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# Present and future status of artisanal fisheries in the Adriatic Sea (western Mediterranean Sea)

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A B S T R A C T

Artisanal fisheries represents an important source of employment and income for many Mediterranean coastal communities, as well as an important cultural and traditional identity factor at a regional level. However, despite its importance, it is generally under-studied, in both ecological and socio-economic terms, so hampering the chance of developing sustainable and integrated management measures. At present, on the West coast of the Adriatic Sea, within the three-mile area, artisanal fisheries and hydraulic dredging are the only approved commercial fishing activities. This study confirmed the importance of the artisanal fisheries in this area, representing a multitarget and multigear activity. Despite the 39 exploited species, however, we found high vulnerability both for species (76% of total catches depend upon only three species—cuttlefish, mantis shrimp, and sole) and thermal affinity groups (cold and temperate species contributed to the entire catches). Furthermore, our data showed that fishing effort and CPUE values were greater than those reported at the regional level, and also indicated that the discard rate was lower than in other Adriatic areas. Regarding ecological effects, the two trophodynamic indicators that we applied showed a sustainable situation, but scenarios of possible changes in environmental or fishing effort conditions highlighted the proximity of the stock to the unsustainability threshold. Our findings suggest the need for an adequate management strategy to cope with possible future changes in population boundaries and conditions.



## 1. Introduction

Artisanal and small-scale fisheries are often equated (see FAO glossary), because they share common features, such as low capital investment, ownership by fishermen, and the exploitation of coastal fishing grounds located within a few hours' travel from the port (Colloca et al., 2004). Generally, artisanal activities can be characterized by the relative level of technology (or "artisanality") and by whether they are multitarget and multigear, as seasonal changes in fishing techniques are implemented to maximize catches and, therefore, profitability (Farrugio et al., 1993; Battaglia et al., 2010; Forcada et al., 2010). Despite these common features, artisanal fisheries tend to be highly heterogeneous in space, and strictly depend upon local environmental and socio-economic conditions (Stergiou et al., 2006; Guyader et al., 2013). Typically, these activities are deeply rooted in coastal populations, and play crucial socio-economic roles in both developing and developed countries, including those along European coastal zones. These factors may be magnified in the Mediterranean basin, where the multispecificity of catches and dispersion of fleets across a high number of small ports are the main features of all of its fisheries. Such characteristics could represent major reasons why the artisanal fisheries in the Mediterranean Sea and Europe are generally not well characterized (Battaglia et al., 2010; Guyader et al., 2013).

Small scale and artisanal fisheries are often attributed with the potential to contribute to food security, economic growth, the development of coastal areas, and the preservation of marine ecosystems (FAO, 2005; Garcia et al., 2008). However, limited data are available at the regional level regarding production or the socio-economic and ecological implications, which substantially limit opportunities to produce a real assessment of such issues and generate effective management strategies.

Within this context, the Italian situation may represent an interesting case study. Since June 2010, the implementation of Council Regulation (EC) no. 1967/2006 introduced a ban of trawling activities within three nautical miles of the coast or within the 50 m isobaths where this was closer to the shoreline. As a consequence,

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artisanal fishing remained almost the only exploitative activity within the coastal area. For example, on the West coast of the Adriatic Sea within the three-mile area, artisanal fisheries and hydraulic dredging for striped venus clams (*Chamelea gallina*) are the only permitted activities (Pranovi et al., 2015). Nevertheless, very few studies have been carried out to characterize the possible ecological effects and management strategies that result from this regulation (Fabi and Grati, 2005; De Mauro et al., 2007).

To begin to address this issue, this present study aims to assess the following criteria:

(1) the basic features of artisanal fisheries along the Venetian coast, in terms of fishing strategies and catches;
(2) the potential vulnerability of artisanal fisheries, also in relation to the potential effects of climate change; and
(3) the sustainability of exploitative activities, also considering the expected modifications of fishing effort and/or environmental features.

## 2. Materials and methods

### 2.1. Study area

The Northern Adriatic Sea includes all of the critical elements attributed to a ‘typical’ coastal area, such as the concentration of many economic activities and the presence of different types of anthropogenic pressures, including important fisheries, aquaculture activities (mussel farms), widely distributed seaside tourism, and extended seaport activities. Furthermore, the provision of many goods and services, including renewable resources, are particularly critical in the trade-off between ecological status and the impacts of exploitation. Additionally, this area is particularly exposed to the effects of climate change because of its local geographic features. Indeed, the zone has been described as an area where Mediterranean climatic conditions are replaced by boreal conditions, supporting the presence of ‘glacial relicts’ and representing a type of ‘*cul de sac*’ for some species (Ben Rais Lasram et al., 2010; Libralato et al., 2015).

The study area is located on the West coast of the Northern Adriatic Sea, between Caorle and Cavallino–Treporti (Fig. 1). It is a flat coastal area characterized by the presence of sandy beaches, transitional water systems (laguna di Caorle e laguna del Mort) and river mouths (Tagliamento and Sile), which results in high habitat diversity. Caorle and Jesolo represent the two most important ports in this area, and they are the home to the major fishing fleets of the region apart from Chioggia, which is the largest port in the entire basin.

### 2.2. Fleet characteristics and sampling activities

This study was focused on two main fleets (Jesolo and Caorle) located along the northern part of the Venetian coast (Fig. 1). A preliminary description of these fleets was performed based on the EU Fleet Register (number of vessels and licences) and local fishermen's cooperatives (number of fishermen per vessel and days at sea). These data were subsequently validated by interviewing fishermen and performing direct observations at the quay.

Descriptions of catches, both in qualitative and quantitative terms, were performed by onboard observations that were carried out bi-monthly on four vessels (two per fleet) from January to December 2014. According to the sampling protocol, each individual organism that was caught was classified at the species level and weighed (grams of wet weight); in cases of uncertain classification, samples were collected and successively identified in the laboratory. All catches were divided into target species, by-catch, and discarded organisms (both commercial and non-commercial species). Data were integrated with weekly observations on the quay in which the same vessels were followed.

### 2.3. Data analysis

Based on the collected data, the catch per unit of effort (CPUE) for each gear and species was estimated in terms of biomass per day per vessel (kg $v^{-1}$ $d^{-1}$). To assess the total catches per year at the fleet level, the following criteria were used: CPUE data, number of days at sea, and number of artisanal fisheries vessels in the area. For the number of days at sea, two different estimates were used: 150 days, which was based on the official statistical data from 2012, to 214 days, which was based on observations from 2014 carried out during this present study. The bootstrapping method was applied to estimate the 95% confidence interval (Shao and Tu, 1996; Lehtonen and Pahkinen, 2004). According to the procedure, CPUE samples were randomly drawn from the database, repeating the process for 1000 times. Once built, the new dataset (composed by all targeted species) was used to estimate the confidence interval ($\alpha = 0.05$).

To investigate the sustainability of artisanal fisheries and their associated ecological effects, the Primary Production Required (PPR) to sustain the fishery (Pauly and Christensen, 1995) and L-index (Libralato et al., 2008) were estimated.

The PPR enabled the quantification of fishing pressures on the ecosystem, as it calculated the amount of energy exported from the system by landings. It is usually standardized as a percentage of the annual Primary Production of the area, and can be calculated as follows,

$$PPR = \sum_{i=1}^{n} \frac{L_i}{CR} \left(\frac{1}{TE}\right)^{(TL_i - 1)}$$

with $L_i$ = landing of *i*-species; CR = conversion rate of wet weight-to-carbon (fixed at 1:9, according to Pauly and Christensen, 1995); TE = transfer efficiency (fixed at 10.5%, according to Libralato et al., 2015); TL = trophic level of *i*-species (assigned according to Pranovi et al., 2014).

Primary production for the NAS was estimated by using monthly chlorophyll-a data derived from the MODIS satellite (http://neo.sci.gsfc.nasa.gov/), according to Behrenfeld and Falkowski (1997).

The L-index is a synthetic index that takes into account both ecosystem properties (primary production and transfer efficiency) and features of fishing activities (trophic levels of catches and PPR). This index allows for estimates about how the effects of energy extracted from the system by exploitative activities can be propagated through the trophic chain.

The L-index is defined as,

$$Lindex = \frac{PPR\ TE^{TL_c - 1}}{PP\ \ln(TE)}$$

where PPR = Primary Production Required (see above); TE = transfer efficiency (fixed at 10.5%, according to Libralato et al., 2015) TLc = the mean trophic level of catches; PP = Primary Production (see above).

The method allows also for estimates of the probability that such energy loss is sustainable based on a non-linear empirical relationship between the L-index and the probability to be sustainably exploited (psust) for an ecosystem (Libralato et al., 2008).

To simulate the possible effects of changes in both social and environmental conditions, the PPR% and L-index indicators were