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# The compromise model - one way to a better performance of a nautical tourism port

**Juraj Bukša[1], Alen Jugović[2]*, Donald Schiozzi[3], Renato Oblak[2]**

[1] Adriatic Croatia International Club Plc., Rudolfa Strohala 2, 51000 Rijeka, Croatia
[2] University of Rijeka, Faculty of Maritime Studies, Studentska 2, 51000 Rijeka, Croatia
[3] Port authority Rovinj, Obala Alda Rismonda 2, 52210 Rovinj, Croatia

**Abstract**

There are at least three vantage points to the successful operation of a nautical tourism port - that of its management, of its customer and of the common interest to protect the environment. The management focuses mainly on financial results, i.e. whether the revenues exceed expenses and whether there is a return on investment as envisaged by the business plan. The customer is interested in always having an available berth and accompanying facilities with a satisfactory overall appearance and price level. The increasing awareness of the need to protect the marine environment and the stricter regulations that follow pose a real challenge before the management of the nautical tourism port and the management must rise to that challenge.

From the management's perspective, an ideal situation would be to have a fully occupied marina all year round, to have the formed service price cover all fixed and variable costs, to make a profit which will make for a happy owner/shareholder and to operate without any adverse effects on the environment. The yachtsman sees an ideal situation in having a secured and available berth and accompanying facilities, a good "value-for-money" ratio where the price is concerned, and secured removal and disposal of all liquid and solid waste from the yacht.

The ideal situation for the environment would be to have minimal or zero reception of vessels, or a pollution-free reception if such a reception exists. Some of these views may appear conflicting, because it is becoming increasingly difficult to satisfy all three interests. Therefore, based on the compromise model of these three aspects or processes – economic indicators, customer satisfaction and marine environment protection – this paper is attempting to structure a model which would demonstrate an optimal example of successful operation of a nautical tourism port.

The solution to this problem is finding a compromise between stakeholders with opposing preferences. The complexity of formulating a compromise model (through optimization, or linear programming) consists of a large number of logical and numerical variables which significantly limits research, i.e. narrows it down to the financial component or three key variables – revenue, environmental costs and berth price.

*Keywords:* compromise model, nautical tourism, optimization, nautical marina, management

## 1. Introduction

Considering the focus on ever - more rigorous and demanding regulations on marine environment protection and coastal landscape protection and the obligations of integrated coastal management and sustainable development of nautical tourism, every new development, in an already sensitive littoral zone, is subject to rigorous checks which almost regularly and justifiably stall the development of new nautical tourism infrastructure.

*Corresponding author: Alen Jugović (ajugovic@pfri.hr)

It is therefore understandable that due to the increasing number of vessels sailing and permanently or occasionally staying on the East Adriatic Coast, more and more attention is paid to environmental protection as a limiting factor for the development of nautical tourism.

Accepting this reality, but also fostering the development nautical tourism as a significant industry, it is necessary to find a compromise model which would enable the enlargement of nautical capacities with the least possible threat to the environment, biological diversity and protected natural and cultural heritage.

## 2. Literature review

The review of relevant literature related to the given topic will analyze the fundamental thinking of presented authors and lay out the framework guidelines as the basis for this paper.

The term nautical tourism can be defined as a multifunctional tourism activity with a strong maritime component. It can basically be divided into nautical tourism ports, charter and cruising (Luković, 2007). Nautical tourism has evolved markedly in the last few decades, so in order to sustain it, it is necessary to consider the basic development issues and the economic effects it creates on the environment (Luck, 2007). It has become an important industry that provides a variety of employment opportunities, and has developed solely by promoting the natural, historical and cultural beauties of coastal countries (Seving and Guzel, 2017). The development opportunities of nautical tourism can only be realized on a market basis, but only if administrative and legal preconditions have been created (Luković, 2015). The applied innovative practice in marina development was analyzed by a study of the specific challenges that have been set in achieving the sustainable development goals of coastal and maritime tourism in Europe (European Commission, 2016). Sea ports for nautical tourism constitute an open, dynamic and complex system that is rapidly evolving, however, this requires continuous monitoring and research activities to preserve their environment and ecosystems. For nautical tourism to be environmentally sustainable, it is necessary to continuously invest in infrastructure and control (Andre set al., 2017). The analysis of nautical tourism through the Blue Growth concept should be considered and linked to three different but interrelated aspects. These are economic growth, social and social impact resulting from the implementation of various development policies and environmental protection (Canavate et al., 2019).

The competitiveness of nautical tourism poses an extremely significant challenge for nautical destinations that must be continuously aligned with market demand, especially in terms of their capacity and quality. Offering nautical tourism, price competitiveness and the perception of competitiveness of nautical tourists are important elements in attracting nautical tourists and make distinctions between individual nautical destinations (Horak et al., 2006). The influence of sociodemographic characteristics and frequency of tourists' travel on their perception of nautical tourism shows some limitations. They can be divided into three basic dimensions such as intrapersonal, interpersonal, and structural constraints (Jovanovic et al., 2013). However, the perception of European nautical tourists in relation to nautical destinations shows different results with regard to the nautical sports offer and the type of nautical destinations. By analyzing the demand for particular types of nautical services, effective marketing strategies can be developed with which to achieve satisfactory positioning in the nautical market (Lam Gonzales et al., 2015). In addition, climatic conditions can significantly affect the way tourists undertake certain activities at destinations. Favorable climatic conditions contribute to the increase in demand for maritime activities, and thus have a positive effect on the consumption of nautical tourists (Lam Gonzales et al., 2019).

Port management is a challenge for all managers who make business decisions and make market decisions. However, their awareness of the environmental effects they produce is

relatively weak. Therefore, it is of utmost importance to introduce an assessment of future managerial staff in relation to the perception of environmental risk and environmental awareness (Petrosillo et al., 2009). The development of nautical tourism leads to an increase in the number of vessels, ie berths and new nautical ports and increases the possibility of pollution of the sea and the coast. Nautical ports are one of the largest users of the marine area and the coast, and if they are to develop successfully, they should strive to promote environmental protection (Dogan and Mršić, 2013). In their development plans, they should necessarily include an environmental impact assessment if they are to maintain a high level of environmental awareness (Guerra et al., 2015). One of the biggest problems with nautical ports is the issue of ship waste collection. Although the protection of the marine environment is mainly governed by the International Convention for the Prevention of Pollution from Ships (MARPOL) and applicable environmental legislation, in practice situations arise when large quantities of ship-generated waste need to be disposed of in a short period of time. In addressing such a problem, the authors of Lapko et al. (2019) analyzed waste collection models with the primary goal of achieving greater safety for all participants. The authors of Madariaga et al. (2015) also define in their paper a methodology for nautical port waste management in line with the national nautical tourism development strategy. They conclude that the key factor for the sustainable development of all nautical ports is the necessity of finding a compromise between the need for economic development and the need to preserve the natural environment. According to research by the author Santic et al. (2011) cruise ships produce large quantities of wastewater and a variety of hazardous and non-hazardous waste, but do not fully bear all the costs of pollution. Therefore, according to the "polluter pays" principle, additional environmental fees should be paid to cover all direct and indirect costs arising from environmental pollution.

## 3. Nautical tourism ports in general

Nautical tourism ports - hereinafter NTPs, are regulated by the Maritime Cod (Official Gazette, 26/2015), the Maritime Domain and Seaports Act (Official Gazette, 56/2016), as well as various subordinate legislation regulating the types and categories of ports, minimal requirements for such ports, as well as the categorization of ports and vessels in nautical tourism. An NTP is primarily intended for berthing and accommodation of vessels of nautical tourism and it is properly equipped to provide services to customers and vessels. Pursuant to the Ordinance on Classification and Categorization of the Nautical Tourism Ports (Official Gazette, 72/2008), an NTP represents a business, construction and functional whole in which a legal or natural entity conducts its business and provides tourist services in nautical tourism, as well as other services serving tourist consumption (commerce, hospitality, etc.).

In NTPs, special attention is paid to safety of navigation, marine environment protection and security of the marina. The Ministry of the Sea, Transport and Infrastructure, via the directly competent Harbormasters' Office, is authorized to supervise safety of sailing and environmental protection in marinas, being a part of maritime domain and internal waters. Security in most marinas is achieved through video surveillance and an organized mariner security service, and many marinas outsource to private security agencies.

The degree of safety of navigation, marine environment protection and security in a marina is also supported through the system of insurance against potential damage. The functioning of a marina can hardly be imagined without quality insurance of the marina against various risks, primarily liability insurance of the marina concessionaire towards berth users or third parties (Padovan, 2013).

The general issue which reflects upon the state of the maritime environment can also be found in the fact that vessels, such as sailboats and boats, are exempt from applying the

MARPOL Annex IV due to their tonnage and the number of persons they are certified to carry, even though some of them are under 12 meters in length and still fall within a category which enables them to sail in international waters.

Yachts and boats built for longer navigation are equipped with limited capacity sewage holding tanks which have to be discharged occasionally. More often than not, these tanks are discharged into the sea, and mainly closer to the coast than MARPOL allows, as MARPOL does not apply to these vessels (pursuant to MARPOL, this distance for untreated sewage is 12 Nm or more from the nearest land). On the other hand, there is still a shortage of land reception stations for sewage from vessels (either in number or frequency) built in marinas, berths and quays for boats and yachts.

During the summer, in countries with developed nautical tourism such as Croatia the total number of persons on board yachts and boats exceeds by far the total number of persons on board all merchant ships in the same coastal zone. Therefore, this results in a far greater burden and pollution of the sea with sewage from vessels exempt from application of MARPOL Annex IV, as opposed to vessels falling within the scope of application of MARPOL Annex IV.

The Croatian Adriatic coast is a destination for nautical, sports and recreational tourism (seasonal sunbathing). Being a shallower and semi – enclosed sea, the Adriatic is particularly vulnerable and susceptible to pollution. Untreated waste waters mainly from inland sources and vessels aggravate this situation furthe. Discharging sewage in internal waters and bays harms both tourism and tourists. This danger is more imminent with vessels such as yachts, boats and fishing boats which are exempt from application of legislation at the EU and MARPOL Annex IV level.

### *3.1 Management of nautical tourism ports*

Apart from entailing standard issues related to management and decision - making, management of nautical tourism ports is specific for at least three reasons. First, the development of basic services is limited by spatial capacities. Second, there is a prominent seasonal character of the services which is difficult to extend in duration due to the specificities in the use of boats. Third, the NTPs are located in the environment of an extremely ecologically sensitive coastal zone.

Regarding the environment, one must also mention the significant influence of the local community which is, as a rule, divided between commercial and ecological interests.

Apart from the above, there is also the issue of compensation of damage from pollution incurred in the NTP due to a fire or sinking caused by fuel in the vessels. The sole determination and compensation of actual damage caused by pollution is carried out according to general rules on obligations and is not difficult in itself. However, pollution of the marine environment can reflect on numerous businesses which are directly or indirectly linked to the sea, which then also gives rise to damage in the sense of loss of profit.

Responding to the above issues constitutes a compromise which necessarily means that not all wishes can be satisfied. Any imposition of unilateral solutions will inevitably lead to confrontations which sometimes surpass the limits of socially responsible business. The following table presents the frequency (F) of vessels served in the NTP (land and sea) and capacity utilization (CU) for the period between 2014 and 2017 per county.

Table 1: The number of vessels and NTP capacity utilization for the period between 2014 and 2017

| | *2014* | | *2015* | | *2016* | | *2017* | |
|---|---|---|---|---|---|---|---|---|
| | *F* | *CU* | *F* | *CU* | *F* | *CU* | *F* | *CU* |
| Republic of Croatia | 13,793 | 61.04% | 13,399 | 59.67% | 13,422 | 60.17% | 13,433 | 61.97% |
| Istarska | 2,888 | 65.53% | 2,807 | 63.75% | 2,835 | 66.49% | 2,634 | 69.39% |
| Primorsko-goranska | 3,117 | 59.66% | 2,848 | 57.90% | 2,561 | 58.48% | 2,648 | 62.04% |
| Zadarska | 2,961 | 64.69% | 2,877 | 60.43% | 2,710 | 55.91% | 2,804 | 56.29% |
| Šibensko-kninska | 2,783 | 61.82% | 2,656 | 57.99% | 2,788 | 60.33% | 2,835 | 63.11% |
| Splitsko-dalmatinska | 1,588 | 53.56% | 1,755 | 61.73% | 1,950 | 63.85% | 1,928 | 64.12% |
| Dubrovačko-neretvanska | 456 | 49.57% | 456 | 48.00% | 578 | 50.57% | 584 | 51.54% |

Source: Croatian Bureau of Statistics

The data shown in Table 1 represent standard statistic indicators which point to stagnation or declining trends and relatively poor utilization. The reasons for this can be found in obsolete monitoring methodology, i.e. not updating berth capacities. Namely, the structure of vessels coming to NTPs has changed during the last decade. The vessels have gotten bigger and therefore wider (they take up more space), there are more multihulls (catamarans), the number and capacity of anchorages have increased, etc. Therefore it is more acceptable to analyze an NTP according to realized profit, considering that tariffs are mainly not subject to change.

### *3.2 Pollution risks in an NTP*

Preservation of the environment with rational utilization of natural resources represents one of the most relevant issues in further technological and economic growth of any country. Construction of NTPs and accompanying infrastructure lacking in control and vision often leads to total loss and depreciation of the aesthetic value of the landscape.

Table 2: Nautical tourism impact on marine environment

| *Sources of pollution in an NTP* | *Measures for preventing pollution of the marine ecosystem in an NTP* |
|---|---|
| • waste water originated during the washing of vessels;<br>• paint used to paint vessels;<br>• waste waters originated in the washing of the engine during repairs and waste waters from washing underwater surfaces;<br>• oily rainwater from asphalt – covered handling zones, zones for vessel and vehicle storage and internal roads;<br>• sewage and ballast water;<br>• mineral oils from vessels;<br>• polyester resin particles originating from works on plastic parts of the vessel;<br>• biocides contained in anti – fouling paints, during the vessel's stay in the marina. | • sustainable use and management of marine resources;<br>• increase of berthing capacities through restoration, reconstruction and revitalization of existing nautical tourism ports to enable berthing of large yachts;<br>• setting up a system for surveillance and management of navigation;<br>• control and equipping of boats and yachts and nautical tourism ports with devices and equipment for protection of the sea from pollution;<br>• application of new ecological standards. |

Source: Author's processing according to Dogan and Mršić (2013)

As a rule, nautical tourism is not a great polluter if the infrastructure has been done according to appropriate technical standards (Dogan and Mršić, 2013). The solution lies in avoiding high concentrations of nautical tourism ports in the coastal zone because the pollution of the sea is harder to control. It should be noted that in the construction of marinas, caution is required in the use of coastal space. Thus, in ecologically sensitive and extremely valuable zones commercial construction should be limited.

Therefore, coastal zones should be managed applying the principles of environmental ecology, as the cornerstone of the environment as a whole. This means that we must establish development priorities where marine environment protection comes first, while the development of nautical tourism ports and marinas must be in line with fundamental ecological criteria (Dogan and Mršić, 2013).

### *3.3 Structure of the NTP's primary business activity*

During the year, back to back services are provided in two basic types of NTPs - a) marinas and b) dry dock marinas. Accordingly, an NTP provides two basic types of services: a) berthing and accommodation of boats and b) lifting, transport and storage of boats.

It is assumed that each vessel of nautical tourism entering the marina for berthing or dry docking somehow pollutes the environment. The owner of the marina bears the costs incurred by documented pollution which it then charges to the owner (master) of the vessel. It is clear that the owner of the marina is insured against pollution from vessels within the marina (both sea and land), so one of the costs incurred by pollution are premiums paid for insurance against the risk of pollution. The second part of costs includes possible environmental levies imposed by the local community, costs of supervising the seabed, sea surface and dry dock, costs of waste separation and management, collection of oily liquids…

The third part pertains to training costs for marina personnel, promotional materials for customers, sea quality measurements in the marina, air quality measurements, etc.

Certainly, the simplest way is to calculate these costs in the service price, which would increase revenues but would still reflect on the profits.

### *3.4 Revenues from primary business activity*

In this paper, the author will go on to show the dynamic of revenues from primary NTP services based on research (Dogan and Mršić, 2013) on a sample of 32 NTPs (a sample representing 43.84% of NTPs and 12,345 berths, which represents 70.86% of total marina capacity in Croatia) and an approximation of investment into environmental protection by NTP management, duly noting that any investment into environmental protection represents a cost from the NTP management's standpoint.

An NTP's revenue from primary business activity is determined by the number of boats whose value is formed as meter/day. Given that boats are divided in seven categories according to length (up to 6 m, 6-8 m, 8-10 m, 10-12 m, 12-15 m, 5-20 m and over 20 m), the daily berthing tariffs are formed according to said groups as shown in the below table.

Table 3: Revenue from primary business activity

| *Length over all [m]* | *Number of boats in 2017* | *NTP's berth capacity* | *Daily wet berth (€)* | *Environmental unit cost (3%)* | *Total revenue for 2017* | *Projected environmental costs for 2017* |
|---|---|---|---|---|---|---|
| up to 6 m | 138 | 656 | 90 | 2.7 | 5,520 | 373 |
| 6-8 m | 692 | 1,224 | 100 | 3 | 34,600 | 2,076 |
| 8-10 m | 1,648 | 2,756 | 120 | 3.6 | 98,880 | 5,933 |
| 10-12 m | 3,358 | 4,283 | 150 | 4.5 | 268,640 | 15,111 |
| 12-15 m | 3,969 | 4,773 | 160 | 4.8 | 396,900 | 19,051 |
| 15-20 m | 1,404 | 2,650 | 180 | 5.4 | 210,600 | 7,582 |
| over 20 m | 432 | 725 | 200 | 6 | 86,400 | 2,592 |

Source: Financial reports published by NTP managements (tariffs are approximated and presented in €)

Here it's worth noting that, for reasons of simplification, the author used the average tariffs for the daily, monthly and annual berth broken down to the daily berth value. This approach resulted in obtaining relevant data consistent with actual data.

The table shows that the CU is lowest with boats of up to 6 m (21%), followed by the 15-20 m category (53%), 6-8 m category (57%) and + 20 m (60%). The highest CU is achieved with boats in the 10 – 12 m category (78%) and the 12 – 15 category (83%).

The causes of such a distribution can be found in the increasing number of anchorages that meet the needs of small boats whose owners are confident of their seafaring skills and large yachts which are self – sufficient and independent of the berth in the NTP. The CU of berths in 2017 amounted to 68.2%, equal to revenue utilization (68.2%).

According to relevant indicators from financial reports published by NTP managements, the environmental protection costs in the Croatian part of the Adriatic (which is not shown as such, but extrapolated per item from the overall costs) range between 2.8% and 3.4% of total revenue.

Such cost margin is mainly acceptable to NTP managements and they calculate them in their plans and development strategies. The thing that is impossible to plan, but can be foreseen and estimated is the risk of possible pollution on a larger scale, when the consequential cost and damage to the environment can seriously jeopardize the NTP's business. The below combined chart shows revenues and environmental costs.

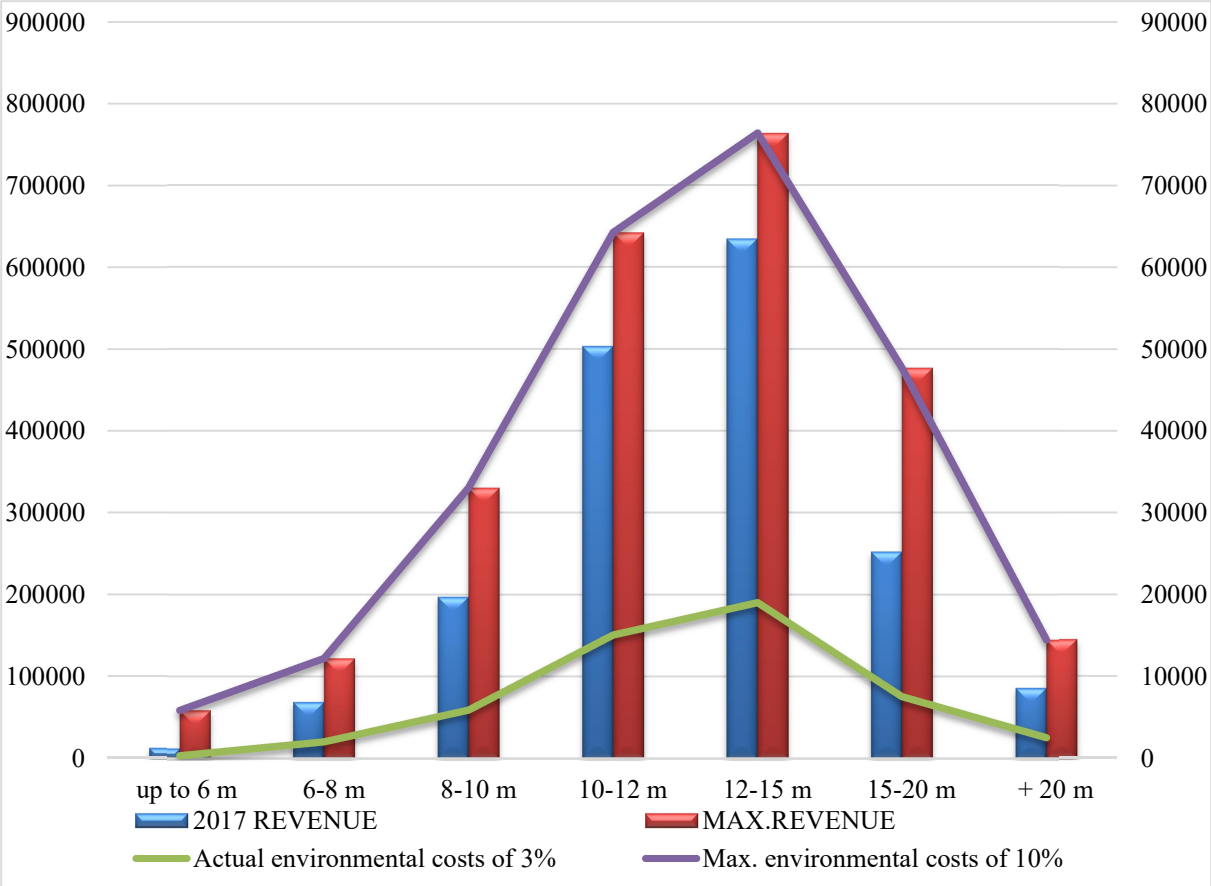


Figure 1: Distribution of revenues per vessel (the left axis of the chart) and the approximation of environmental costs (the right axis of the chart)
Source: Financial reports published by NTP managements

The combined chart shows the distribution of revenues per vessel (the left axis of the chart) and environmental costs (the right axis of the chart). Considering that the environmental costs are serving the CU, their correlation is clear. It also shows the normal distribution (Gauss) which characterizes the number of meter/days and thus the revenues realized according to vessel length.

## 4. Environment protection costs

There are several approaches to resolving the environmental protection problem, from education to prevention and the like. As a rule, these approaches are effective, but practice shows they are insufficient. Namely, nautical tourists nowadays are not exclusively ecologically aware sea and environment enthusiasts. Any pollution poses a significant cost before the management of an NTP which will have an impact on business results. Therefore, the author will attempt to analyze the notion and approach to environmental costs as an additional contribution to environment preservation.

Environmental costs (eco costs) are conditional upon the nature of a business activity, the approach in creating the range of services, the selection of the technological process and the equipment used to achieve the goal of sustainable development, taking into account the systemic reduction of negative impact on the environment, which has to be balanced with the goal of a profitable business (Peršić, 2005).

Environmental costs should be analyzed as process costs which start at the design phase of the NTP and end after the breakdown of the last piece of waste long after the NTP's life span. Environmental costs are a complex category and not always easily identifiable. We always start with conventional environmental costs, i.e. those cost positions which ae easily identifiable and connectable to activities within the NTPs aimed at the improvement and protection of the environment, such as capital costs connected with the eco-investment, the costs of eco-acceptable current and fixed assets, increased duties for improving the state in a tourist destination (green tax, increased tourist tax, …), depreciation costs, maintenance and use of joint facilities at the level of the destination (e.g. management and treatment of waste water, waste oil, garbage incinerator, compost, settlement pond, etc.).

Environmental costs are connected with the product and the process, but also with the conditions in which the service is provided, observed through the tasks and assignments which must be directed at decreasing costs and increasing revenues, systemically improving the relation towards the environment. However, environmental costs are not always easy to identify because some are only partially a consequence of actions concerning the environment, some are a consequence of past events, and some will only possibly be incurred, as is shown in the below table.

Table 4: Theoretical starting points for the classification of environmental costs

| *Conventional costs (costs of capital, assets, materials, stock, utilities, investments…)* | | |
|---|---|---|
| *Potentially hidden costs* | | |
| Standard (planning, training, examination, information, targeted supervision, testing, modelling, correcting, noting, marking, insurance, taxes, remuneration to target management…) | Anticipatory (R&D, licenses, examinations, location preparation, permits, engineering…) | Consequential (stopping or closing, destroying equipment, protecting the location…) |
| | Voluntary (feasibility studies, recycling, protection, community relations, testing…) | |
| *Unforeseeable costs* | | |
| Costs of adjusting to future requirements; Penalization; Fines; Liability for future damages; Improvement measures; Potential damage to national resources, from loss of property to reduction of personal rights, etc.; Legal charges… | | |
| *Image costs and costs of relations with interest groups* | | |
| Corporate image creation costs; Costs of relations with buyers, investors, insurers, managing structures, employees, suppliers, lenders, the community, the legislature… | | |

Source: Peršić and Janković, Management Accounting of Hotels, 2006

A part of the costs will be incurred if regular investments are made into environmental protection and improvement, and another part if such actions are ignored, so that there are consequences if global trends are not followed.

As stated by Peršić (2005), environmental costs can be observed as (a) positive costs and (b) negative costs, as is shown in the below table.

Table 5: Types of environmental costs

| *Positive environmental costs* | *Negative environmental costs* |
|---|---|
| Investments are observed from the starting point of their contribution:<br>• Raising the market image (potential for future demand)<br>• Reorientation of business systems to new target groups (higher financial solvency);<br>• Customer satisfaction through a higher ecological level and a better eco-offer quality (additional revenues – higher sales prices) | Not observing the ecological rules normally leads to a decrease in the profit of business systems:<br>• Because in the modern, eco-aware market it is damaging to the image, which causes a decrease in demand and thus a systemic decrease of sale prices;<br>• Consumer dissatisfaction because of the low standard of cleanliness, landscaping, eco-diet, etc. which leads to reclamations, returns, damages and consequently to increased (poor)quality costs;<br>• Taking no action to systemically reduce costs of energy, water supply and waste management increases this item in the cost structure. |

Source: Peršić and Janković, Management Accounting of Hotels, 2006

Costs reflect the impact of certain business activities on the possible cost structure, which is different in any business organization. In accordance with the research topic, below is an overview of synthesized environmental costs in ACI as an example.

Table 6: Recapitulation of environment - related costs in 2017

| *Activity* | *Amount* |
|---|---:|
| Management of municipal and non-hazardous waste | 2,266,040 |
| Management of hazardous waste | 394,929 |
| Waste water analyses (Institute of Public Health) | 102,332 |
| Charges to Hrvatske vode Ltd. | 1,610,763 |
| Construction, reconstruction and servicing of waste water treatment facilities | 303,480 |
| Monitoring and optimization of energy consumption | 697,430 |
| Water tightness testing | 271,521 |
| Blue flag - membership | 60,000 |
| Total 2017 | 5,706,496 |
| Total costs | 176,128,230 |
| Share in total costs | 3.24% |
| Total revenue | 201,136,579.56 |
| Share in total revenue | 2.84% |

Source: Author's processing according to ACI Plc. Data

The example shown in table 6 demonstrates how the environmental costs influence the NTP's business. Costs recorded as environmental costs have been extrapolated from the balance sheet as unequivocal, but as such, they are incorporated into many other costs (fuel, electricity, water supply, charges…), and thus, they are valued as minimal environmental costs. As such, they participate in total costs in the range between 2.7 and 3.2%.

By simulating the increase of environmental costs, provided the revenue and other costs remain a constant, the NTP's business would come into question if the recorded environmental costs would reach 10% of total revenue.

## 5. Compromise model

The optimization methods enable the finding of the best solutions to various types of problems and are very well suited for solving problems in business economics. Typical business problems are related to the use of limited resources, but also consequential costs which are ever more significant and exactly proportionate with the raised awareness on protecting the environment. The goal is to find the appropriate model to adequately resolve the issue of environmental protection requirements and the management's interest to maximize profit.

### *5.1 Linear optimization of the compromise problem*

The most frequently used methods in business economics are methods of linear optimization which enable the finding of the most favorable solutions where both the objective function (revenue) and the resource consumption (costs) are linearly proportional to values of independent variables (the number of services produced).

It is necessary to formulate a model for linear programming, emphasizing that building the model is up to the user, while the calculation of the optimal solution and sensitivity analysis of the model is carried out by the program by using the appropriate algorithms. Result interpretation is again up to the user. The problem of linear programming therefore leads to the optimization of the value of a linear function of decision-making variables, satisfying a certain number of linear consraints expressed in the form of inequations. The function being maximized is called the objective function, and the coefficients within the constraints are called technological coefficients.

The optimization is carried out using the LINDO (Linear Interactive and Discrete Optimizer) computer program.

A model with two inequations is created, specifically (as shown in Figure 2):

1) The MAX, which uses indicators from Table 3 to search for optimal values for the maximum CU. Constraints posed before the first inequation (SUBJECT TO) are the ranges between values observed in 2017 and those maximum possible values considering the capacity of individual variables, and the second inequation;
2) The MIN, which searches for optimal values of environment costs - EC. The constraints for this inequation have been created in a way that EC are determined for each individual variable in the range between the observed (EC in 2017) and the maximum EC acceptable (the presumed 10% of TR).

```
MAX BERTH INCOME IN EUR 656x1+1224x2+2756x3+4283x4+4773x5+2650x6+725x7<2540290
(1 - 7 - DAILY WET BERTH BY LENGHT IN EUR)
SUBJECT TO
138x1+692x2+1648x3+3358x4+3969x5+1404x6+432x7>1757240 (BERT INCOME IN 2017)
X1+X2+X3+X4X+5X+X6+X7>11641 (NUMBER OF BOATS IN 2017)
X1+X2+X3+X4X+5X+X6+X7<17067 (TOTAL BERTH CAPACITY)
END
MIN ENVIRONMENTAL UNIT COSTS IN EUR (3%) 138x1+692x2+1648x3+3358x4+3969x5+1404x6+432x7>52717
(1 - 7 - ENVIRONMENTAL UNIT COSTS BY LENGHT IN EUR)
SUBJECT TO
656x1+1224x2+2756x3+4283x4+4773x5+2650x6+725x7>76209 (MAX ENVIRONMENTAL INCOME IN EUR)
X1+X2+X3+X4X+5X+X6+X7>11641 (NUMBER OF BOATS IN 2017)
X1+X2+X3+X4X+5X+X6+X7<17067 (TOTAL BERTH CAPACITY)
END
```

Figure 2: Lindo Cost Optimization Model
Source: Author

Based on the range of variables, the model suggests target values. In the observed example it's TR=2,032,232, which is 20% lower than the maximum revenue with CU=100%. The model decreases the value of variables and reduces costs starting from maximum values.

The model also satisfies the second inequation by adjusting the minimum values with the optimal ones from the first inequation and calculates the increase of costs (EC). The model indicates Slack or Surplus and Dual Price, which should be taken into consideration in the sensitivity analysis.

The results obtained are shown in the below figure.

| | |
|---|---|
| Global optimal solution found: | |
| Objective value: | 2032232 |
| Infeasibilities: | 0.000000 |
| Total solver interactions: | 0 |
| Elapsed runtime seconds: | 0.04 |
| Model Class: | LP |
| Total variables: | 7 |
| Non linear variables: | 0 |
| Integer variables: | 0 |
| Total costraints: | 15 |
| Nonlinear constraints: | 0 |
| Total nonzeros: | 21 |
| Nonlinear nonzeros: | 0 |

| TARGET MAX | | | TARGET MIN | | |
|---|---|---|---|---|---|
| | | | Objective value: | | 87862.000 |
| Variable | Value | Reduced cost 20% | Variable | Value | Increase cost 2% |
| X1 | 525.0000 | 11808.000000 | X1 | 138.000 | 2484.00000 |
| X2 | 979.000 | 2448.000000 | X2 | 692.000 | 13840.0000 |
| X3 | 2205.000 | 6614.000000 | X3 | 1648.00 | 39552.0000 |
| X4 | 3426.000 | 128490.000000 | X4 | 3358.00 | 100740.000 |
| X5 | 3818.000 | 152736.000000 | X5 | 3969.00 | 127008.000 |
| X6 | 21200.000 | 95400.000000 | X6 | 1404.00 | 50544.000 |
| X7 | 580.0000 | 29000.000000 | X7 | 432.000 | 17280.000 |

| Row | Slack or surplus | Dual price |
|---|---|---|
| 1 | 2032203 | 1.000000 |
| 2 | 527.0000 | 0.000000 |
| 3 | 0.000000 | 90.00000 |
| 4 | 532.0000 | 0.000000 |
| 5 | 0.000000 | 100.0000 |
| 6 | 1108.000 | 0.000000 |
| 7 | 0.000000 | 120.0000 |
| 8 | 1415.000 | 0.000000 |
| 9 | 0.000000 | 150.0000 |
| 10 | 804.0000 | 0.000000 |
| 11 | 0.000000 | 160.0000 |
| 12 | 1246.000 | 0.000000 |
| 13 | 0.000000 | 180.0000 |
| 14 | 293.0000 | 0.000000 |
| 15 | 0.000000 | 200.0000 |

Figure 3:Results of the Lindo Model
Source: Author

The obtained optimization RESULT shows that the optimal solution would be for CU to amount to 80%, and accordingly, for EC to amount to 5% of total revenue. The result is

expected and logical, but the program pointed to the "bottlenecks", i.e. the unevenness in the lengths of vessels and accordingly, to inadequate utilization of capacities.

However, as previously stated, the distribution of incoming vessels according to size is a problem to be dealt with by NTP managements through more proactive marketing and commercial policies.

### *5.2 Sensitivity analysis*

Finding the optimal solution does not conclude the problem solving analysis, but rather it should be completed by conducting the sensitivity analysis, aimed at examining changes in the model's output values as consequences of changes to individual input parameters of the model. The sensitivity analysis of solutions obtained by linear programming is carried out by using standard output data obtained by using the simplex algorithm.

Namely, the values of parameters in the optimization model are normally estimates. Given that models are created because of decisions to be made in the near or distant future, the estimate of parameter value (e.g. environmental costs) must be based on the prediction of their future values, which inevitably leads to mistakes.

Every increase in revenue proportionally increases investments into environmental protection, which is in line with socially responsible business. The optimal solution would be for every increase in traffic of vessels within an NTP to result in a proportional increase of pollution costs. Only this approach can satisfy the interests of environmental protection.

Apart from the above, one should always keep in mind the risk of pollution on a greater scale. The basic risk relation is R= l x c, where the ***l*** stands for the likelihood or frequency of an incident and the ***c*** stands for the consequence which can range from insignificant to catastrophic.

The definition of risk implies that the risk will be greater if the number of certain occurrences is higher, which indicates that maximizing the intake of boats (up to full capacity) entails the increased risk of an incident. Therefore, from the viewpoint of marine accidents, it is inopportune to strive for maximum capacity utilization.

Environmental protection is a process starting with the philosophy on the need to preserve the environment, which therefore does not end until there is a balance between the natural environment system and its exploitation. All the research can be presented through the algorithm of preserving the environment in an NTP in three possible scenarios.

### *5.3 Algorithm of sustainable development of an NTP*

The algorithm of sustainable development of the NTP is a logical sequence of actions and decisions to be implemented to come from the initial intention to the desired objective. Before setting up the algorithm, one must define the answers to the basic questions posed in the below table.

Table 7: Requirements for ensuring the quality of the environment preservation process

| *What is the desired result?* | *Enable sustainable development of an NTP* |
|---|---|
| Who makes the decisions? | NTP management |
| Who are the executors? | Quality management system, Environmental protection service |
| What should be done? | Carry out vertical and horizontal differentiation according to technical complexity, quality requirements and environmental protection within the NTP |
| What are the objectives? | I. Keeping the current market position by maintaining the current product quality with the current environment protection system;<br>II. Improving the market position by creating a competitive advantage based on the quality of service and systemic improvement of activities related to the protection of nature and preservation of the environment;<br>III. Achieving the leading position on the market based on the eco NTP brand |
| How to achieve them? | I. Through systemic monitoring of the environment within the NTP<br>II. Through systemic investments into the environment protection system<br>III. Through systemic education of all stakeholders in nautical tourism |
| What are the obstacles? | Environment protection costs |
| What are the decision – making parameters? | Survival in the market, investment/achievement ratio, opinions by expert consultants, benchmarking, signals from the surroundings. |

Source: Authors

The answers provided will create the following scenarios:

Table 8: Sustainable development scenarios

| *Scenario I* | *Scenario II* | *Scenario III* |
|---|---|---|
| The existing quality management and environment protection systems | Systemic improvement of the quality of infrastructure and superstructure of the NTP, investments into modern energy management equipment, use and treatment of water | Reaching excellence in quality management and environment protection systems; meeting all requirements of preserving the environment |
| CU = 68% Environment protection costs TR*0,03 | CU = 80% Environment protection costs TR*0,05 | CU = 99% Environment protection costs TR*0,08 |
| Permanent exposure to inspections, monitoring by environmental organizations, activists, scrutiny and evaluations of professional publications…. | Obtaining passing marks from all relevant stakeholders in environmental protection, raising the NTP's rating, cooperation with the local community concerning the improvement of environmental protection | Creating the brand of an ECO NTP, reaching the leading position in the nautical tourism market; socially responsible business |

Source: Authors

The proposed scenarios show that any plans for sustainable development of an NTP is based on three key factors, specifically: capacity utilization - CU, total revenue from primary business activity - TR and environmental costs shown as a percentage of the TR. According to Table 8, scenario I shows low environmental costs at low capacity utilization, while scenario III shows higher environmental costs at high capacity utilization rates. In scenario II, the medium level of capacity utilization also reflects the medium level of environmental costs, which is in line with the obtained results of the optimization carried out.

However, the amount of environmental revenue allocated will determine the level and type of equipment and infrastructure that NTP will implement in its systems. This refers to fenced work surfaces for servicing vessels with sewage treatment plants, receiving stations for sewage from vessels, tanks for separate collection of hazardous and non-hazardous waste, eco vessels for the rehabilitation of sudden marine pollution, protective dams to prevent the spread of marine pollution, and other equipment and infrastructure that will enhance the environmental system in the NTP.

## 6. Conclusion

If optimal results are desired, one should strive for systemic planning of the development of nautical tourism ports and training personnel for successful management and organization of existing ports and ports yet to be constructed. With the objective of minimizing pollution coming from nautical tourism and nautical tourism ports, any disposal of waste into the sea, however small, should be prevented, and the removal of all waste and oils from the sea surface and the coast should be ensured. The consequences of the potential slowing down of the replacement of sea water within the marina should be compensated with the prohibition of introduction of any waste, particularly organic (nitrates and phosphates) waste resulting from washing dishes, taking showers or food preparation on boats. Disposal of any solid waste into the sea should be strictly prohibited, as well as the discharge of sewage from boats.

One of the biggest problems in environment protection during the use of the development is preventing the pollution from every - day work and life on board the vessels (various types of waste, sewage). In that sense, the method of discharging the sewage tanks should be worked out and determined. To reduce the pollution, the sewage should be discharged and disposed according to relevant legislation in force in Croatia, while all opposite actions should be strictly prohibited and penalized.

It is clear that damage from pollution cannot be entirely avoided, but it must be minimized to the greatest extent possible. A quality control system should be set up in nautical tourism ports due to its accelerated development, which should contribute to raising awareness on possible long – term consequences alongside the legal measures. Apart from the above, the surveillance system for those individuals avoiding compensation of damages should be enhanced and those individuals should be penalized by fines and other measures.

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