A large population of *Pinna nobilis* L. in a suboptimal shallow coastal habitat

Patricia Prado, Nuno Caiola and Carles Ibáñez
**Introduction**

**Taxonomic position**
- Phylum: Mollusca
- Class: Bivalvia
- Order: Mytiloidea
- Family: Pinnidae

**Species distribution**

[Map showing species distribution]

- **Adults**
- **Juveniles**
Introduction

- The fan mussel *Pinna nobilis* (Linnaeus, 1758) is the largest Mediterranean bivalve sometimes exceeding 1 m in length (García-March et al., 2007).
- It lives with up to one-third of the shell buried in the substrate, and attaches itself to the substrate using a strong byssus composed of many silk-like threads which were used to be made into cloth (sea silk). These keratin fibres that the animal secretes using the byssus gland are up to 6 cm long.
Introduction

- Which habitats are suitable for the development of *Pinna nobilis*?

  - Macroalgal beds
  - Rocky habitats
  - *Cymodocea nodosa*
  - *Posidonia oceanica*
  - Sandy habitats
  - Silty habitats

- *P. nobilis* occurs at a water depths ranging between 0.5 and 60 m (Butler et al., 1993), although population maximums are usually reported from ca. 3-4 m to ca. 14-15 m (García-March et al. 2006, Katsanevakis 2007, Coppa et al. 2013).
Introduction

Population densities
• *P. nobilis* populations usually show *aggregated* distributions and highly variable densities (Katsanevakis, 2005; Richardson et al., 2004), ranging between 0.001 (Centoducati et al., 2007) and 600 ind. 100 m$^{-2}$ (Catsiki and Catsikieri 1992; De Gaulejac and Vicente, 1990).
Introduction

Reproduction
• Protandric hermaphrodite. The reproduction period usually ranges from early June to September. Larvae are undistinguishable from those of other bivalve larvae and little is known about their patterns of abundance, although the duration of the planktonic stage appears to be low (5-10 days (De Gaulejac & Vicente 1990).

Feeding and Predation
• It feeds on planckton by filtration. Individuals can filter about 10 L of water/day, which may also constrict their own settlement in areas with high density of adults.
• Recruits and juveniles can be predated by octopus and some fish such as the gilthead sea bream *Sparus auratus.*
Recruits
Recruitment is often assessed with artificial collectors and used as a proxy of larval supply (e.g., Kersting and García-Marsh 2007).
Introduction

Juveniles
Include sizes < 20 cm (Richardson et al. 1999, 2004) and ca. 1 year of age. They are often subjected to depth segregation, and occur in higher numbers of juveniles in shallow areas (Katsanevakis 2006).

Species Situation
Category: Vulnerable (BOE order 22 Jun 1999) and Barcelona Convention, protocol ASPIM Annex 2
Introduction

**Main threats**

**Habitat destruction**: Creation of ports, marinas, and trawling.

**Habitat alterations**: Eutrophication and salinity variations.

**Damage to individuals**: Anchoring, damage with motors in shallow areas, direct culling of individuals.
**Western Mediterranean**

- *P. nobilis* is known to occur in Alfacs Bay (Ibáñez 1997), but the area is not included in the Red Book of Endangered Species or in the scientific literature.
- The entire Banya Sandspit is a Natural Park and Nature Sanctuary.
- Maximum depth of ca. 6 m, but usually no more than 3 m.
- *Cymodocea nodosa* with some mixed areas of *Caulerpa prolifera* as dominant habitat.

**Alfacs Bay, Ebro Delta**

- Salt pans
- Bay mouth
- Sant Carles de la Rápita
- Maximum depth of ca. 6 m, but usually no more than 3 m.
- *Cymodocea nodosa* with some mixed areas of *Caulerpa prolifera* as dominant habitat.
Objectives

- Which is the population abundance and size distribution of *P. nobilis* in the Alfacs Bay?
- How is it spatially distributed?
- Which are the main factors responsible for the observed patterns of abundance?

T1

T2  0-6m
Materials and Methods

- **102 shore-parallel transects** were conducted along the entire Banya Sandspit, covering the full depth range of the shallow shelf (ca. 10 to 130 cm depth).

**Line transects**

- In each line transect (ca. 100 m), individuals (alive, death, and marked by propeller scars) were counted by two observers wading in front of a support boat.

- For each individual, we recorded: the perpendicular distance from the transect line, shell width and height, valves’ orientation, depth, and seagrass cover

- A third observer (on board) recorded environmental variables at each transect: depth, seagrass cover, pH, temperature, salinity, and oxygen levels.
Materials and Methods

Distance 6

• Distance 6 computer package was used to assess the underestimation of the population density at increasing distances from the observers’ transect.

• A number of key functions (half-normal, polynomial, etc.) were run in order to obtain the best fitting model.

• Selection of the appropriate key function for a given data set relies on model selection criteria (minimum Akaike’s Information Criterion).

• The program also computes possible underestimation of individuals induced by environmental factors (covariates) such as seagrass cover and depth (MCDS approach).

• Output variables given by the distance 6 included: transect width, density of individuals · m⁻², and the total Nº of individuals within the specified area (line transects).
Materials and Methods

• There were two clearly different areas with high and low densities of individuals that we named Good Habitat and Bad Habitat; the latter in front of the dike of the salt pans.

• The whole area of both habitats was estimated by conducting 10 batimetric survey transects from ca. 130 cm to 30 cm (depths of Pinnids’ distribution).

• The area of GH and BH per depth intervals of 10 cm was estimated as the percentage of points at each depth times the total estimated surface of each habitat.

• Densities per m² by depth intervals within transects were multiplied by the area of GH or BH at each depth interval and the number of individuals added to estimate total abundance in the Bay.
Results - Abundance of individuals

No. of individuals observed in across-shore transects conducted between the surface and the maximum depth of the bay (0 to 6 m). No individuals were found prior 30 cm or after 130 cm of water column.

- Alive: 1068 (50 in BH and 1018 in GH)
- Pulled up: 11 (in GH) and 54 scared
- Death: 22 (3 in BH and 19 in GH)

![Graphs showing abundance of individuals by depth intervals in BH and GH during shore-parallel transects.](image)
Results - Abundance of individuals

Habitat features

Depth

Depth-GH = 73.3 ± 2.6
Depth-BH = 85.3 ± 3.1

Seagrass cover

CN-GH = 48.7 ± 4.1 % (NS)
CN-BH = 46.2 ± 4.3 %

Frequency of distance values at which individuals were detected during surveys in the BH (max. width of 2 m), and the GH (max. width of 7.9 m).
Results - Abundance of individuals

Summary of area estimates, densities, and numbers of individuals in the entire BH and GH per depth class of 10 cm.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>BH Area (m²)</th>
<th>Nº ind.</th>
<th>Density · 100m²</th>
<th>GH Area (m²)</th>
<th>Nº ind.</th>
<th>Density · 100m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-19</td>
<td>18,056.96</td>
<td></td>
<td></td>
<td>12,796.52</td>
<td>15.35</td>
<td>0.12</td>
</tr>
<tr>
<td>20-29</td>
<td>198,626.52</td>
<td></td>
<td></td>
<td>140,761.74</td>
<td>84.42</td>
<td>0.06</td>
</tr>
<tr>
<td>30-39</td>
<td>379,196.09</td>
<td></td>
<td></td>
<td>268,726.96</td>
<td>2,417.45</td>
<td>0.90</td>
</tr>
<tr>
<td>40-49</td>
<td>469,480.87</td>
<td></td>
<td></td>
<td>332,709.57</td>
<td>3,491.88</td>
<td>1.05</td>
</tr>
<tr>
<td>50-59</td>
<td>559,765.65</td>
<td>531.77</td>
<td>0.09</td>
<td>396,692.17</td>
<td>3,806.53</td>
<td>0.96</td>
</tr>
<tr>
<td>60-69</td>
<td>487,537.83</td>
<td>2,701.74</td>
<td>0.55</td>
<td>345,506.09</td>
<td>10,774.94</td>
<td>3.12</td>
</tr>
<tr>
<td>70-79</td>
<td>451,423.91</td>
<td>3,573.73</td>
<td>0.79</td>
<td>319,913.04</td>
<td>15,109.09</td>
<td>4.72</td>
</tr>
<tr>
<td>80-89</td>
<td>325,025.22</td>
<td>2,646.60</td>
<td>0.81</td>
<td>230,337.39</td>
<td>6,170.26</td>
<td>2.68</td>
</tr>
<tr>
<td>90-99</td>
<td>252,797.39</td>
<td>873.29</td>
<td>0.35</td>
<td>179,151.30</td>
<td>6,088.40</td>
<td>3.40</td>
</tr>
<tr>
<td>100-109</td>
<td>216,683.48</td>
<td>1,029.23</td>
<td>0.47</td>
<td>153,558.26</td>
<td>4,052.11</td>
<td>2.64</td>
</tr>
<tr>
<td>110-119</td>
<td>288,911.30</td>
<td></td>
<td></td>
<td>204,744.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120-129</td>
<td>343,082.17</td>
<td></td>
<td></td>
<td>243,133.91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11,356.37</td>
<td></td>
<td></td>
<td>52,010.43</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results- Size classes

Regression between valves’ length and width, for intact individuals found death during the study. The relationship was used to estimate the length of living individuals.

No. of individuals by size in shore parallel transects along the Banya Sandspit in the BH, and the GH. Dashed lines indicates cohort numbers in modal class progression analyses.
Results-Habitat features

Shell orientation

- In the good habitat most of the individuals were oriented N-S and NE-SW
- In the bad habitat, both N-S and E-W orientations were important, but the latter tended to be larger

At least for the good habitat shell orientation coincides with exposure to dominant local winds Mistral (N): 337 to 24° and Garbi (SW): 180-210°
Results-Habitat features

Effects of depth and seagrass cover covariates on the detection probability for the GH and the BH models.

**GH:** ca. 33.5 % underestimation  
**BH:** ca. 6 % underestimation

3.6 ind. $\cdot$ 100 m$^{-2}$, and a total of 3064.9 ind.

0.5 ind. $\cdot$ 100 m$^{-2}$, and a total of 106.4 ind.
## Discussion

### Comparison with other Mediterranean populations

<table>
<thead>
<tr>
<th>Location</th>
<th>Investigated area (m²)</th>
<th>Depth range (m)</th>
<th>Total popul. (No. ind.)</th>
<th>Mean density (Max) (ind./100 m²)</th>
<th>Substrata</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Souda Bay (Crete, Greece)</td>
<td>14,715,000</td>
<td>4-22</td>
<td>130,900</td>
<td>0.89 (53)</td>
<td><em>C. nodosa</em>/<em>C. racemosa</em></td>
<td>Katsanevakis and Thessalou-Legaki (2009)</td>
</tr>
<tr>
<td>Alfacs Bay (Ebro Delta, Spain)</td>
<td>7,096,300</td>
<td>0.3-1.3</td>
<td>64,546</td>
<td>1.04 (20)</td>
<td><em>C. nodosa</em> sand</td>
<td>This study</td>
</tr>
<tr>
<td>Lake Vouliagmeni (Korinthiakos Gulf, Greece)</td>
<td>1,504,000</td>
<td>1-23</td>
<td>8,501</td>
<td>0.57 (17)</td>
<td>mud</td>
<td>Katsanevakis (2006)</td>
</tr>
<tr>
<td>Chafarinas Islands (Morocco)</td>
<td>182,000</td>
<td>7.4-11.2</td>
<td>NA</td>
<td>2.9 (NA)</td>
<td><em>P. oceanica</em>/<em>C. nodosa</em>/<em>macroalgae</em></td>
<td>Guallart and Templado (2010)</td>
</tr>
<tr>
<td>Gulf of Oristano (Sardinia, Italy)</td>
<td>67,200</td>
<td>2-10</td>
<td>1,285</td>
<td>2.7 (6.7)</td>
<td><em>P. oceanica</em>/<em>C. nodosa</em></td>
<td>Coppa et al. (2013)</td>
</tr>
<tr>
<td>Gulf of Hammamet and Gabes (N and E coast, Tunisia)</td>
<td>33,600</td>
<td>0-6</td>
<td>845</td>
<td>2.5 (20)</td>
<td><em>P. oceanica</em>/<em>C. nodosa</em>/<em>macroalgae</em></td>
<td>Rabaoui et al. (2008)</td>
</tr>
<tr>
<td>Gulf of Hammamet and Gabes (E and SE coast, Tunisia)</td>
<td>21,100</td>
<td>0-6</td>
<td>327</td>
<td>1.5 (56)</td>
<td><em>P. oceanica</em>/<em>C. nodosa</em>/<em>macroalgae</em></td>
<td>Rabaoui et al. (2010)</td>
</tr>
<tr>
<td>Ghar El Melh lagoon (Tunisia)</td>
<td>5,024</td>
<td>0.3-0.5</td>
<td>152</td>
<td>3.01 (9.6)</td>
<td><em>Ruppias spp./N. noltii</em>/C. nodosa/<em>sand</em></td>
<td>Zakham-Sraieb et al. (2011)</td>
</tr>
<tr>
<td>Gulf of Oristano (Sardinia, Italy)</td>
<td>4,500</td>
<td>2-8</td>
<td>530</td>
<td>6.3 (29)</td>
<td><em>P. oceanica</em>/<em>C. nodosa</em></td>
<td>Addis et al. (2009)</td>
</tr>
<tr>
<td>Mljet National Park (Croatia)</td>
<td>1,928</td>
<td>3-15</td>
<td>180</td>
<td>10.9 (29)</td>
<td><em>C. nodosa</em></td>
<td>Siletic and Peharda (2003)</td>
</tr>
<tr>
<td>Columbretes Islands (Castellon, Spain)</td>
<td>7 areas of 100-314</td>
<td>20-34</td>
<td>55</td>
<td>1.5 (16)</td>
<td><em>C. nodosa</em></td>
<td>García-March et al. (2006)</td>
</tr>
<tr>
<td>Moraira Bay (Alicante, Spain)</td>
<td>1314</td>
<td>6 and 13</td>
<td>20 and 103</td>
<td>6 and 10.3</td>
<td><em>P. oceanica</em></td>
<td>García-March et al. (2007)</td>
</tr>
<tr>
<td>Theraikos Gulf (Greece)</td>
<td>70</td>
<td>2-3</td>
<td>73</td>
<td>104 (130)</td>
<td>NA</td>
<td>Galinou-Mitsoudi et al. (2006)</td>
</tr>
<tr>
<td>Murcia, Almeria, Columbretes and Balearic Islands (Spain)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>10</td>
<td>NA</td>
<td>Guallart and Templado (2012)</td>
</tr>
<tr>
<td>Almeria coast (SE Spain)</td>
<td>323</td>
<td>2-17</td>
<td>55</td>
<td>17 (30)</td>
<td><em>P. oceanica</em></td>
<td>Richardson et al. (1999)</td>
</tr>
</tbody>
</table>
Conclusions

• **Largest shallow population reported for the Mediterranean:** Observed densities were on the range of others previously observed in other studies, but the extension of the study area is the second largest reported and result on a greater local number of individuals (total: 64,546 ± 21,623).

• **Homogeneous size-classes:** Most individuals ranged between 40 and 55 cm. The presence of recruits might be greater at very shallow waters (<30 cm) and need to be further investigated. Homogeneity in size may be related to depth and not to the absence of age variability, as “dwarf” individuals have been indicated for shallow habitats (García-March et al. 2007).

• **Habitat features:** Population occurs at unusual shallow depths (30 to 130 cm of water). Slight variations in water depth strongly influence the abundance of individuals (peak at 70-80 cm), but have no apparent effect on the size of individuals. Large seagrass covers (90-100%) also favor the abundance of individuals.

• **Local management:** Our results suggest that the presence of the salt pans could be impacting the population abundance of *P. nobilis* in the Bad habitat. In addition, the management agenda should include protection from boating in order to avoid shell damage and occasional pull up of individuals. The discharge of agricultural water in the northern part of the bay should be avoided in order to enhance the available habitat for the development of *P. nobilis*.
Acknowledgements

THE END

THANK YOU
FOR YOUR ATTENTION!!