Research Article

Evaluation of Environmental Impact of Yacht Marina Development in Malta

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Summary. *The past few decades have witnessed a rapid development of yachting activities and of marinas in Malta. This trend is expected to persist, with new marinas being included in the latest development projects at Spinola and at Manoel Island. Limited coastal resources and other factors have led, however, to significant concern being expressed about the associated environmental implications of such trends. The potential risks of marine contamination resulting from both the construction phase and the operation of such marinas are identified. A brief review of the risk management strategy being used for a new marina which is presently being developed, is then given. Subsequently the available data on the quality of coastal waters is used to assess the significance of such risks for the marinas in Marsamxett Harbour. On the basis of the experience of the past few years, a national strategy for marina development and management is proposed.*

Keywords: Yacht marinas, marine contamination, risk assessment

In view of its position at the crossroads of the Mediterranean, Malta's economic and social development has always been directly and indirectly influenced by maritime transport. The maritime sector is in fact responsible for approximately 95% of Malta's trade with other countries, with the islands' ports currently handling 2.6 million tonnes of cargo annually. This excludes the trans-shipment activities of the more recent port at Marsaxlokk. As a seafaring people, many Maltese have a close relationship with the sea and a significant percentage own small water craft for pleasure or to earn a living. Most of the bays and creeks in Malta act as convenience or mooring harbours throughout the year.

Over the past two decades, Malta has witnessed a dramatic increase in yacht marina development coinciding with a parallel increase in the tourist industry and improvement in the local standard of living. In one local main harbour, Marsamxett, the number of available berths have increased by more than 100% over a period of 10 years. The Msida marina within Marsamxett now consists of no less than 870 berths and represents the main yachting centre in Malta. Figure 1 shows the various locations of the main harbours and marinas as well as of those areas which are exposed to heavy boating activities during most of the year.

The national Structure Plan for Malta (Ministry for Development of Infrastructure, 1990) states that 'favourable consideration will be given to suitable development proposals that contribute towards the creation of an integrated and comprehensive network of various types of safe havens for yachts around the coasts ...to attract cruise and flotilla sailing, marine sports, and marine plus culture high yield tourism markets'.

Since 1990, a number of proposals for new marinas have been made, each ranging from 100 to 1500 new berthing capacities. The proposed sites for such new marinas included Salina Bay, Xatt l-Ahmar (Gozo), Spinola, Manoel Island, Xlendi (Gozo), Kalkara and others. It is evident that while most of these proposals have not in fact been successful (mostly due to environmental considerations), one should still expect a continuation in the present trend of expansion of berthing capacities in existing marinas and possibly of new marinas. Presently, a new marina is being constructed on the Spinola headland with an expected berthing capacity of up to 150 berths. Furthermore, the Manoel Island and Marsamxett area is expected to act as the principal focus of such new marina development. The latest proposed development project for Manoel Island and Tigne', include a new marina at Lazzaretto Creek with 340 new berths.

While the economic benefits of yachting development are self evident, environmental considerations are bound to limit such development to ensure sustainablility.

Malta has one of the highest population densities in the world (approx. 1300 persons km^{-2}) which is periodically increased significantly by seasonal tourism. Coastal geology and topography are such as to produce natural deep-water harbours and a series of inlets and bays on a limited stretch of coastline, leaving much of the southwestern areas of mainland Malta and most of Gozo as rugged and inaccessible coast. These factors led to intense coastal development over a limited coastline causing rapid loss of natural habitats and other associated environmental problems. Intense boating and port activities (including one of the largest ship-repairing yards in the Mediterranean) as well as marina developments may present a number of marine contamination risks. In the present paper, attention will be focused on these risks resulting principally (though not exclusively) from marina developments. Wherever possible, such risks will be assessed on the basis of

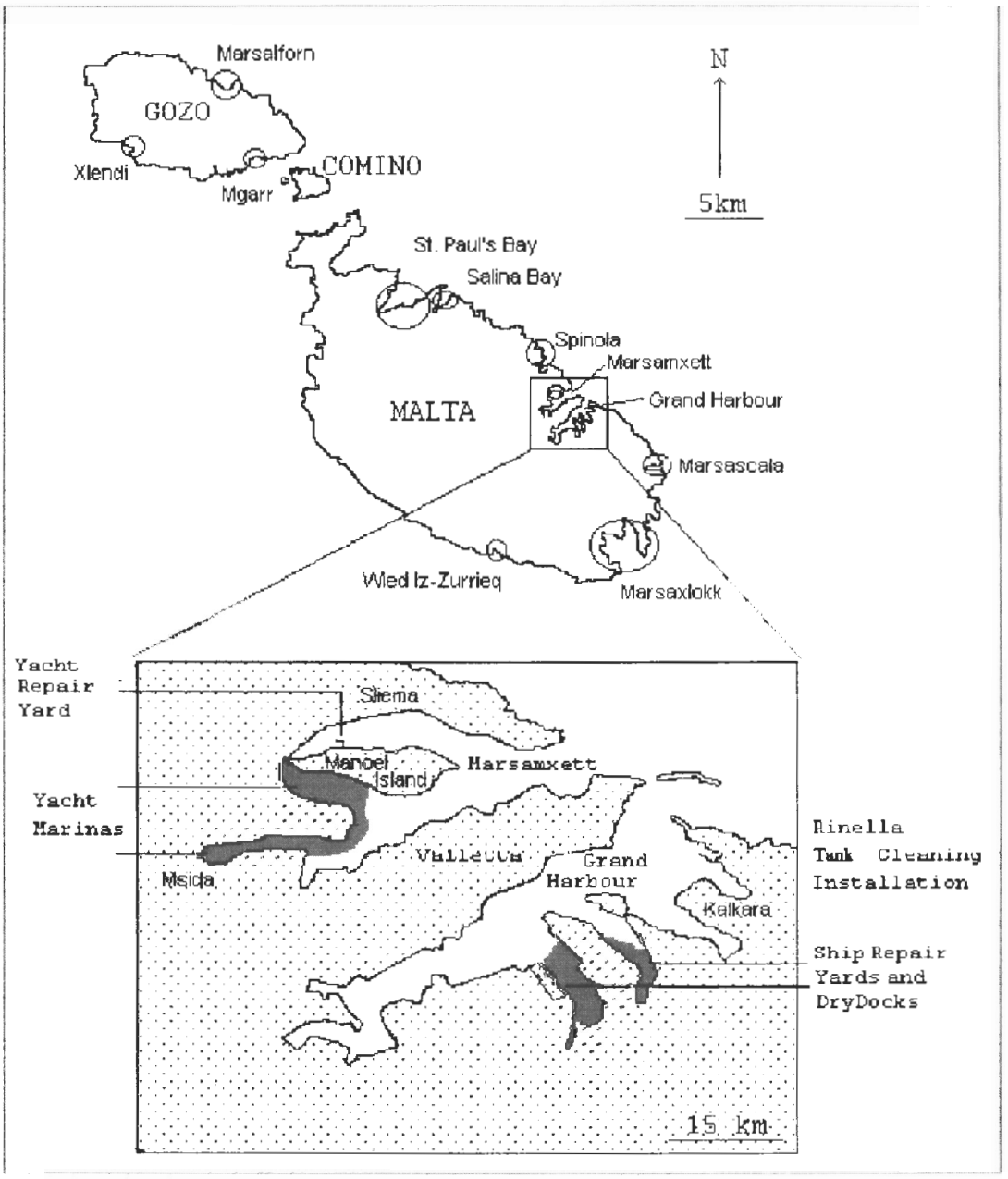


Figure 1. The Maltese Islands and locations of major ports, marinas and areas generally exposed to heavy boating and berthing activities.

presently available data. Finally specific recommendations will be made for a national strategy for marina development and management in Malta.

Environmental risk during the construction phase of marinas

During the construction phase of a marina, extensive coastline alteration and marine works may lead to loss of ecologically important habitats, including rockpools and littoral seagrass meadows. The resultant release of suspended matter in the water column as well as of resuspension of contaminants from sediments during dredging may lead to a general deterioration of water quality. *Posidonia* (and other sea grass) meadows are particularly vulnerable to reduced water visibility and benthic habitat disturbances. The construction of breakwaters and marina piers may lead to changes in the prevalent water hydrodynamics with wide-ranging effects on sediment transport, shore erosion and transport of potential contaminants.

To-date, most of the marina developments in Malta have been limited to Marsamxett harbour which was already heavily urbanised, and as such the environmental risks related to construction as identified above have not been significant. Nonetheless, there is evidence to suggest that heavy dredging activities within Lazzaretto Creek during the early 1990s led to significant increases in dissolved nitrates and phosphates over large areas within Marsamxett and moderate eutrophic conditions were evident (Axiak et al, 1992).

Any new marina developments in more pristine coastlines (as proposed on various occasions during the past few

years) such as on the northern coastline of Malta and along most of the island of Gozo may be expected to result in more significant and pronounced environmental impacts.

Awareness of the potential environmental risks resulting from major coastal engineering works associated with new marina development, has led the planning authorities to formulate an extensive marine environmental monitoring programme for the new marina being presently constructed at Spinola. This monitoring programme was initiated in June 1996. To date, four water monitoring surveys, as well as three sediment and *Posidonia* monitoring surveys were carried out, together with a benthic survey of the vegetation communities along the Spinola headland (Axiak et al, 1996; Axiak et al, submitted to PA, 1997).

Demolition of the old Hilton Hotel started in August 1996, while rock cutting and transport using barges started in September 1996. No marine dredging works have been as yet undertaken. This means that most of the data collected so far may be considered to be baseline data which essentially characterize the relevant environmental parameters before that phase of project which is associated with the highest environmental risks. Baseline levels have now been established for a number of relevant parameters including dissolved nutrients, primary productivity (Chlorophyll *a* content), water transparency (in terms of beam attenuation coefficients and Secchi depths), surface and sub-surface currents, microbiological indicators, as well as petroleum hydrocarbons and organotins in superficial sediments in the area likely to be affected. Furthermore an extensive benthic survey has been carried out to identify the biological resources of the area mostly at risk from the proposed development. The geographical extent of *Posidonia* meadows as well as the state of health of such meadows have been now established using certain bioparameters including shoot density, adult leaf length, leaf density and epiphytic growths on leaves.

On the basis of such baseline information, and on the basis of environmental quality objectives being proposed for this monitoring programme, a number of environmental quality standards and threshold limits have been submitted to the Planning Authority for most water and sediment parameters being measured.

The proposed general environmental quality objective set for the area will be to maintain the existing environmental quality so as to protect bathers, aquatic life and the general water quality required for tourism and recreation (including aesthetic and visual properties of surface waters).

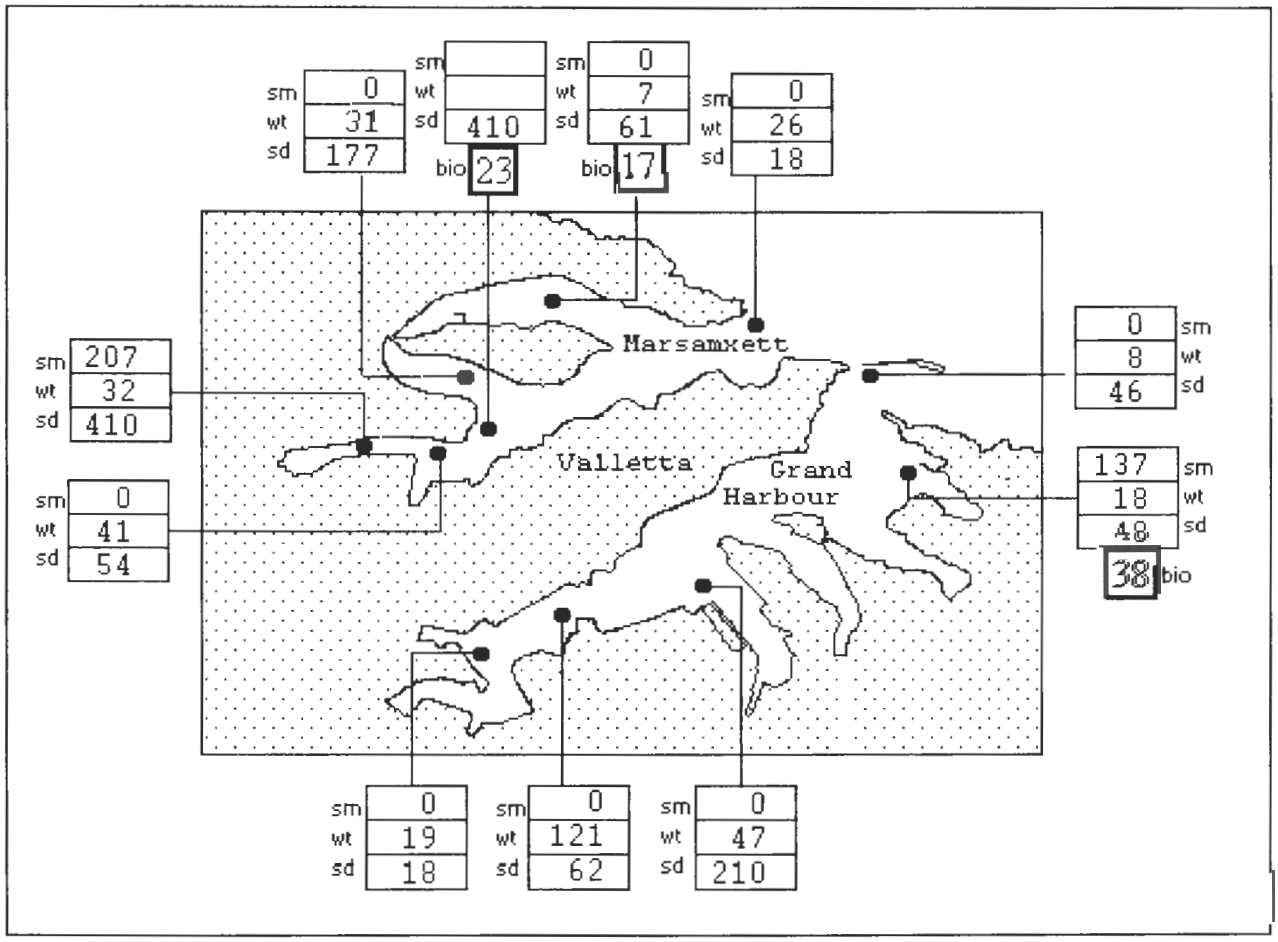


Figure 2. Environmental levels of TBT during the period Summer 1993 to Spring 1994. sm: levels in surface microlayer (ng Sn/l); wt: levels in water columns at 1m depth (ng Sn/l); sd: levels in sediments (ng Sn/gDW); bio: levels in *Hexaplex trunculus* (ng Sn/gDW). Values expressed as a mean of 3 readings.

With reference to *Posidonia* meadows, the environmental quality objective will be to prevent any degradation of such meadows, beyond the state as assessed prior to the commencement of the project.

Future monitoring will be for surveillance purposes with the aim of detecting any environmental damage and of bringing into effect the appropriate mitigating measures at the earliest possible stage. Compliance with the set environmental standards and thresholds as applied under certain specific conditions will ensure a satisfactory control of environmental risks associated with the construction phase of this marina. It may be pointed out that this marina development was the first major coastal development project in Malta to be submitted to a rigorous environmental risk management which incorporates comprehensive environmental monitoring and subsequent surveillance. It is hoped that other similar coastal projects (including future marina developments within Marsamxett) will be submitted to similar environmental risk management.

Environmental risk during the operation of marinas

During the operation of marinas, release of antifouling agents and petroleum hydrocarbons from boats (and boat yards), the generation of liquid and solid wastes, and the reduced water circulation, may lead to rapid deterioration in environmental quality not only within the marina basin proper but also in the surrounding areas. The evaluation of significance of such risks as identified above will depend on the availability of environmental data which is unfortunately very limited. The following account will review such data with the aim of establishing the real significance of such risks.

TBT antifouling agent

There is evidence to suggest that the present marinas in Malta are (together with ship-repair yards) the major sources of coastal contamination by the antifouling agent tributyltin (TBT). This is possibly one of the most toxic substances which is intentionally discharged into the marine environment. No legislation currently exists in Malta to limit the use of TBT-based paints on boats. An extensive chemical monitoring programme for butyltins in surface microlayers, water column and superficial sediments in local marinas and in their vicinity have been carried out recently (Axiak et al, 1995; Vella et al, in preparation,) and a synopsis of results is presented in Fig. 2. Levels of TBT in the sediments, and the water column within the marinas were found to be high and comparable to those near the drydocks. Such levels were found to vary with time presumably depending on the time of year when boats are repainted annually. The highest levels of TBT within the surface microlayers were detected within the marinas. Such levels are generally higher than those which would be expected to exert a significant environmental impact (generally 20 ng TBT/l or less). Levels of butyltins were also monitored in marine organisms collected from Marsamxett and Grand Harbour. In the case of the neogastropod, *Hexaplex trunculus* (Axiak et al, 1995), most of the TBT was found concentrated in the digestive gland/gonad complex.

The likely biological impact of such elevated levels of TBT in Maltese coastal waters has been recently reviewed by Axiak et al (in preparation). Various laboratory investigations have shown that at such levels of TBT, several sublethal responses may be evident including significant reductions in MFO enzyme system activities of fish, digestive cell atrophy in the oyster, *Ostrea edulis*, and induction of imposex in the marine snail, *Hexaplex trunculus*. The latter two biological responses are evident below the 20 ngTBT/l level.

TBT is known to cause imposex, which is the imposition of male sexual characteristics in female neogastropods. This effect may be quantified in terms of a Relative Penis Size Index (RPS) as defined by Gibbs et al (1987). Fig. 3 presents RPS indices for various populations of this species along the Maltese coastline.

All populations of *H. trunculus* were drastically affected by imposex within Marsamxett. Moreover, this effect was evident along most of the coastal areas of the Maltese Archipelago, indicating that TBT may exert a negative biological impact on localities which are several kilometres away from suspected sources of TBT pollution (Axiak et al, 1995). Recent field data however indicate that very low background levels of imposex in some populations of this species may occur even when unexposed to boating activities.

Moreover, the presence of TBT within the two harbours and possibly elsewhere, may interfere with the potential use of MFO induction in fish as a biomonitoring tool for other pollutants. The implications of these results on the future development of biomonitoring of pollution within the Mediterranean are self-evident.

Petroleum hydrocarbons

Studies undertaken from 1987 to 1993 indicate that the levels of petroleum hydrocarbons (such as diesel, fuels and oil products) in superficial sediments from several coastal areas show an upward trend (Axiak et al, 1993). Such levels of petroleum hydrocarbons may be expressed as micrograms per dry weight gram of sediment (Chrysene Equivalents). For the Mediterranean, levels which exceed 10 ug/g dry weight of sediment are usually considered as indicative of significant pollution by oil. Over the period 1987-1993, mean levels of petroleum hydrocarbons in superficial sediments collected from Pieta and Msida creeks increased from 7 and 16 to 43 and 48 ug/g dry weight, respectively. This represents an almost five-fold increase in oil pollution load in these areas, over this period. Operational and accidental spillages of diesel, fuels and oil products from boats are evidently responsible for this. During such period there was a rapid development of the Msida marina with an increase in berthing capacities and construction of a breakwater at the mouth of Msida Creek.

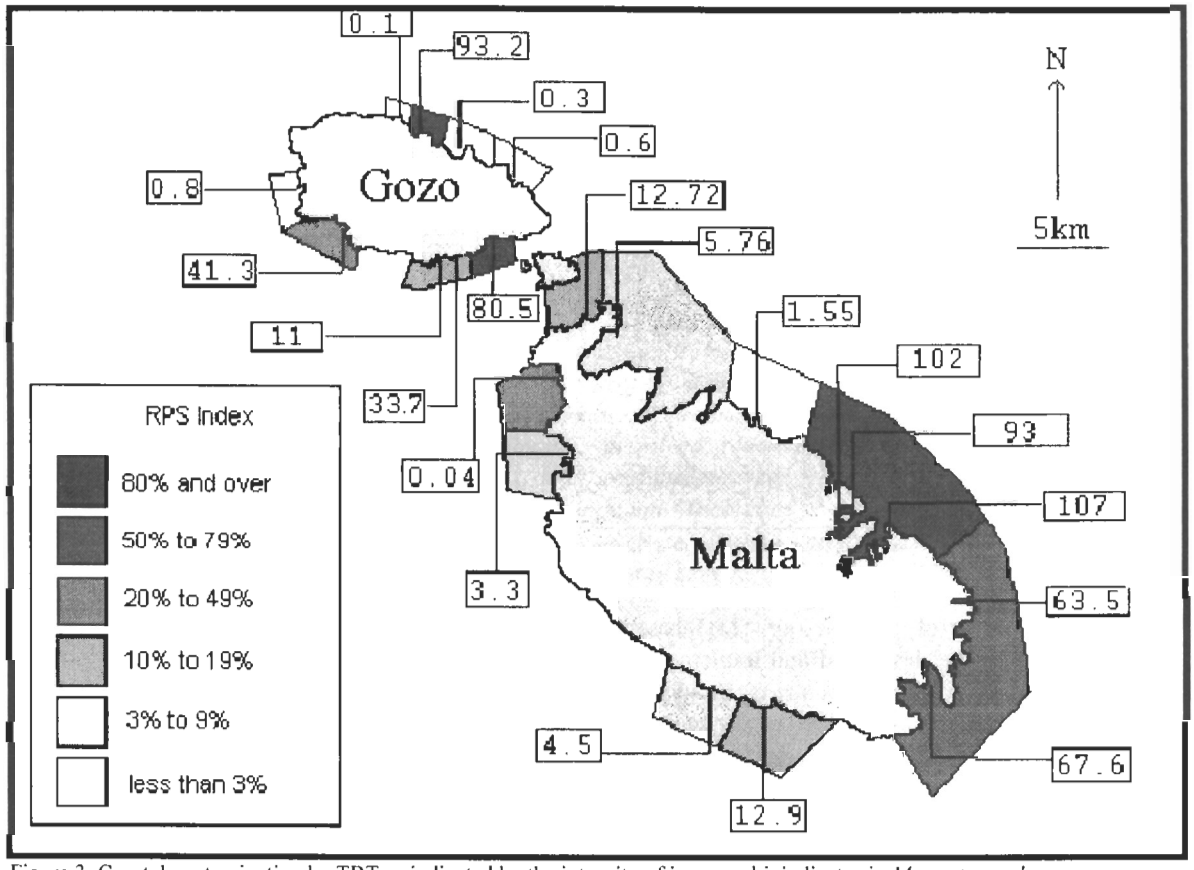


Figure 3. Coastal contamination by TBT as indicated by the intensity of imposex bioindicator in *Murex trunculus* (expressed in terms of the Relative Penis Size Index, RPS).

These data indicate that though the coastal waters of Malta have not yet been exposed to any massive oil pollution incident, chronic low-level pollution by oil and petroleum products from boats and yachts is becoming increasingly significant. There is an urgent need to improve practices within the marinas so as to minimize such risks of oil pollution which may present a hazard both to the environment as well as to the safety of the boats themselves.

Other contaminants

Mismanagement of liquid and solid wastes within a marina may lead to increased coastal contamination by sewage, elevated nutrient levels and in cases exposed to reduced water circulation, the resultant risks of eutrophication become significant. Evidence of moderate eutrophic conditions associated with various parts of Marsamxett and especially within Msida marina is available (Axiak et al, 1992). Landsat satellite TM data of coastal water quality within Marsamxett during 1995 have confirmed such data (Axiak and Geraci, 1995).

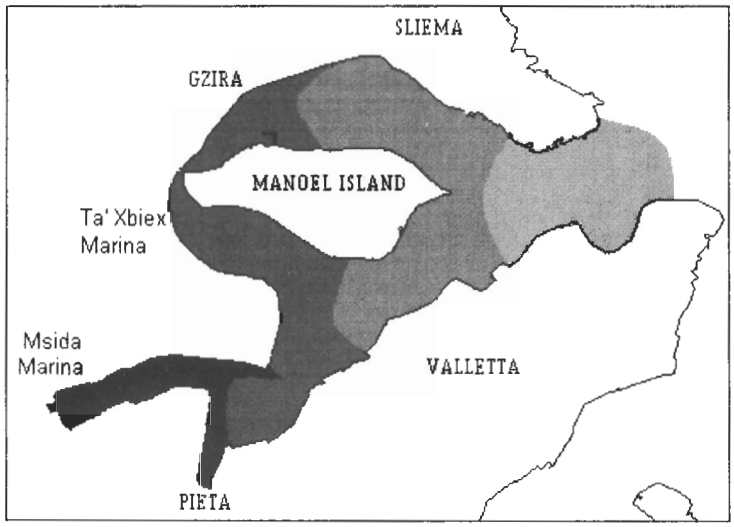
These available data confirm that elevated levels of nutrients, chlorophyll *a* and high water turbidity, which are usually indicative of eutrophic conditions are evident within the Msida marina and in the vicinity. This is illustrated in Fig. 4.

Conclusions and Recommendations

The above account has identified the trend in yachting activities and development of marinas in Malta and the associated risks of marine contamination associated with such development both during the construction phase and during their operation. Any further marina developments in Malta should be designed so as to fully control and mitigate against such risks.

A national strategy for marina development and management should be formulated and implemented as soon as possible. This should be carried out within the existing administrative frameworks and should be the result of close collaboration between the various management partners involved, including the Department for Environmental Protection, the Planning Authority and the Malta Maritime Authority. Such a strategy should identify priorities and desired objectives. It should be based on a comprehensive assessment of the present environmental problems related to the existing marinas. Such information may then be utilized to identify potential localities for new marina development, and to set an upper limit to the number of yacht marinas, as well as to the maximum berthing densities to be accommodated. Present data suggest that it would be undesirable to extend marina development well beyond the immediate vicinity of Sliema, Marsamxett and Grand Harbour.

Guidelines should be formulated to regulate marine works during the construction of coastal structures associated with marinas, as well as to ensure proper design (such as the prevention of surface run-off from jetties and piers of any spilt diesels and oil into the sea). Furthermore any new marina projects will need to be submitted to a rigorous environmental risk management which should include compliance and surveillance monitoring. An example of such an approach has been given above, with respect to the new marina at Spinola.



	Water turbidity in Secchi depths (m)	Nitrates (μg-at N/l)
	7	less than 15
	5 to 6.5	16 to 19
	4	generally 19 to 20
	3.5 or less	generally above 20

Figure 4. Eutrophication in Marxamxett Harbour related to marinas as monitored by water turbidity (measures by Secchi depths in m) and nitrate levels, during 1989-1991.

Legislation on the control of use of TBT-based antifouling paints should be developed and implemented as soon as possible. Moreover regulations should be developed to regulate liquid and solid waste management within marinas as well as to control normal boating practices within such basins.

Future marina development and operation in Malta which would be conforming with sustainable coastal development as well as with environmental protection would only be possible within the context of such a national strategy for marina development and management.

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