Silting Effect on Tidal Basin Circulation: A Case Study

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Abstract. Management of coastal lagoons is of paramount importance for ensuring the safeguarding of ecosystems and human activities. The growing threats due to climate change and anthropogenic pressure require specific measures to be addressed in these areas. Thus, a detailed knowledge about the dynamics of these coastal systems is needed for planning and designing strategies aimed at preserving their integrity. This study is focused on the investigation, monitoring and analysis of the environmental integration framework of the complex drainage system located in the wetland areas of the municipality of Porto Cesareo (southern Italy). In particular, the study area is characterized by the hydraulic system of Bacino Fede, a coastal lagoon designed in the wider framework of the land reclamation activities carried out during the twentieth century. This research was carried out in relation to the morphological, hydrological and hydraulic characteristics of the study area, with the purpose of identifying and investigating any induced critical states, both general and specific, related to the hydraulic functionality of the system. Relevant insights on the hydraulic behavior of the Bacino Fede basin were obtained through mathematical modeling, thus leading to an improved knowledge of the dynamics of the area. The technical and scientific contribution thus acquired could represent an important resource for the stakeholders and decision-makers that play an active role in management of this area.

Keywords: Coastal lagoon · Tidal basin · Land reclamation · Hydrodynamic and environmental modeling

1 Introduction

Coastal lagoons are very important and unique ecosystems. They are usually connected to the sea through channels (inlets) whose presence plays a crucial role as – among others - it helps in maintaining a good water quality inside the lagoon. These inlets are very often intermittent, as they can open or close as a consequence of both natural and artificial phenomena, and this can in turn impact the salinity and trophic status of these water bodies. Without the effective operation of these openings, the tidal exchange can be negatively impacted, causing a degradation in tidal exchange and, in turn, in water quality.

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Coastal lagoons are the habitat for numerous species at least for part of their life cycle, and the flux of water between each lagoon and the open sea results in the lagoon being primarily marine or freshwater. They are characterized by high biodiversity levels [1, 2], as they represent the point where marine and continental flora and fauna come into contact and they are populated by ecosystems engineers, like seagrasses, that can create specific habitats [3]. Moreover, these inner basins are highly productive systems, thanks to organisms, such as green algae and phytoplankton, that absorb inorganic substances such as carbon dioxide and water to produce at a high-rate organic compounds that can be used as a source of energy for other living organisms.

Coastal lagoons are relevant also from an environmental and economic perspective: in fact, due to their characteristics, they often host extremely productive fisheries and various kinds of aquaculture [4], and they can be also used as a resource for salt mining [5]. Due to their exploitation for economic profit, inland basins are heavily impacted by anthropogenic activities, and this makes them vulnerable to an increased risk of environmental degradation, especially with respect to water quality issues. This can cause eutrophication, which represents a threat for the health of these ecosystems. In order to be able to plan interventions that can help maintain a sufficient water quality and, more generally, a satisfactory health level for the whole ecosystem, it is first necessary to assess the quality of water in lagoons, which makes it important to carry out studies on their circulation.

Many studies have been carried out on transitional water bodies [6–8] as they are the basis for planning interventions and maintenance. Coastal lagoons are very common in Italy, the most famous one being the Venice Lagoon, which is also the largest wetland in the Mediterranean Basin, but many smaller lagoons are located all along the Italian coastline. In particular, some of these systems were artificially built during the land reclamation works that took place in Italy during the twentieth century [e.g., see [9]. In this paper, we focus on one of these operas, the *Bacino Fede* basin, located in the municipality of Porto Cesareo (Salento peninsula, southern Italy). This area is geographically framed in the wider portion of territory known with the toponym of *Arneo*, as area historically subject to marshes that made this territory inhospitable and without significant human settlements until nineteenth century [10]. After 1920, this area was interested by a relevant activity of land reclamation, which can be testified in the municipality of Porto Cesareo by the presence of six hydraulic systems nowadays classified as coastal lagoons. These operas allowed a restoration of the whole area, who was progressively interested by an intense urbanization, often devoted to tourist accommodation. With the aim of safeguarding the ecosystems, a number of protected areas were established. Among the most important, there is the Porto Cesareo Marine Protected Area, established by a decree from the Ministry of Environment in 1997 as a National Marine Reserve. Since these areas are very significant from an environmental standpoint, effective management is required, thus they require regular monitoring, in order to plan adequate maintenance and guaranteeing their hydraulic effectiveness. For performing the required interventions, it is important to monitor and study the environmental status of the lagoons.

The goal of this paper is to study the water circulation inside a coastal lagoon, Bacino Fede (located in Porto Cesareo, southern Italy), and how it is affected by silting

in different scenarios. The paper is organized as follows: in Sect. 2, the case study and the numerical methods employed for the study of water circulation are illustrated. In Sect. 3, results from the various simulated cases are presented and discussed. Finally, in Sect. 4 the main conclusions are reported.

2 Study Area and Methodology

2.1 The Case Study: Bacino Fede

This study is focused on the Bacino Fede, a coastal lagoon near the site of Torre Castiglione, in the municipality of Porto Cesareo, a city located in the northern part of the Salento peninsula, southern Italy (Fig. 1). As reported in the Introduction section, a significant activity of land reclamation was carried out during the twentieth century, thus restoring lands who were later urbanized and cultivated [11]. In this context, the design and the building of coastal lagoons played a key role in the renewed hydraulic asset of the site.

For the reclamation of the Fede marsh, a connection to the sea through lakes was considered, which had to be created and could also be used by the inhabitants for fishing. In fact, the purpose of these reclamation works was nothing but to improve the quality of life in these areas and exploit the territory, encouraging the inhabitants to cultivate even those agricultural lands. Therefore, Bacino Fede behaves as an autonomous lagoon and it is connected to the sea through two tidal inlets. For the purpose of this analysis and consistently with data availability, we modelled the system only considering the aforementioned elements. The water exchange between the basin and the sea ensures a gradual variation in salinity, with higher values during the summer months and lower values in the winter. In summer days, when the freshwater table decreases and flow rates are lower, the salinity in the basin increases due to the inflow of seawater, resulting in higher oxygen levels and higher temperatures. The obstruction of channels disrupts the gradual salinity transition and mixing processes and has severe repercussions on the ecosystem of the area. Additionally, the closure of channels during specific periods of the year, when there is fish migration between breeding and growth areas, would impede this natural process.

To safeguard this artificial environment, regular maintenance measures should be implemented, including periodic cleaning of channel mouths to maintain the overall quality of the ecosystem. Furthermore, interventions should be carried out in compliance with vital periods of the valuable animal species in that area, such as the nesting seasons for species like the Kentish plover or marine turtles.

2.2 Numerical Model

Hydraulic simulations of the coastal lagoon investigated in this paper were carried out by means of the 2D hydrodynamic model (HD) MIKE 21, a modeling tool for oceanographic, coastal and estuarine numerical studies distributed by the Danish Hydraulic Institute. The software is able to simulate two-dimensional free-surface flows, and it is designed to be modular, which makes it applicable to simulations of hydraulics, water



Fig. 1. Photogrammetric capture of the study area (adapted from Google).

quality and sediment transport in water bodies [12, 13]. The model has been applied in numerous previous studies and tested by means of field measurements [14–19]. A review of MIKE 21 studies carried out in several fields concerning the flow modeling, with the objective of developing an understanding of how and where it can be applied, can be found in Warren and Bach [20].

MIKE 3 is composed of three fundamental modules, i.e. the hydrodynamic (HD) module, the advection-dispersion (AD) module and the turbulence module.

The HD module solves the time-dependent three-dimensional conservation equations of mass and momentum, the Reynolds-Averaged Navier-Stokes (RANS) equations in a Cartesian coordinate system, in order to predict water level changes, circulation and transport driven by winds, waves, tides, river discharge or density forcing. The closure problem is solved in the turbulence module by relating turbulent fluctuations, i.e., the Reynolds stresses, to the mean velocity field, according to the Boussinesq eddy viscosity concept.

The flow field and pressure variation are computed by the mathematical model in response to a variety of forcing functions. In the present study, forcing considered were the wind and the tide. The intensity values for these forcings have been obtained from the tide gauge station in Porto Cesareo, at 15 min intervals. The historical time series obtained from the present study covers the period from 2007 to 2015, with the exception of 2010, when no tide data is available. The performance of the data acquired over the years is shown in Fig. 2. Three years relatively close to each other (2011, 2014, and 2015) were analyzed, given their high performance compared to other years, with the aim of observing the evolution of water circulation over the years, as well as the variations that could occur for different years. In particular, the year 2011 was taken as a reference for the period of analysis, as it has a high data yield. Thus, the 2011 solar year was differed into wind rose seasons to verify which season has the most frequent winds

(Fig. 3 and 4). The season that agrees the most with the annual wind rose and with the most frequent wind direction is from January to March, therefore the whole numerical model was implemented relative to this period.

Along with the HD module, the Ecological module (ECO Lab) was used, in order to estimate the quality of the waters within the basin through the analysis of the transport of state variables by advection-dispersion processes based on hydrodynamics. The reference analysis parameters considered for the ecological study of the basin are the BOD5 and dissolved oxygen (DO). Deoxygenation is caused by the oxygen consumption carried out by bacterial flora. An increase in bacterial activity results in a higher consumption of dissolved oxygen in the water. Depending on the BOD values, the level of water contamination can be determined, with values below 1 mg/l considered as non-contaminated. DO is also a chemical parameter used to characterize the pollution level of a water system and, consequently, the survival of the complex organisms living in that system. Eutrophication and the generation of redox equilibria are among the main causes of a reduction in DO, which can lead to critical situations with typical values of hypoxia (between 3 and 1 mg/l) or anoxia (less than 1 mg/l), preventing aquatic life.



Fig. 2. Performance of the wind and tide data acquired from the tide gauge station in Porto Cesareo.

Regarding bathymetry, as a first approximation data obtained with LiDAR and converted to ASCII with a resolution of 2 m has been considered. For the study of the potential impact of obstructing the two connecting channels between the Bacino Fede and the open sea, a comparison was made between simulations without obstruction, where the channels had a depth of -0.3 m, and simulations with an obstruction of 50 m length, resulting in a 30% and subsequently 50% reduction in the initial depth.

The goal was to compare the circulation of currents within the basin with and without obstruction, a circulation that undoubtedly affects water quality.

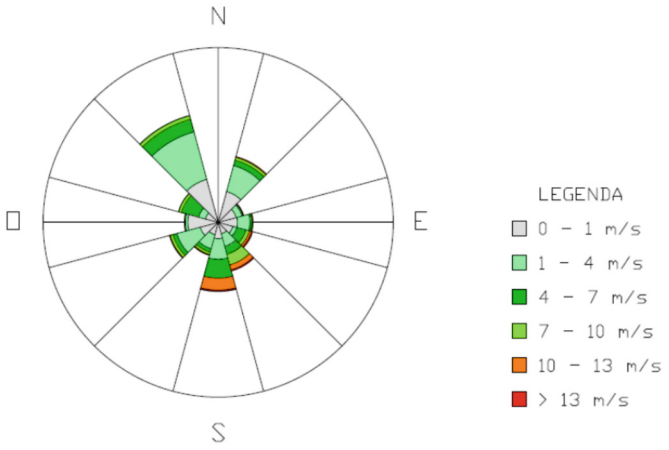

Fig. 3. Annual wind rose for 2011.

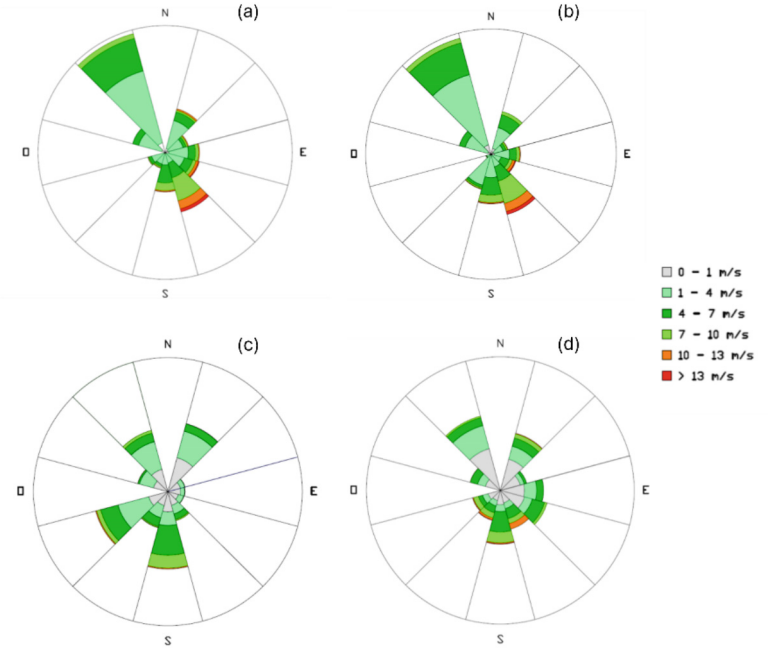

Fig. 4. Seasonal wind roses for 2011 (a) January-March, (b) April–June, (c) July-September, (d) October-December.

3 Results and Discussion

The results of the simulations carried out following the procedure outlined in the previous paragraph are shown below. In particular, simulations were conducted for three months (from January to March) over three different years (2011, 2014, and 2015) and considering three different configurations:

(i) no channel silting;
(ii) silting of the channel for a length of 100 m (starting from the sea and moving inland) and reduction of the water depth by 30% compared to the case without silting;
(iii) silting of the channel for a length of 100 m (starting from the sea and moving inland) and reduction of the water depth by 50% compared to the case without silting.

The last two configurations refer to a situation of silting, which could occur due to poor maintenance. For each simulation, the hydrodynamics, i.e., flow elevations and velocities, were examined. Moreover, the water quality was investigated by analyzing the concentrations of BOD and OD, taking into account the potential discharge of pollutants from the open boundary into the basin through the western open boundary.

The objective of the analyses, that is of the whole study, is to demonstrate that silting and obstruction of the channels have an impact on the water quality within the basin and consequently on all the surrounding ecosystems.

3.1 Hydrodynamic Simulations

Hydraulic simulations of Bacino Fede have been carried out through the use of a numerical code that simulates water bodies for which the plane bidimensional hydrodynamic approximation for vertically homogeneous fluids can be used. A hydrodynamical module (HD) simulating variations in the level of currents as a response to different types of forcings considered has been employed, and this allows the simulation of a large range of hydraulic phenomena even in the presence of complex structures.

Analyses have been carried out simulating different scenarios, with the aim of comparing the current circulation in the basin and taking into account the problems that emerge linked to channel silting. In order to analyze the elevation and velocity values within the Bacino Fede accurately, as the extent of silting of the channels varied, five points were taken into account (Fig. 5). The results reported in Table 1 confirm how in the five points analyzed, the estimated elevation values undergo a reduction in depth by increasing the value of the silting of the channels. This result is not particularly expected for points 2, 3, and 4, which are distant from the mouths of the two channels. Furthermore, for the year 2015, data are missing in points 1 and 5 under the condition of 50% channel obstruction compared to the initial depth. The year 2015 proved to be the most critical, with the disappearance of water in the initial part of both channels considering a 50% silting. This result is evident in Fig. 6, which depicts the distribution of elevation changes relative to the free surface at the end of the three-month simulation period. From the water depth results, it is evident that the obstruction leads to a reduction in elevation variations and, consequently, to minor fluctuations in the free surface.

Vector field analysis confirmed the results obtained by analyzing the water elevations. From Table 2, it is noticeable that, in general, the velocities are sufficiently small to be

Table 1. Punctual elevation values (see Fig. 5 for point location).

Point	Year	Silting (%)	H_{min} (m)	Date	H_{max} (m)	Date
1	2011	0	-0.1273	18/02	-0.1266	04/02
	2011	30	-0.0484	25/02	-0.0471	07/01
	2011	50	-0.0154	25/02	-0.0132	04/03
	2014	0	-0.0966	11/02	-0.0857	25/03
	2014	30	-0.0394	11/02	-0.0255	25/03
	2014	50	-0.0134	11/02	0.0011	25/03
	2015	0	-0.1300	21/01	-0.1277	25/03
	2015	30	-0.1099	04/02	-0.0906	28/01
	2015	50	N.A	N.A	N.A	N.A
2	2011	0	−0.1276	25/02	−0.1268	25/03
	2011	30	−0.0483	25/02	−0.0474	25/03
	2011	50	−0.0153	25/02	−0.0138	25/03
	2014	0	−0.0886	11/03	−0.0816	11/02
	2014	30	−0.0288	11/03	−0.0214	11/02
	2014	50	−0.0021	11/03	0.0052	11/02
	2015	0	−0.1296	28/01	−0.1255	04/03
	2015	30	−0.0917	14/01	−0.0875	04/03
	2015	50	−0.0902	28/01	−0.0864	04/03
3	2011	0	−0.1273	25/02	−0.1271	25/03
	2011	30	−0.0480	25/02	−0.0477	25/03
	2011	50	−0.0150	25/02	−0.0141	25/03
	2014	0	−0.0886	21/01	−0.0871	11/02
	2014	30	−0.0287	11/03	−0.0268	11/02
	2014	50	−0.0020	11/03	$2.45 \cdot 10^{-5}$	11/02
	2015	0	−0.1294	28/01	−0.1286	25/03
	2015	30	−0.0916	14/01	−0.0905	25/03
	2015	50	−0.0900	28/01	−0.0894	18/03
4	2011	0	−0.1274	25/03	−0.1270	25/02
	2011	30	−0.0480	07/01	−0.0477	25/02
	2011	50	−0.0150	07/01	−0.0141	11/03
	2014	0	−0.0889	25/03	−0.0881	14/01
	2014	30	−0.0290	25/03	−0.0280	14/01

(*continued*)

Table 1. (*continued*)

Point	Year	Silting (%)	H_{min} (m)	Date	H_{max} (m)	Date
	2014	50	−0.0023	25/03	−0.0013	14/01
	2015	0	−0.1305	04/03	−0.1291	11/03
	2015	30	−0.0923	04/03	−0.0908	11/03
	2015	50	−0.0913	04/03	−0.0898	11/03
5	2011	0	−0.1290	25/03	−0.1254	25/02
	2011	30	−0.0497	25/03	−0.0446	25/02
	2011	50	−0.0155	07/01	−0.0113	25/02
	2014	0	−0.1141	11/02	−0.0873	21/01
	2014	30	−0.0586	11/02	−0.0267	11/03
	2014	50	−0.0332	11/02	−0.0002	11/03
	2015	0	−0.1442	25/03	−0.1279	28/01
	2015	30	−0.0917	07/01	−0.0908	14/01
	2015	50	N.A	N.A	N.A	N.A

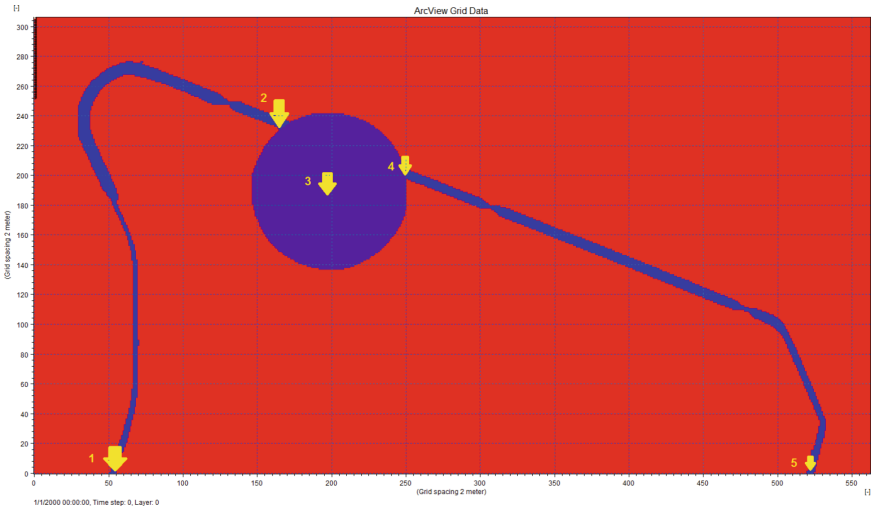

Fig. 5. Position of the numerical monitoring points in the Bacino Fede.

regarded as nearly negligible. As observed, the reduction in depths in the channels leads to a progressive decrease in velocities, although the reduction is of modest magnitude. Consequently, this decrease dampens the velocities within the basin, resulting in a poor water circulation in the Bacino Fede, compromising the beneficial effect of mixing on oxygenation and, thus, water quality.

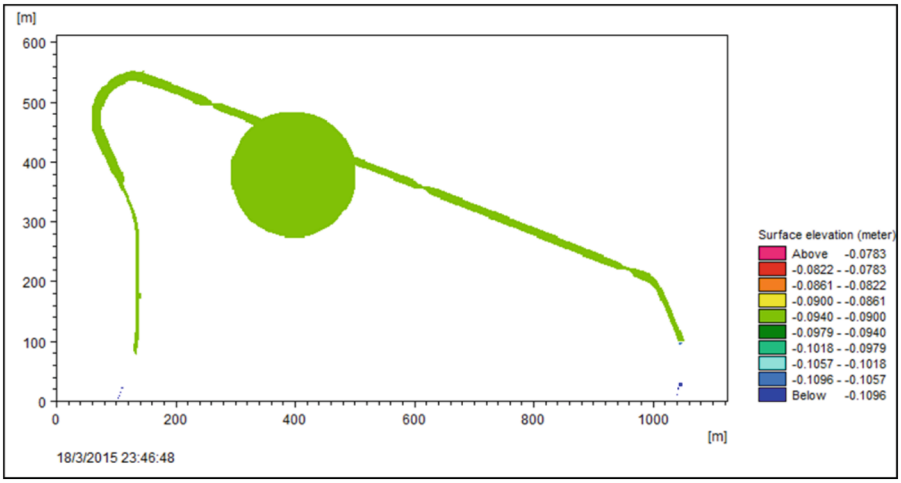

Fig. 6. Value of the elevation for configuration with 50% silting of canals, year 2015.

3.2 Water Quality Simulations

The analysis of water quality in the Bacino Fede was conducted examining the parameters BOD and OD through simulations carried out by ECO Lab module that considered two distinct scenarios, differentiated by boundary conditions. The first scenario simulates a situation where the basin is only fed from the sea with a defined BOD of 0.5 mg/l. The second scenario represents a situation in which the basin receives input from both the sea and external agents, such as anthropogenic discharges, the latter characterized by a BOD value of 11.36 mg/l at the western open boundary.

The input values considered for BOD, OD, temperature, and salinity at the two boundaries were provided by the Regional Agency of Environment Protection (ARPA PUGLIA), while within the basin, due to the absence of field measurements, a reliable set of values were used (see Table 3). Parameters implemented for simulating the two scenarios are reported in Table 4 and Table 5.

The simulation period considered is the first week of January 2011, and the results of the BOD and OD fields to be presented refer to the final step of the simulations, in the three cases analyzed, i.e. without silting, silting of 30%, and silting of 50%.

The results of the simulations within scenario 1 and considering the real and current situation, show BOD values that reduce both in the channels and within the basin, with the final result of BOD between 0–1 mg/l in the basin and values lower than 0.5 mg/l in the channels. With a 30% silting of the canals, a homogeneous variation of BOD is noted within the basin, to final values of 0.6–0.7 mg/l and 0.2 mg/l at the entrance of the basin and in the channels, respectively. Finally, in the configuration with a 50% silting, at the end of the simulation, the BOD presents values of 0.7–0.75 mg/l in the basin, while in the channels they tend to be zero. Overall, the analysis of the BOD data in scenario 1 does not show large differences within the basin in the configuration with 50% silting compared to 30%, while compared to the condition without silting the reduction in BOD over time occurs more slowly.

Table 2. Punctual time-average velocity values (see Fig. 5 for point location).

Point	Year	Silting (%)	Vel_{min} (m/s)	Date	Vel_{max} (m/s)	Date
1	2011	0	$2.99 \cdot 10^{-6}$	11/02	$5.46 \cdot 10^{-6}$	21/01
	2011	30	$1.55 \cdot 10^{-6}$	18/03	$4.07 \cdot 10^{-5}$	25/02
	2011	50	$8.25 \cdot 10^{-6}$	25/03	$7.12 \cdot 10^{-5}$	14/01
	2014	0	$6.37 \cdot 10^{-6}$	18/03	$5.58 \cdot 10^{-5}$	04/02
	2014	30	$1.75 \cdot 10^{-6}$	18/03	0.0001	18/02
	2014	50	$3.89 \cdot 10^{-6}$	07/01	0.0002	18/02
	2015	0	$4.27 \cdot 10^{-6}$	18/03	0.0001	04/03
	2015	30	$1.41 \cdot 10^{-1}$	28/01	$3.50 \cdot 10^{-5}$	14/01
	2015	50	0.0000	N.A	0.0000	N.A
2	2011	0	0.0003	28/01	0.0078	21/01
	2011	30	0.0001	18/03	0.0049	21/01
	2011	50	$5.80 \cdot 10^{-5}$	11/03	0.0050	25/02
	2014	0	0.0003	07/01	0.0082	25/03
	2014	30	0.0001	28/01	0.0051	18/02
	2014	50	0.0007	18/03	0.0059	14/01
	2015	0	0.0003	18/03	0.0105	25/03
	2015	30	0.0005	18/03	0.0109	25/03
	2015	50	0.0003	18/03	0.0109	25/03
3	2011	0	$6.78 \cdot 10^{-5}$	04/03	0.0006	18/03
	2011	30	$5.25 \cdot 10^{-5}$	14/01	0.0005	18/03
	2011	50	$3.89 \cdot 10^{-5}$	25/02	0.0004	18/03
	2014	0	$9{,}44 \cdot 10^{-5}$	18/03	0.0016	21/01
	2014	30	0.00004	14/01	0.0008	21/01
	2014	50	$4.76 \cdot 10^{-5}$	11/03	0.0003	11/02
	2015	0	$6.07 \cdot 10^{-5}$	18/03	0.0010	04/02
	2015	30	$6.95 \cdot 10^{-5}$	18/03	0.0008	04/02
	2015	50	$7.13 \cdot 10^{-5}$	18/03	0.0008	04/02
4	2011	0	0.0002	28/01	0.0097	25/03
	2011	30	0.0001	11/03	0.0039	25/03
	2011	50	0.0001	11/03	0.0037	25/02
	2014	0	$7.51 \cdot 10^{-5}$	28/01	0.0287	11/02
	2014	30	0.0001	07/01	0.0065	04/02

(*continued*)

Table 2. (*continued*)

Point	Year	Silting (%)	Vel_{min} (m/s)	Date	Vel_{max} (m/s)	Date
	2014	50	0.0001	25/02	0.0245	11/02
	2015	0	0.0002	07/01	0.0295	25/03
	2015	30	0.0001	14/01	0.0241	25/03
	2015	50	0.0001	18/03	0.0240	25/03
5	2011	0	$4.91 \cdot 10^{-6}$	14/01	$4.58 \cdot 10^{-5}$	18/02
	2011	30	$5.64 \cdot 10^{-6}$	11/03	$6.27 \cdot 10^{-5}$	18/02
	2011	50	$2.74 \cdot 10^{-6}$	07/01	$9.60 \cdot 10^{-5}$	21/01
	2014	0	$8.10 \cdot 10^{-6}$	18/03	$7.11 \cdot 10^{-5}$	18/02
	2014	30	$2.69 \cdot 10^{-6}$	25/02	0.0001	04/02
	2014	50	$2.52 \cdot 10^{-6}$	18/03	0.0002	04/02
	2015	0	$6.54 \cdot 10^{-6}$	14/01	0.0001	25/03
	2015	30	12.3	14/01	$2.18 \cdot 10^{-5}$	07/01
	2015	50	0	N.A	0	N.A

Table 3. Parameters set in the inlet waters of the Bacino Fede.

Parameters	Values
BOD (mg/l)	12
OD (mg/l)	7.69
Temperature (°C)	26.41
Salinity (psu)	8.2

Table 4. Parameters set at the open boundaries of the Bacino Fede. Scenario 1.

Parameters	Western open boundary	Eastern open boundary
BOD (mg/l)	0.5	0.5
OD (mg/l)	7.28	7.28
Temperature (°C)	19.7	19.7
Salinity (psu)	38.7	38.7

The analysis of the results of the second configuration (scenario 2) simulations highlights that not the entire basin appears to have BOD values lower than 1 mg/l as in scenario 1, but a part of the western canal assumes BOD values greater and around 2 mg/l, the one on the east 0.2–0.4 mg/l and the internal waters 0.6–0.8 mg/l. The BOD values,

Table 5. Parameters set at the open boundaries of the Bacino Fede. Scenario 2.

Parameters	Western open boundary	Eastern open boundary
BOD (mg/l)	13.36	0.5
OD (mg/l)	7.28	7.28
Temperature (°C)	19.7	19.7
Salinity (psu)	38.7	38.7

for the configuration with a 30% obstruction, vary almost equally for both the channels and the basin, with a continuous reduction of BOD reaching values at the last step of 0.6–0.8 mg/l within the basin. Compared to the scenario without channel interruption, with a 50% silting there is a slightly slower reduction in BOD. The BOD values for the channel to the west decrease more rapidly, while inside the basin they remain almost constant. Between scenario 1 and scenario 2, a faster reduction in BOD is observed in the former, although not significantly notable, whereas configurations of silting lead to similar results.

The results of simulations for scenarios 1 and 2 are further discussed in relation to the scalar fields of OD concentration. In the real configuration and considering scenario 1, there is an observed increase in OD over the simulation time, reaching values of 7.3–7.5 mg/l within the basin and in the channels near the basin with values even reaching 8.25–8.4 mg/l, leading to an equilibrium within the basin. With 30% silting, the OD reaches final values of 6.7–6.9 mg/l and 8.4–8.55 mg/l respectively in the basin and in the channels. Similar OD values are achieved by assuming a 50% silting along the channels. Comparing all three cases within scenario 1, it is observed that between the configuration without interruption and with interruption, in the latter, there is a slight reduction in the accumulation of oxygen, leading to a slower oxygen uptake. The higher oxygen content in the channels is found in the part closest to the internal basin.

If we analyze scenario 2, for the condition of uninterrupted channels, OD values within the basin are around 7–7.15 mg/l, and in the channels, they range from 7–8.35 mg/l, with values of 8.35 mg/l located in the upper part of the channels near the basin. Assuming a 30% obstruction, OD values of 6.45–6.75 mg/l are observed within the basin, and 8.35–8.45 mg/l values are noted in the channels, similarly to configuration with 30% silting and to scenario 1. In general, compared to scenario 1, slightly higher OD values are obtained considering different boundary conditions and pollution source at the inlet.

4 Conclusions

The present study describes the analysis of water dynamics in the Bacino Fede within the protected area of Porto Cesareo in southern Italy. The goal is to demonstrate the necessity of maintenance interventions on the channels connecting the internal waters of the basin with the open sea. Numerical hydrodynamic and ecological simulations were conducted to demonstrate that the low depth of the channels and their silting, by

the currents that transport solid material and sediments from the open sea into the same basin, lead to a low circulation in the coastal lagoon.

From the results of the simulations, it emerges that the reduction in depth leads to a decrease in elevation variations, consequently resulting in greater water steadiness within the basin and channels. There is even an observation of the absence of water in certain stretches of the channels during specific periods of the year. As for velocities, they appear lower when depth is reduced, exerting an impact on the circulation within the basin, which becomes weaker.

The BOD and OD are inversely correlated; to decrease BOD, oxygen is required. Therefore, a low BOD value and a high OD value are indicative of good water quality. In the absence of channel interruption, BOD has slightly lower values at the end of the simulation compared to cases with interruption, and it decreases more rapidly. On the other hand, OD exhibits higher values and increases more rapidly in scenarios without interruption. Assuming open boundary conditions on both sides, specifically at the two channels connecting to the open sea, with BOD values set at 0.5 mg/l, results in slightly higher OD values and slightly lower BOD values compared to cases with different boundary conditions. Furthermore, the study analyzed the impact of potential external factors that could alter the balance and water quality in that area, by introducing BOD values of 12 mg/l in one of the two channels, i.e. the western open boundary. The goal was to determine whether the mixing generated from internal currents is sufficient for the dilution of such discharges. Further investigation is needed to assess the actual possibility of discharges from external sources that could alter the balance and water quality in the area under study.

The results achieved highlight the negative effect of the silting of the canals on the exchange of the internal waters in question, with serious repercussions on the ecosystem of the area. It should also be noted that channel interruption, as observed in simulations, particularly at the mouth, would hinder the migration of fish fauna between reproduction and growth areas during specific periods of the year. Our study could useful insights for supporting current management techniques of such areas. In particular, further research could be dedicated to the ecological implications of potential climatic scenarios and could be supported by specific monitoring actions.

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