How nautical tourism ports affect the environment

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Abstract

A nautical tourism port is a tourist facility, which, from a business, spatial, construction and functional aspect, provides a venue and service in its entirety for satisfying the requirements of nautical tourism and nautical tourists, namely boaters. In countries with a developed nautical tourism economy, an increased number of nautical tourism ports have been observed. It is therefore reasonable to expect the increase of their impact to the environment. In this paper the authors analysed stages in construction, exploitation and termination of exploitation of nautical tourism ports taken at the sample of 47 marinas in the archipelago of the Republic of Croatia. Nautical tourism ports have been created in compliance with legal regulations which currently conform to EU directives and construction practice. Their influence has been analysed for each phase, measures for preventing and eliminating environment disasters have been presented, as well as the programme of monitoring the environment status. New measures aimed at optimal managing of nautical tourism ports from the starting point of their influence to the environment have been proposed.

Keywords: nautical tourism port, environment, influence, new measures.

1 Nautical tourism and nautical tourism ports

The main elements of nautical tourism are nautical tourism ports. A nautical tourism port is essentially a tourist facility, which, from a business, spatial, construction and functional aspect, provides a venue and service in its entirety for satisfying the requirements of nautical tourism and nautical tourists, namely boaters. A nautical tourism ports offer tourist services, commercial, catering and

WIT Transactions on Ecology and the Environment, Vol 127, © 2009 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/RAV090111

other services. Nautical tourism ports are managed by legal or physical entities (concessionaires). Nautical tourism ports in Croatia are classified according to their types:

- anchorages [2],
- berths,
- dry marinas, and
- marinas.

An anchorage is a part of a water area suitable for anchoring vessels in a bay protected from bad weather.

A berth is a part of a water area and a coast, adapted for landing of vessels and equipped with berthing facilities. If the capacity of the berthing area permits so, a part of the berthing water area may be designated for anchoring of vessels.

A dry marina is a part of the coast separated and adapted for providing services of storing and safekeeping of vessels, and of transporting vessels to or from the water area of a dry marina.

A marina is a part of the water area and land especially constructed and developed for providing services of berthing and safekeeping of vessels, and of accommodating tourists – boaters, and optionally, of servicing and maintaining vessels. Nautical tourism ports accommodate special kind of vessels. In conformity to the Convention on Safety of Life at Sea – SOLAS of the *International Maritime Organization – IMO*, ships are classified into two categories:

- Convention ships, and
- Non-Convention ships [3].

Convention ships are the ships included in the provisions of SOLAS Convention. Non-Convention ships are all other ships, for instance, fishing, military, sports and recreational ships. The latter most frequently stay in nautical tourism ports. It has to be emphasised that the number of Non-Convention ships is constantly increasing, especially of vessels for recreation and entertainment [4]. Consequently, the traffic accommodation density in nautical tourism ports also grows, especially in countries with distinctive nautical tourism business. Figure 1 illustrates the ratio between the number of Convention and Non-Convention vessels in nautical tourism ports in the Republic of Croatia.

It may be concluded that due to the increase of nautical tourism ports in the countries with strong nautical tourism business their impact to the environment is definitely not insignificant.

2 Marinas and environment threats

The impacts to a marina environment can be observed during the stages of:

- construction,
- exploitation, and
- termination of exploitation.

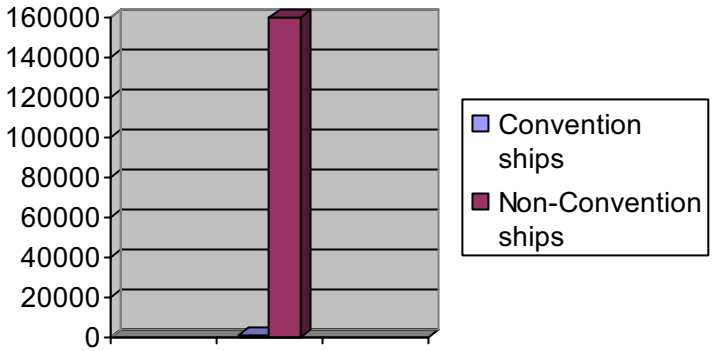

Figure 1: The ratio of Convention and Non-Convention ships in the Republic of Croatia in 2007 [5].

During the construction phase, there is construction machinery, equipment and vehicles on the site. They can cause temporary undesired effects like noise, dust, vibration and gas emissions. They are also the source of pollution of the land and the sea by various sorts of oil derivates. Construction of new facilities or reconstruction of the existing ones generates construction or metal waste. The waste has to be properly managed and waste disposal into the sea needs to be avoided. If peers and breakwaters are built as anchored or fixed pontoons, slight sea pollution occurs. More substantial pollution can be prevented by planning works and protective preliminary works. Construction works on the coast cause negative effects to benthic communities along the coast. It is considered that the average time of their renewal is several years. During the construction phase of a marina, pollution of the sea by oil derivates and other pollutants may be prevented by applying adequate control of transportation means and machinery. A possible discharge of fuel can be prevented by forbidding the transfer of fuel in the construction site of the marina. During the cleaning and construction phase of a marina, there is plenty of waste material. It should be stored at a location well protected from precipitation washing. The waste has to be sorted out and transported to appropriate locations. If the waste contains harmful substances then it has to be removed by an authorised institution.

Dust dispersion can, for instance, be prevented by wetting roads and limiting the speed of vehicles. Materials for the construction of a marina need to be prefabricated. It is not advisable to crush the stones or similar activities on the site. During the works in the sea, living organism on the seabed have to be protected from unnecessary mud, sediment and sand. Noise has a particular impact to the environment; it is therefore recommended to limit it to the lowest possible volume, and plan the type and the power of the noise source in the system when completed. This, for instance, refers to electric generators, ventilation and heating systems etc. and noise absorbers and isolation materials should be used. If relevant documentation about archaeological finds in the location of the future marina does not exist, the competent administrative bodies should be informed in case such finds are discovered.

Exploitation of a marina begins upon the completion of construction. For instance, after pontoon breakwaters are built and construction works finished, sea organisms inhabit pontoon supports, concrete parts of the coast, and on other sections submerged under the surface. In this way the population of organisms will be partly or fully regenerated on the sediment and stony bottom. The use of anti-biofouling paints for ships, anchor chains and shadows created by anchored ships have a negative effect to bottom biocenose in the location of a marina. It is necessary to know that discharge of wastewater from anchored ships and biocide from underwater parts of ships when combined with the brackish layer of the sea will indirectly affect the benthic communities. Pollution is the most significant negative effect of a marina to the environment. Sea pollution is possible in the following cases:

- waste water during the washing of ships,
- paints during the painting of ships,
- waste water during the cleaning of engines when being repaired,
- waste water during the cleaning of underwater surfaces of ships,
- oily precipitation water flowing from paved surfaces of a marina used for traffic or from areas for parking of vessels and vehicles,
- waste water from ships, i.e. faecal waters, sanitary, bilge and ballast waters,
- mineral oils from ships,
- particles of polyester resins during the work with plastic parts of vessels,
- biocides present in anti-biofouling paints.

It is necessary to prevent any and all disposal of waste into the sea. Hence, the removal of waste and oils from the land and sea surface need to be organised. The consequences of slow exchange of sea within a marina should be compensated by banning waste substances, especially of organic origin, like nitrates and phosphates. They occur as the result of dishwashing, showering and food preparation on ships. Also, throwing away solid waste and bilge waters must be prevented. Increased concentrations of solved copper may be expected in the brackish layer of the sea in a marina. The quantity of concentration depends on the currents in the marina. More currents cause higher dispersal of solved copper. When the currents are weaker more copper is deposited in the sea layer. In any case, the copper concentration directly affects the adequacy of the sea for swimming and the benthic biocenose.

In the phase of exploitation of a marina, a problem for the environment protection is to prevent pollution that is a consequence of customary work and life aboard, e.g. the occurrence of various waste, bilge and sanitary waters. It is therefore necessary to organise emptying and disposal of bilge waters, and to have it done by certified institutions. Solid waste from ships also needs to be collected and stored in appropriate places from where it is taken by certified institutions to places where it is recycled or permanently deposited and the required documentation is kept. A marina must have a proper sewage system. All facilities of a marina are connected to the system of drainage of faecal waters.

Wastewaters occurred in marina facilities, for instance from laundry and restaurants, need to be previously filtered. Precipitation waters are usually collected from the surface through drains and grids and through the system of manholes and PVC pipes. They are then taken to separators and mud drums and then into the sea. Used batteries need to be disposed into special, tightly closed containers. Wastewaters occurring after removing anti-biofouling paints and washing surfaces have to be purified through mud drums and separators before being taken into the sea. Occasional chemical analyses will show the presence of toxic metals, since it is reasonable to expect high concentrations of copper, cadmium and tin. Technologically safe waste of land or sea source, with the structure similar to common communal waste has to be managed by communal organisations. In order to protect the air, major works on ships, like grinding, scraping, painting etc. have to be performed in closed spaces equipped with filters installed in ventilation systems. It is advisable to plant the area of a marina with tress, since, besides their aesthetic function, trees also purify the air and decrease the effect of the noise. The noise in catering facilities of a marina and hours for major noisy works are regulated by internal regulations of the marina. It is also necessary to control periodically the level of noise in working spaces and objects for catering. During the exploitation of a marina it is necessary to perform annual cleaning of the sea bed around the pontoons and berths especially because of unacceptable but unavoidable solid waste from the ships. It is necessary to forbid ships which have an open system of discharge of waste waters from toilets during their stay in a marina. It is also forbidden to use detergents on ships that have the open system of discharge of waste waters, and to use detergents for cleaning ships, except when the waste waters can be collected and treated in the public sewage system on land.

The termination of the use of a marina is not usually planned. It can however be a decision of the concessionaire or a result of *force majeure*. In the case of termination of the use of a marina all products and waste hazardous for men and the environment have to be managed in compliance with legal regulations. All other activities of the termination of the use of a marina need to be developed in details in a special project.

In order to decrease the influence of possible ecological disasters in the environment it is necessary to develop:

- measures for preventing and relieving the consequences of ecological disasters, and
- programmes for monitoring the marina environment.

It is necessary to design an operational plan for the protection of the water area of a marina from oil and oil derivates pollution [6]. The concessionaire has to use a floating wall for cases of accidental discharge of oil or oil derivates and of other floating pollutants. They must have oil dispersants and absorbents for cleaning the land and the sea, large containers with sand and the equipment for the protection of land and sea environment. A marina should have a supply of means for prompt and efficient extinguishing of fire. It is necessary to control regularly the installations on the coast and on the vessels. Fire protection drills

will enable the personnel for qualified and quick extinguishing of the fire. It is therefore necessary to provide emergency access of fire engines to the marina. The waste occurred in accidents has to be separated into appropriate space or containers. Specialised companies are engaged in final waste management and cleaning.

It is necessary to monitor the quality of waste waters at all discharge outlets in compliance to the appropriate certificate. Hence, it is advisable to measure general parameters in particular locations: temperatures, melted oxygen, pH, redox, nutrient salts, total and faecal coliform bacteria. Also, it is necessary to measure in equal intervals the traces of toxic metals: mercury, cadmium, lead, copper and zinc, and the capacities of excited states of copper. Measuring will also include concentrations of mercury, cadmium, lead, copper, zinc, manganese, chromium and arsenic. It is advisable to examine the benthic living communities, for instance once in three years. It is necessary to revise the data obtained in the programme for controlling the environment, and depending on the results advise the concessionaire about possible activities and changes in the system.

3 Proposal of new measures

The current legal regulations referring to the construction of marinas adequately regulate legal matters relating to their effects to the environment in all stages. Practice in construction of marinas has demonstrated satisfactory level of preservation of the environment. During the exploitation phase it is important to monitor the influences of the most significant pollutants performing:

- measuring,
- analyses of the current state, and
- automation and construction of the integrated system of monitoring.

Measuring should include parameters as listed in Table 1.

The data sources for measuring can be found in:

- marinas, and
- on ships.

They have to be collected in a proper manner. Appropriate sensors could be placed in marinas for each parameter (P_1, P_2, P_3, P_4, P_5, P_8, P_9, P_{10}, P_n) represented by model (G) of general scalar function:

$$G\left(P_1, P_2, P_3, P_4, P_5, P_6, P_9, P_{10}, P_n\right) \tag{1}$$

Appropriate sensors could make wireless connections with the central control computer.

The sensors located on ships may be used for measuring the proposed parameters (P_6 and P_7) represented by model (V) of general scalar function:

$$V\left(P_6, P_7,\right) \tag{2}$$

Table 1: Some parameters for measuring effects of a marina to the environment.

Parameter	Description	Measuring unit
P_1	Consumption of water during washing of ships	l
P_2	Consumption of waste waters during the washing of ship's engine when repaired	l
P_3	Consumption of waste waters for washing underwater surfaces of ships	l
P_4	Consumption of paint per metre of the ship being currently painted	l/m
P_5	Quantity of oily precipitation waters from paved roads of a marina and surfaces for parking vessels and vehicles	l/m^2
P_6	Total capacity of tanks with waste waters from ships (e.g. faecal, sanitary, bilge and ballast waters)	M^3
P_7	Total power of ship's engine and the quantity of mineral oils from ships	M^3
P_8	The quantity of particles of polyester resins during the work on parts of vessels	kg/m^3
P_9	Quantity of biocides contained in anti-biofouling paints per metre	l/m
P_{10}	Chemical analyses of the sea	In conformity with the type of measuring
P_n	Other	In conformity with the type of measuring

Data could be automatically sent to the central control computer of the marina. In order to obtain necessary information about parameters from ships it is proposed to adjust the devices of the standard *Automatic Identification System – AIS* [7].

The analysis of the current situation would be done in the central control computer on the basis of data collected in various measuring sites. Consequently, a suitable programme support should be developed. For instance, the analysis of the quality of oily precipitation waters from the marina roads and from the areas for parking vessels and vehicles (V_v) need to be considered in relation to the quantity of precipitations (K) per observed surface of the marina (P) in eqn (3):

$$V_v = \frac{K}{P}(l/m^2) \tag{3}$$

In the analysis of the quantity of discharged wastewaters into the sea the change of the volume of water masses during high and low tides has to be

considered. In case of the excess border values the discharge has to be adjusted, i.e. decreased according to the possible absorption capacity of each marina. The possible absorption of a marina is the quantity of waste waters which has no substantial effects to the sea environment of the marina defined in the environment study by the zero or starting level of the environment at the moment of the beginning of exploitation of the marina, which can be expressed by eqn (4):

$$V_t = V - V_{po} \tag{4}$$

The current volume (V_t) equals the difference of the zero volume (V_o) and the volume influenced by high and low sea tides (V_{po}).

The level of saturation by pollutants of sea environment of a marina (T_{ug}) equals to the ratio of the current volume of the marina sea environment (V_t) and the quantity of discharged pollutants (I_v), eqn (5):

$$T_{ug} = \frac{Vt}{I_v} \tag{5}$$

It can be seen that it is necessary to monitor permanently the quantity of pollutants in the sea environment and in the air of the marina. In case of an excess or a decrease in relation to zero values of the parameters it is necessary to implement appropriate measures, for instance: limit or completely terminate activities until the ecological system of the marina reaches satisfactory state. The analysis of the environment of a marina has to be conducted systematically and permanently in compliance to the proposed measures. Other measures have to be included for the purpose of minimising the harmful influences of a marina to the environment. For example, in order to estimate a potential hazard for the marina environment in the territory of a particular country the density (G_s) of the total number of marinas (B_m) per kilometre of the coastline (l) can be calculated as in eqn (6):

$$G_s = \frac{B_m}{l} \tag{6}$$

The analysis of the proposed measures will facilitate and allow for optimal monitoring of the state of the marina environment, which is shown in a hypothetical example in Figure 2.

Thus, it is necessary to control a relatively large number of parameters significant for the environment. It is, therefore, proposed to implement the automation in controlling the effects of a marina to the environment. It would allow for the optimal managing of the system in the following manner: providing warnings, operations of turning on/off the discharge, decreasing or increasing the discharge etc. It is also necessary to develop an integrated system of control and programme support for the computers. Unit systems of control should be integrated into a system network of all marinas on the territory of a country [8]. The integrated system of control of all marinas will allow for the exchange of information, which will directly contribute to the development and

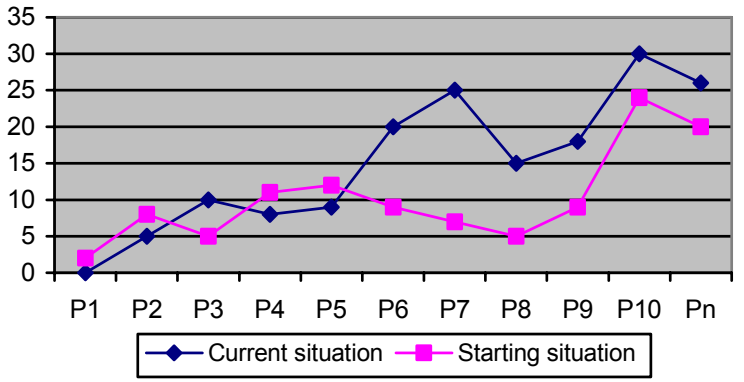

Figure 2: Monitoring significant parameters to the environment of a marina.

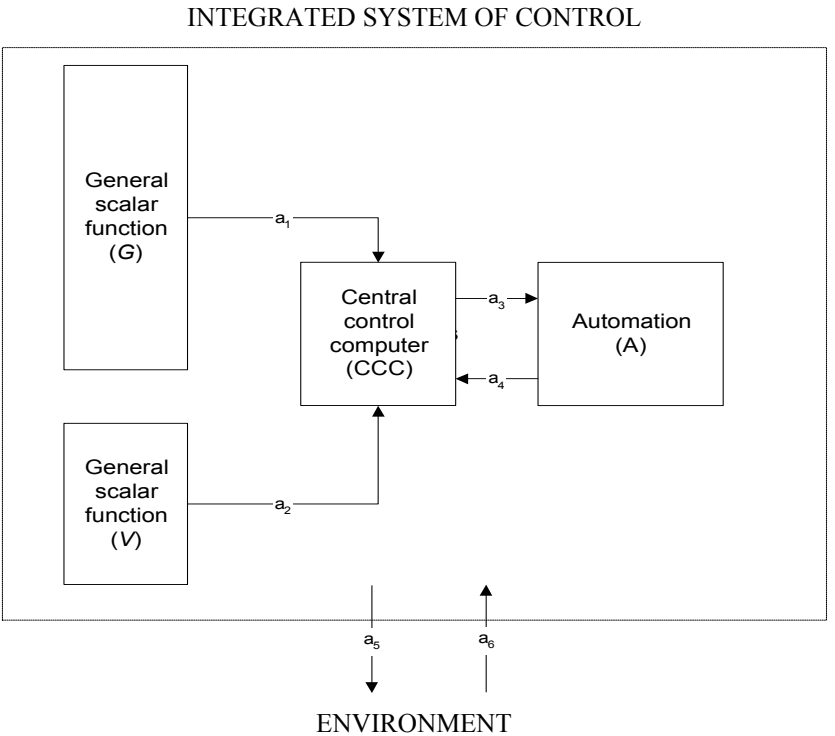

Figure 3: General model of automation of the system of control of the marine environment.

implementation of the e-navigation concept in nautical tourism as a part of maritime economy. It is proposed to develop a system of automatic control of a marina from the aspect of its effects to the environment according to the general model as shown in Figure 3.

4 Conclusion

In countries with developed nautical tourism business the number of nautical tourism ports and vessels for entertainment and recreation is growing. Nautical tourism ports have various influences in terms of business, space, construction and functionality. Their varied influences to the environment are outstanding. They show different actions in time and intensity during the phases of:

- Construction,
- Exploitation, and
- Termination of the use of a marina.

In the construction phase, the influence to the environment is relatively short-term and intensive.

In the exploitation phase the influence of a marina to the environment is relatively long and of medium intensity.

The phase of the termination of work is characterised by the environment impact that is directly proportional to the time of management of hazardous substances in compliance to legal regulations. This phase is rare, as, for instance, there has been no case of closing a marina in the Republic of Croatia, which was confirmed at the sample of 47 marinas in the archipelago of the Republic of Croatia.

It may be concluded that especially in the exploitation phase of a marina it is of extreme importance to manage their impact to the environment. Optimal managing can be improved by implementing the proposed new measures and the model of automation [9].

It is reasonable to expect that the implementation of new measures will substantially improve prevention and elimination of the consequences of ecological disasters, and control of the situation in a marina environment [10].

References

[1] Kasum, J., Grzetic, Z., Marusic E., *Contribution to the development of management and strategic decision making in nautical tourism ports*, Promet, Traffic and Transportation, FPZ, Zagreb, 2007.

[2] Filjar, R., Kasum, J., Kos, S., Sevrovic, M., *Statistical Properties of Quiet Space Weather Northern Adriatic Residual GPS Ionospheric Delay*, Proceedings of NAV08/ILA37 Conference, Westminster, London, Cambridge Press, 2008.

[3] www.imo.org

[4] www.iho.org

[5] www.mmpr.hr

[6] Kasum, J., Marusic, E., Grzetic, Z., *Contribution to the development of the model of managing reambulation in ports*, Conference proceedings of the 1st International Conference on Ports and Waterways, POWA Conference, 2006.

[7] Kasum, J., Baljak, K., Vidan, P., *The Ships Reporting System and Automatic Identification System*, GIS Applications and Development, Hrvatski Informaticki Zbor, GIS Forum, 2006.
[8] Jolic, N., Perkov, N., Kasum, J., *Development of integrated intermodal water transport system within European transport networks,* 7th European Congress on Intelligent Transport Systems and Services, Geneve, ERTICO, 2008.
[9] Kasum J., *Updating sea charts and navigational publications*, The Journal of Navigation 56, United Kingdom, 2003.
[10] Kasum, J., Marusic, E., Grzetic, Z., *Security of Non-Convention Ships and Nautical. Tourism Ports*, TIEMS Conference**,** Seoul, 2006.