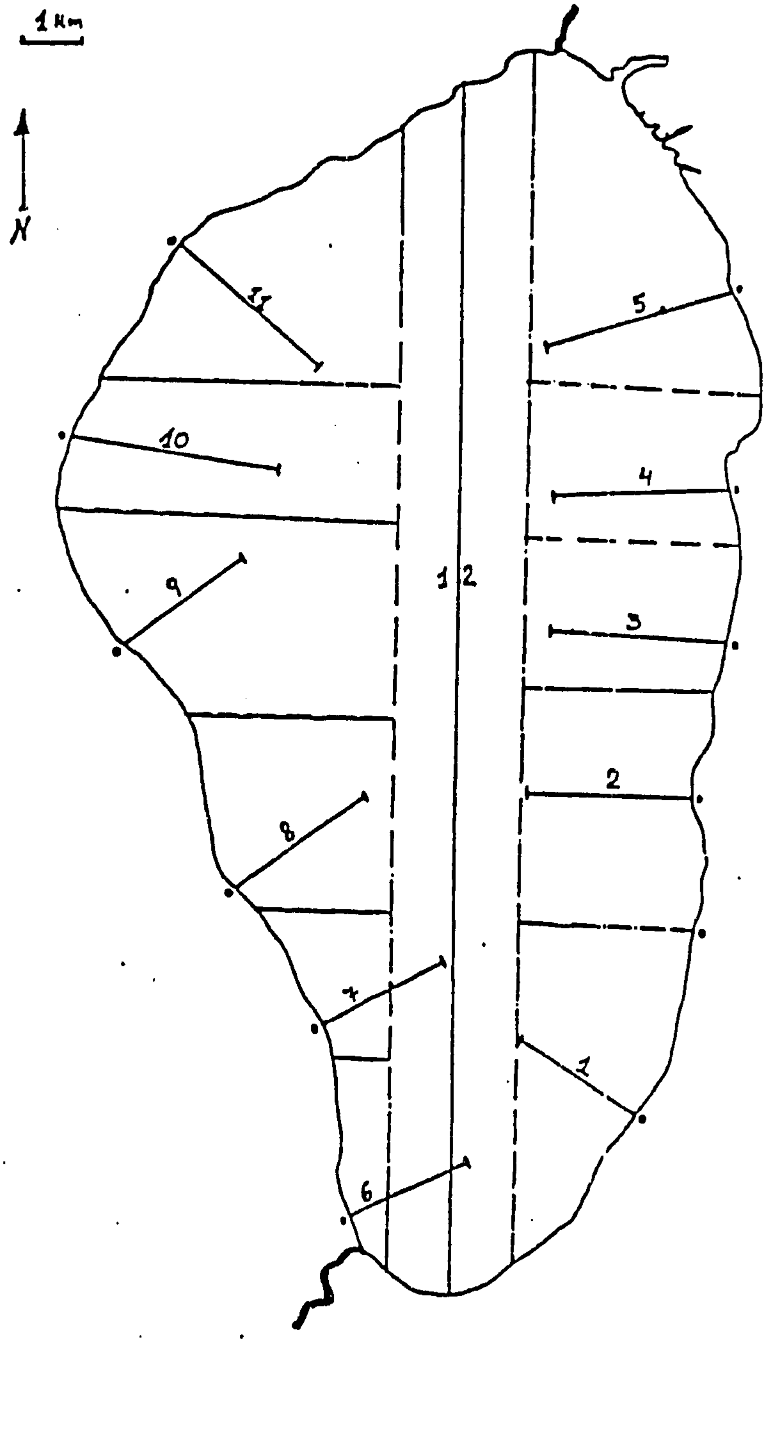


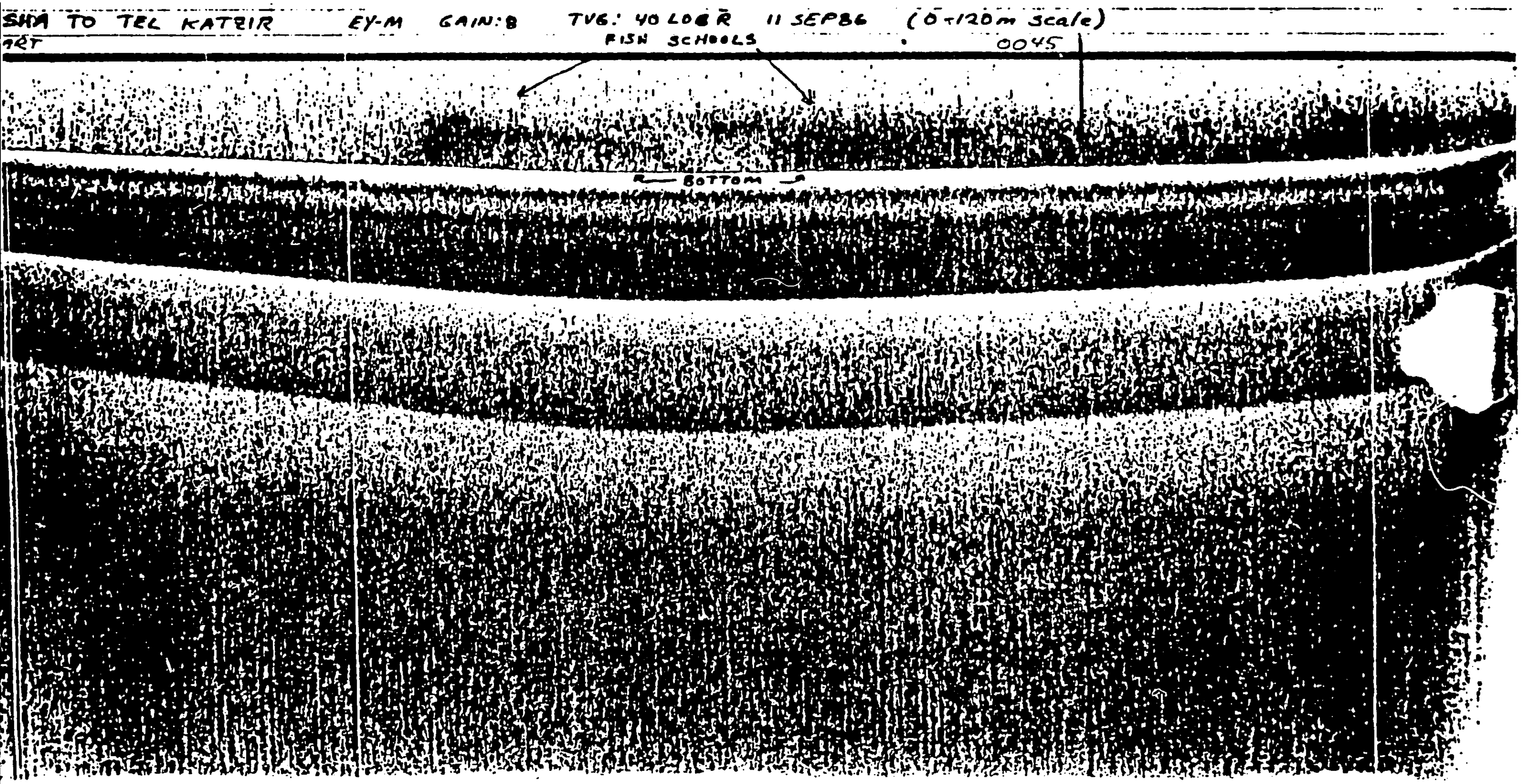
Fig. 4: Map of Lake Kinneret with echo survey transects (1-12) (|——|) and representative areas (|- - -|) covered by each transect.

indicated that most of the fish biomass (about 80% of all size groups) is concentrated in the inshore zone of the lake (<10m depth) and that medium-size fishes (10-20cm TL; 125g) are dominant.

We plan to repeat the survey of 1981 in March of the coming year. This should provide a good measure of changes in population size during the intervening 6 years and provide a background for comparison of results from surveys to be made in other seasons. In the coming year, we also plan to sample during a night when the sardine population is being heavily fished. We will try to quantify the reduction in numbers due to the fishing. An additional important objective for the coming year is to obtain the analysis system and adapt it to our Compaq personal computer so that we can analyze the sonic records of the Kinneret Laboratory, avoiding the delays involved in sending the tapes to Norway.

REFERENCE

Craig, R.E. and S.T. Forbes. 1969. Design of a sonar for fish counting. Fiskerdir. Skr. (Havunders.). 15: 210-219.


SHA TO TEL KATZIR
EY-M
GAIN: 8
TVG: 40 LOG R
11 SEP86
(0-120m Scale)
ART
FISH SCHOOLS
0045
BOTTOM

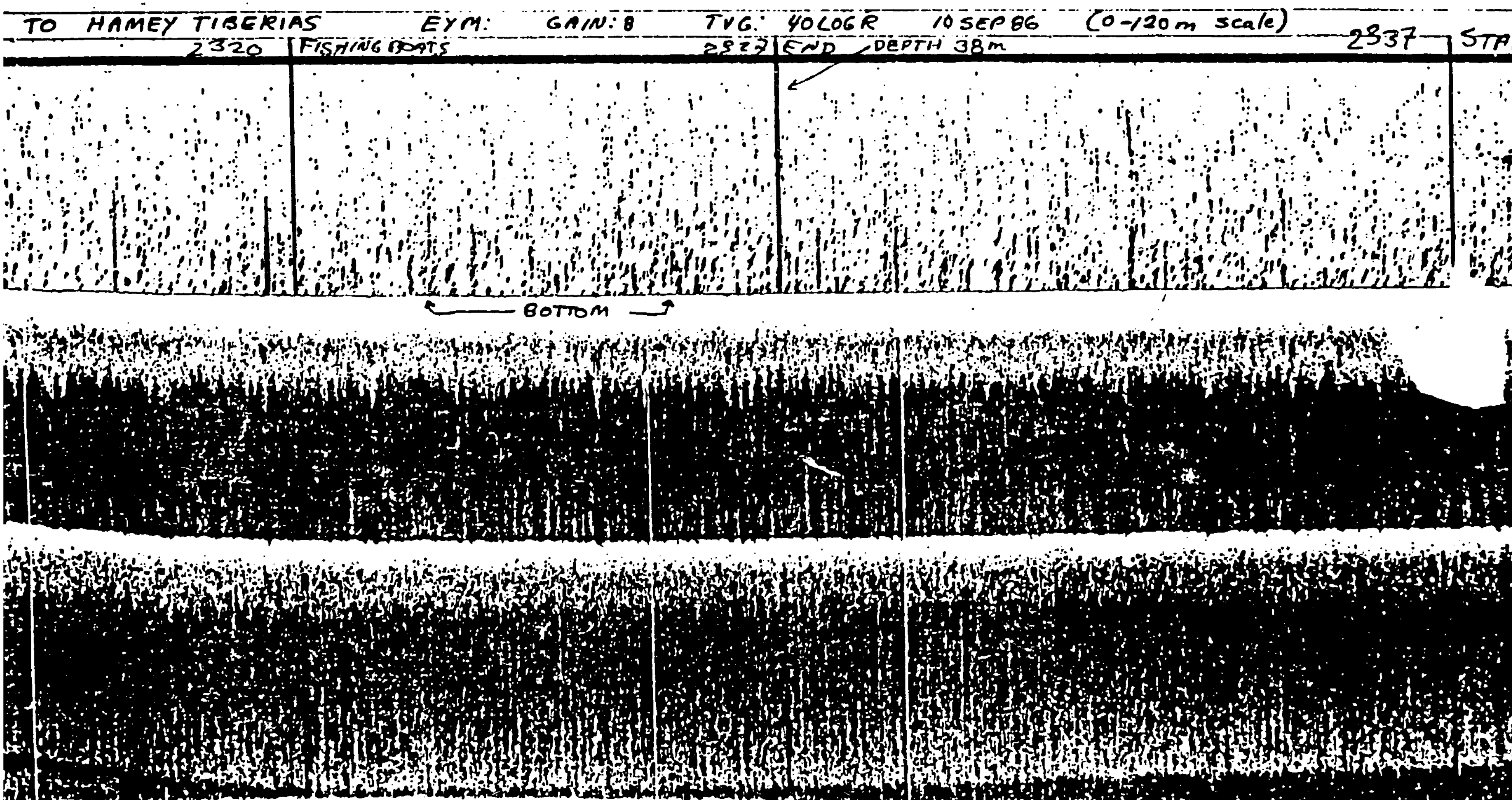
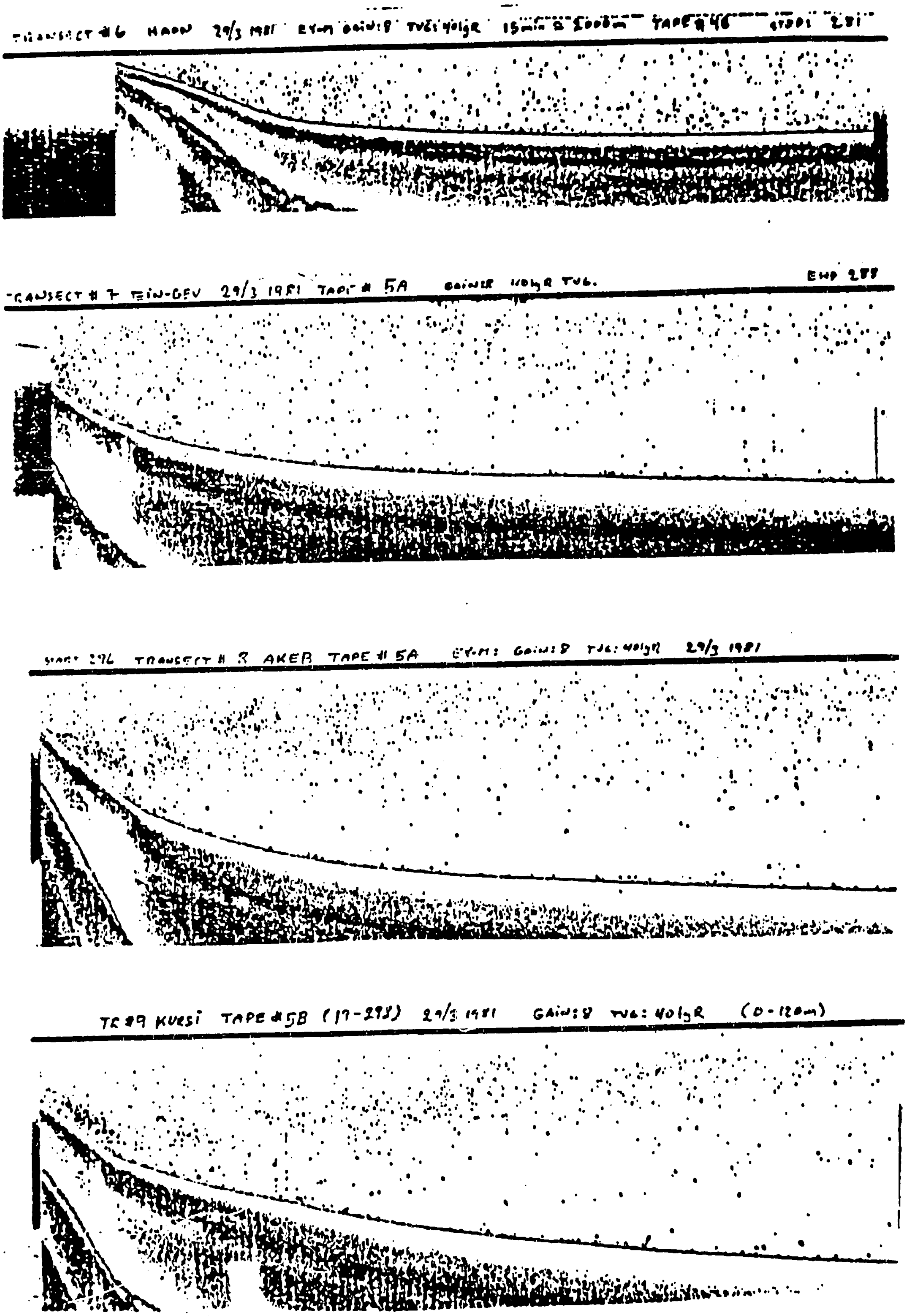

TO HAMEY TIBERIAS
EYM:
GAIN: 8
TVG: 40LOGR
10 SEP 86
(0-120m scale)
2320
FISHING BOATS
2327
END
DEPTH 38m
2337
BOTTOM

FIGURE 2.

FIGURE 3.


TRANSECT #6 29/3 1981 GAIN: 8 TVG: 40lgR
TRANSECT # 7 29/3 1981 TAPE # 5A GAIN: 8 40lgR TVG. END 288
START 296 TRANSECT # 8 AKEB TAPE # 5A GAIN: 8 TVG: 40lgR 29/3 1981
TR #9 KURSI TAPE #5B (17-293) 29/3 1981 GAIN: 8 TVG: 40lgR (0-120m)

ECHOANALYSIS: TEL-KATZIR

DATE : 11 SEP 1986

DATA FROM TRANSECT : TRANSECT#1
ECHOSOUNDER : XXXX HEADING=HAMEY TIBERIAS
REMARKS: TAPE#1A

NUMBER OF PINGS ANALYSED : 1800. START AT PING # 1
IN 1 DEPTHLAYERS FROM 5 TO 15 METER.

CALCULATED MEAN FISH DENSITY ALONG TRANSECT: 4496 FISH/HECTARE.

DEPTH METER	REGISTRATION SINGLE FISH.	INTEGRAL SINGLE FISH.	INTEGRAL SCHOOLS.	TOTAL FISHDENSITY
5-15	3243 FISH/HA	2.38722E7	9.22897E6	4496 FISH/HA.

FISH DENSITY SPLIT INTO 3 SIZEGROUPS.
[CALCULATED WITH DATA FROM SINGLEFISH-ECHOES.]

	SINGLE FISH	RES.	TOTAL.
TS 38-43 DB: DEPTH: 5 - 15 METER.	698 FISH/HA.	72.1 %	967 FISH/HA.
FISHSIZE > 20 CM.		TOTAL :	967 FISH/HA
TS 44-49 DB: DEPTH: 5 - 15 METER.	1171 FISH/HA.	72.1 %	1623 FISH/HA.
		TOTAL :	1623 FISH/HA
TS 50-57 DB: DEPTH: 5 - 15 METER.	1375 FISH/HA.	72.1 %	1906 FISH/HA.
FISHSIZE < 10 CM.		TOTAL :	1906 FISH/HA

ALL SINGLE FISH ECHOES GREATER THAN TS=-37 DB ARE TRUNCATED AND SHIFTED DOWN INTO THE (-38,-37) DB SIZEGROUPE.

IF FISH DENSITY IN A DEPTHLAYER IS FOLLOWED BY A "?", THE NUMBER OF SINGLE FISH ECHOES IS TOO LOW AND THE CALCULATED DENSITY HAVE POOR ACCURACY ! IF "**", THEN TOO MANY MULTIPLE ECHOES.

ROUNDING ERRORS MAY OCCUR DUE TO INTEGER PRESENTATION OF

ECHODISTRIBUTION FROM TEL-KATZIR . DATE : 11 SEP 1986

ECHOSIGNALS FROM TRANSECT : TRANSECT#1
ECHOSOUNDER DATA : XXXX   HEADING=HAMEY JIBERIAS

ANALYSIS OF ECHOSIGNALS FROM SINGLE FISH IN DEPTHLAYER :
5 - 15 METER. CALCULATED MEAN DEPTH: 15 METER.

NUMBER OF PINGS ANALYSED : 1800 OUT OF 1800. START # : 1
BOTTOM HAVE BLOCKED UP 0 PINGS IN THIS DEPTHLAYER.

SINGLEFISH RESOLUTION IN DEPTHLAYER : 72.1 % .
INTEGRATED VALUE FROM SCHOOLS : 9.22897E6

CALCULATED FISHDENSITY IN DIFFERENT SIZEGROUPS.

TS[DB]:	ECHO-NUMBER:	VOLUME DENSITY, FISH/1000 M**3:	AREA DENSITY, FISH/HECTARE:
-38	90	6.601	660
-40	109	1.628	163
-42	124	1.443	144
-44	220	7.354	735
-46	331	8.818	882
-48	319	0.059	6
-50	565	19.061	1906
-52	534	0.000	0
-54	0	0.000	0
-56	0	0.000	0

SINGLEFISH ECH. 2292   TOTAL: 4496 FISH/HA.

RELATIVE SIZEDISTRIBUTION OF FISH.
[THE NUMBERS GIVE PERCENTAGE OF TOTAL DENSITY]

```
I
I                   21 21
I                   ** **
I                   ** **
I                   ** **
I                   ** **
I                   ** **
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I                   ** **
I                   ** **
I                   ** **
I                   ** **      10 10
I                   ** **      ** **
I                   ** **      ** ** 8  8
I                   ** **      ** ** ** **             7  7
I                   ** **      ** ** ** **             ** **
I                   ** **      ** ** ** **             ** **
I                   ** **      ** ** ** **             ** **
I                   ** **      ** ** ** **             ** **
I                   ** **      ** ** ** **             ** **
I                   ** **      ** ** ** ** 2  2  2  2  ** **
I                   ** **      ** ** ** ** ** ** ** ** ** **
------------------------------------------------------------
  56 55 54 53 52 51 50 4  47 46 45 44 43 42 41 40 39 38 37
  SMALL FISH.     TARGET    TH IN -DB.         "BIG" FISH.
```

due to bad TVG

ECHOANALYSIS: TEL-KATZIR

DATE : 11 SEP 1986

DATA FROM TRANSECT : XXXXXX HEADING---->JORDAN R.
ECHOSOUNDER : XXX
REMARKS: TAPE#1B

NUMBER OF PINGS ANALYSED : 1200. START AT PING # 1
IN 1 DEPTHLAYERS FROM 5 TO 15 METER.

CALCULATED MEAN FISH DENSITY ALONG TRANSECT: 15386 FISH/HECTARE.

DEPTH METER	REGISTRATION SINGLE FISH.	INTEGRAL SINGLE FISH.	INTEGRAL SCHOOLS.	TOTAL FISHDENSITY
5-15	2923 FISH/HA	2.48316E7	1.05788E8	15386 FISH/HA.

FISH DENSITY SPLIT INTO 3 SIZEGROUPS.
[CALCULATED WITH DATA FROM SINGLEFISH-ECHOES.]

	SINGLE FISH	RES.	TOTAL.
TS 38-43 DB: DEPTH: 5 - 15 METER.	1620 FISH/HA.	19.0 %	8520 FISH/HA.

FISHSIZE > 20 CM. TOTAL : 8520 FISH/HA

	SINGLE FISH	RES.	TOTAL.
TS 44-49 DB: DEPTH: 5 - 15 METER.	1111 FISH/HA.	19.0 %	5846 FISH/HA.

TOTAL : 5846 FISH/HA

	SINGLE FISH	RES.	TOTAL.
TS 50-57 DB: DEPTH: 5 - 15 METER.	194 FISH/HA.	19.0 %	1020 FISH/HA.

FISHSIZE < 10 CM. TOTAL : 1020 FISH/HA

ALL SINGLE FISH ECHOES GREATER THAN TS=-37 DB ARE TRUNCATED AND SHIFTED DOWN INTO THE (-38,-37) DB SIZEGROUPE.

IF FISH DENSITY IN A DEPTHLAYER IS FOLLOWED BY A "?", THE NUMBER OF SINGLE FISH ECHOES IS TOO LOW AND THE CALCULATED DENSITY HAVE POOR ACCURACY ! IF "**", THEN TOO MANY MULTIPLE ECHOES.

ROUNDING ERRORS MAY OCCUR DUE TO INTEGER PRESENTATION OF REAL VARIABLES.

ECHODISTRIBUTION FROM TEL-KATZIR . DATE : 11 SEP 1986

ECHOSIGNALS FROM TRANSECT : XXXXXX HEADING=---->JORDAN R.
ECHOSOUNDER DATA : XXX

ANALYSIS OF ECHOSIGNALS FROM SINGLE FISH IN DEPTHLAYER :
5 - 15 METER. CALCULATED MEAN DEPTH: 12 METER.

NUMBER OF PINGS ANALYSED : 1200 OUT OF 1200. START # : 1
BOTTOM HAVE BLOCKED UP 0 PINGS IN THIS DEPTHLAYER.

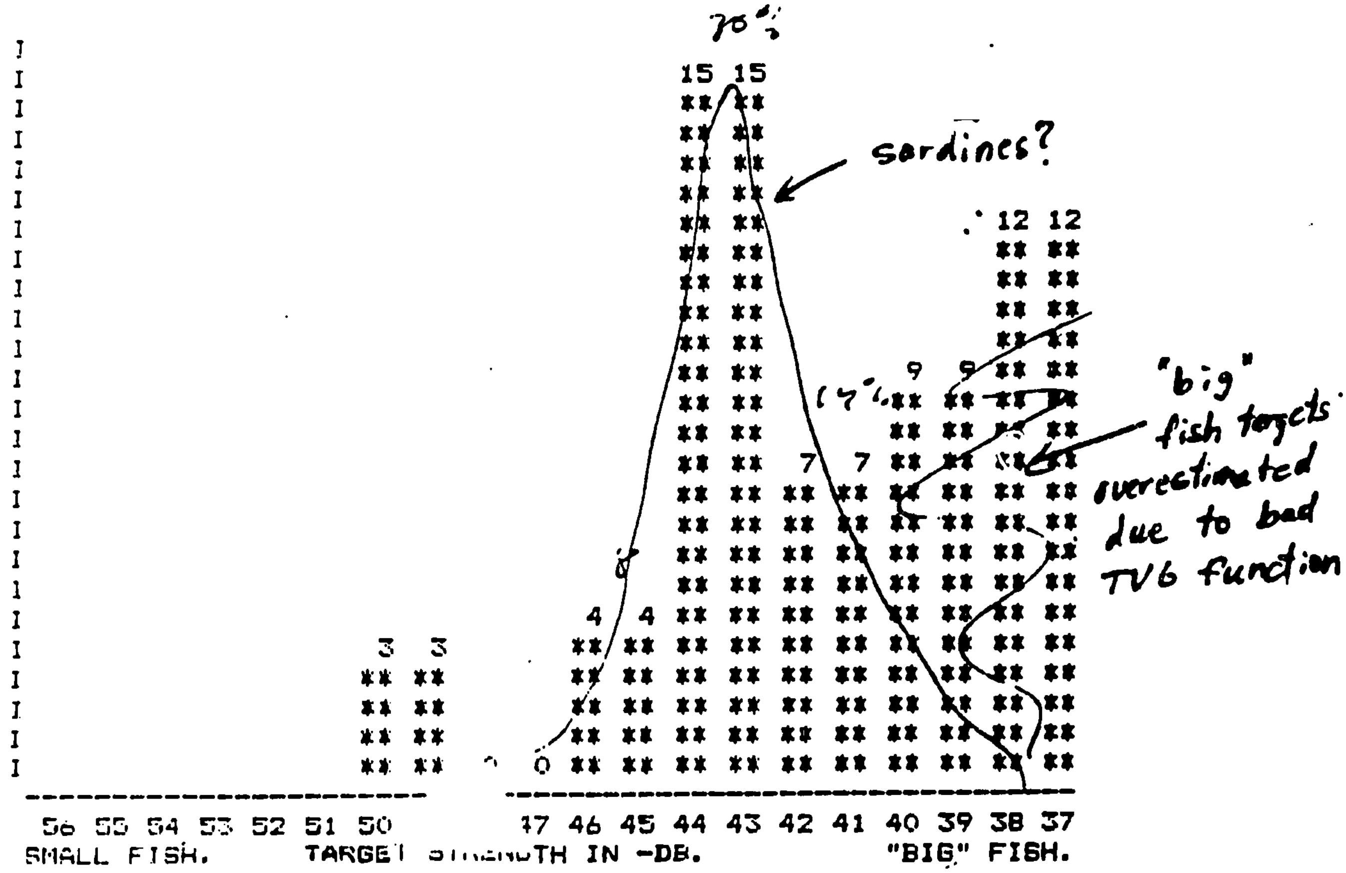
SINGLEFISH RESOLUTION IN DEPTHLAYER : 19.0 % .
INTEGRATED VALUE FROM SCHOOLS : 1.05788E8

CALCULATED FISHDENSITY IN DIFFERENT SIZEGROUPS.

TS[DB]:	ECHO-NUMBER:	VOLUME DENSITY, FISH/1000 M**3:	AREA DENSITY, FISH/HECTARE:
-38	83	52.401	3668
-40	143	39.744	2782
-42	184	29.564	2069
-44	282	66.163	4631
-46	295	15.419	1079
-48	286	1.935	135
-50	297	14.569	1020
-52	232	0.000	0
-54	0	0.000	0
-56	0	0.000	0

SINGLEFISH ECH. 1802 TOTAL: 15386 FISH/HA.

RELATIVE SIZEDISTRIBUTION OF FISH.
[THE NUMBERS GIVE PERCENTAGE OF TOTAL DENSITY]



IV.f. International Cooperation

Upon joining the AID-Lake Management Project in July 1986, Dr. Paul Walline contacted another newcomer to the project, Dr. Talaat Hashem of the Institute of Oceanography and Fisheries in Alexandria, Egypt. Since the AID meeting was originally scheduled for early October, it was planned to have a meeting at that time to discuss two proposals:

1) that Dr. Walline visit Lake Burulus with a view to determining the practicability of making a cooperative acoustic survey of the lake, and

2) that a small symposium be convened at the Kinneret Laboratory to deal with problems of methodology in limnology and to allow presentation and informal discussion of preliminary results by Israeli and Egyptian students involved in the project.

Because the AID meeting was postponed, the meeting between Dr. Walline and Dr. Hashem has also been delayed but should take place in early December.

Dr. Walline attended an intensive short course presented in Seattle by BioSonics. The course, entitled "Hydroacoustic Assessment Techniques I," took place 2-7 November. The course emphasized practical techniques, and the information gained should prove invaluable in furthering the acoustic assessment goals of the project. After the course, Dr. Walline consulted with Dr. Mike Macauley about the acoustic program and also held useful discussions concerning applications of microcomputers with Sally Mizroch of the National Marine Mammal Laboratory of NOAA.

On the return trip, Dr. Walline consulted with Dr. Torfin Lindem of the Physics Institute of the University of Oslo, Norway. Discussions centered around analysis of acoustic tape recordings and plans for transferring the analysis programs to an IBM compatible personal computer and later transferring this system to our lab in Tabgha. Preliminary plans were made for Torfin Lindem to make a working visit to our laboratory in Tabgha to further advise us concerning our acoustic program.