

### א.3. תקציר באנגלית, English Abstract

#### **The Israel National Monitoring Program at the Northern Gulf of Aqaba** Funded by the Israel Ministry of the Environment **Scientific report 2005**

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#### **Introduction**

This report describes the work and results of the Israel National Monitoring Program at the Gulf of Aqaba (NMP) in 2005. It is divided into chapters according to the various fields and methods covered by the program. Each chapter includes a short description of the methods used, a detailed description of the results including data and figures, and a discussion of the findings. A more comprehensive description of the methods used is given in the NMP annual scientific report of 2003.

This year's results could be examined, for the first time, in light of previous results collected by the NMP using similar methods by the same team. This ability provides increased analytical power and confidence in our findings. Accordingly, we chose not to repeat comparisons of the present results with historical data that were collected by previous workers with different methods. A comparison of the present-day state of the reef with historical data can be found in the NMP report of 2004.

This report is available through the Israel Ministry of the Environment's web-site: [www.sviva.gov.il](http://www.sviva.gov.il). The raw data can be obtained through the NMP web-site: [www.inm-eilat.org.il](http://www.inm-eilat.org.il).

#### **Key findings**

##### The coral reefs of Eilat

1. The numerous proxies to coral reef health collected by the NMP in 2005 do not indicate, when compared to the data collected from previous NMP results, a statistically significant change in the state of the reefs of Eilat. Nevertheless, most of the individual parameters are negative, indicating a possible, yet non-significant decline of the reef. Perhaps the elapsed time since the beginning of the NMP is not long enough to distinguish significant trends in reefs, considering their great natural variability. This is only the second year in which the NMP is operating at its full capacity, while ecological reef processes operate on a time scale of years and decades.

Despite the absence of ecological indications for growth and recovery, a major crisis did not occur in 2005. Most of the data is upsetting, but the statistical examination dictates caution when jumping to conclusions. A longer period of careful observations is required before significant conclusions can be reached. From the bulk of available data it seems that the reefs in Eilat are presently under stress. Here are some of the findings:

- In seven out of the eight sites examined we noted a rise in the ratio of area covered by recently dead corals to live coral cover, as a function of total live coverage.

- Re-examination of reef sites through repetitive photography (photo sessions separated by a one year interval) we found a decline in the abundance of most existing coral genera at most sites. This is accompanied by a decline in the total area covered by live corals in the fixed-site repetitive photographic survey.
  - Careful analysis of the fixed-site photographic re-survey indicates that most of the coral mortality occurs within small (young) coral colonies.
  - In 2005 some recovery of crinoids (feather stars) was noted, and a survey of macro-algae in the reef indicates that the reef grazers continue to effectively repress the proliferation of macro-algae in the reef.
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2. Live coral cover in the Eilat reefs varies a great deal from site to site. This variance closely follows the distribution of substrate-type in each site: a relatively high live coral cover is found where more of the sea floor is composed of hard rocky substrate.
  3. There is a significant correlation between the live coral cover and the density of coral colonies. Nevertheless, there is a significant negative correlation between the fraction of small colonies and the efficiency of substrate utilization (ratio of live cover to consolidated rocky substrate) by the reef. The larger the fraction of small colonies in the reef, the smaller the fraction of consolidated substrate that is covered by corals. More than that, from the fixed-site photographic survey we learn that small colonies contribute but little to the total live coral cover: some 70% of the photographed colonies are smaller than 20cm<sup>2</sup>, and these account for about 20% of the total live area. Some 60% of the live coral area is taken by a quarter of the coral colonies, those in the middle size range, 20-200cm<sup>2</sup>. Since in Eilat smaller colonies are more susceptible to stress (suffered relatively higher death rates) it seems that the reefs in which small colonies dominate are especially vulnerable to environmental stress.
  4. A long-term decrease in dissolved oxygen concentration and increase in pH and alkalinity measured in the lagoon of the Nature Reserve Reef continued in the year 2005. While the decrease in dissolved oxygen may stem from changes occurring in the open sea, increasing pH and alkalinity indicate decreasing net calcification in the reef. The decrease in net calcification may be attributed to a decline in calcification by reef organisms or an increase in calcium-carbonate dissolution. While 2005 saw a slight recovery compared to 2004, the values of dissolved oxygen concentration and net calcification are still significantly lower than measured in preceding years and are grim indicators of the state of the reef.

#### Coastal water

5. Several anomalous nutrient concentrations were noted at the northern coastal sampling sites, near the fish farms and off-shore from the Navy base/Hotel Le Meridien. These were exceptionally high compared to the mostly uniform concentrations at the southern stations and the Open Sea. Since high concentrations were not measured at other stations and since most nutrients, and especially ammonium, are rapidly utilized by plankton, these locally high concentrations indicate “point sources” of nutrient pollution. The water sampled off-shore from the Navy/Le Meridien was characterized by a high silicate concentration and low salinity. The likely source is brackish ground-water that is

pumped through the Hotel Le Meridien's cooling system and into the sea. It is harder to pinpoint the polluting source at the northern beach, mainly because of the proximity of two known sources: the aquaculture fish farms and the outlet of the Kinet Channel. From measurements conducted in 2004 as well as the conclusions of the IET project we concluded that the fish farms are the major nitrogen contributor (see the NMP 2004 scientific report). High concentrations of silicate measured on some occasions point to the Kinet Channel as an additional nutrient source.

6. An on going increase in dissolved oxygen concentration, alkalinity, and pH was measured near the surface of Eilat's coastal water. These findings correspond to ongoing eutrophication. Increased primary production may be responsible for elevated pH and dissolved oxygen concentration, and increased alkalinity corresponds to the increase in pH and may stem from a decrease in net calcification in the northern Gulf of Aqaba. Note that these proxies reflect regional scale processes and do not indicate specific point sources along the coast.

#### The open water column

7. Careful examination of chemical data collected by the NMP since September 2001 reveals a consistent trend in several environmentally significant parameters in the northern Gulf of Aqaba. The main findings include a decrease in dissolved oxygen concentration (10-20  $\mu\text{mol/liter}$ ), a rise in the pH ( $\sim 0.05$  pH units), and a rise in alkalinity ( $\sim 0.05$  mEq/kg). Dissolved oxygen concentration decreased in surface waters less than in the deep water, while the increase in alkalinity is greater in the surface water than in the deep water. A similar rise in pH and alkalinity was also noted in the coastal water, while the dissolved oxygen concentration increased in the coastal water.

Higher pH in the surface water and decreasing oxygen concentrations in the deep water probably reflect continuous eutrophication in the northern Gulf of Aqaba. Eutrophication may cause a decline in net calcification in the reef and shallow waters and thus to higher alkalinity values. Increased primary production, caused by eutrophication, increases transport of organic matter to the deep waters where its oxidation leads to a decrease in oxygen concentration. Decreased oxygen concentration in the surface water and elevated pH in the deep water are likely due to vertical mixing that entrains deep, oxygen-poor waters to the surface and transports high-alkalinity surface waters to the depth, which, in turn, leads to a rise in pH in the deep waters.

8. Dissolved inorganic nitrogen concentrations in the deep waters reached values higher than 7  $\mu\text{mol/liter}$  in 2005, the highest values measured since the late 1970's. The deep (600m) vertical mixing in the winter of 2005 did not bring about a significant decline in nitrate concentrations in the deep water as it did in the past (a mixed depth of 640m in 1999-2000, and 850m in 1991-1992). Neither did the vertical mixing of 2005 cause a strong phytoplankton and algal bloom, as was the case in 1992 and 2000. Monthly profiles of nutrient concentrations with depth indicate that the deep mixing in 2005 was shorter as well as shallower than that of the 1992 and 2000 episodes, limiting the amount of fertilizing nutrients entrained to the photic zone. Thus it seems that the ecological consequences of winter-time deep vertical mixing in the Gulf of Aqaba depend on the depth as well as the duration of the mixed layer.

9. Concentrations of phosphate and silicate in the deep waters of the gulf seem to be stable in past few years (since 2001). It should be noted, however, that anticipated changes in phosphate concentrations corresponding to the changes in nitrate concentrations will be at the detection limit, and that silicate concentrations are significantly higher today relative to the early 1990's.

10. Chlorophyll a concentrations and surface temperatures near the Nature Reserve coral reef in Eilat remain stable in the past 18 years in which regular measurements are conducted.

11. Flow regime near the IUI in 2005 resembles the pattern measured there in the past, but the change in flow direction (from a northern to a southern current) occurred approximately a month and a half later than it did in 2004 (early March versus January) and approximately a month later than it did in 1989-1993.