THALASSAS

Thalassas, 26 (2): 33-45
An International Journal of Marine Sciences

TEMPORAL EVOLUTION OF POLYCHAETE ASSEMBLAGES ON INTERTIDAL HARD SUBSTRATA AT TWO LOCALITIES OF THE GALICIAN COAST AFTER THE '*PRESTIGE*' OIL SPILL

XANDRO GARCÍA-REGUEIRA[1], RAMIRO TATO[1], JUAN MOREIRA[1] & VICTORIANO URGORRI[1,2,3]

Key words: *Prestige* oil spill; Polychaeta; assemblages; intertidal; Galicia; Iberian Peninsula; Atlantic Ocean

ABSTRACT

The *Prestige* oil spill on November 2002 affected many coastal areas of the NW Iberian Peninsula. At the Galician coast, many rocky intertidal areas were strongly impacted and large amounts of fuel reached there. The temporal evolution of intertidal polychaete assemblages inhabiting mussel and algal beds at natural intertidal rocky shores were studied in one affected location of the western Galician coast (Caldebarcos) and compared to the temporal trends at one control location (O Segaño, Ría de Ferrol), from winter 2004 to summer 2005. Values of univariate parameters (number of species, abundance, Shannon-Wiener's diversity) and multivariate analyses did not suggest a strong effect on the temporal variability in the composition of assemblages or abundance of taxa. Nevertheless, the lack of baseline data prevents from a full assessment of the impact and the eventual recovery of the polychaete assemblages. In addition, effects of chronic anthropogenic disturbances occurring along the Galician coast and rias might overlap with those of the *Prestige* oil spill according to the trends in temporal evolution observed at the control location.

(1) Estación de Bioloxía Mariña da Graña,
Universidade de Santiago de Compostela, Casa do Hórreo,
Rúa da Ribeira 1, E-15590, A Graña, Ferrol, Spain.

(2) Departamento de Zooloxía e Antropoloxía Física,
Universidade de Santiago de Compostela, Campus Sur,
E-15782, Santiago de Compostela, Spain.

(3) Instituto de Acuicultura,
Universidade de Santiago de Compostela, Campus Sur,
E-15782, Santiago de Compostela, Spain.

e-mail: alexandre.garcia.regueira@usc.es

INTRODUCTION

Oil spills over recent decades have become a major source of pollution in the seas across the world; those spills have, in general, negative effects on marine life (*e.g.* Jewett *et al*., 1999; Dauvin, 2000). The oil tanker *Prestige* sunk off the Galician coast on November 2002 after releasing to the marine environment more than 10000 tons of fuel (Junoy *et al*., 2005). This spill constituted the worst shipping disaster off Spain (Junoy *et al*., 2005) and the fuel affected both intertidal, subtidal and bathyal habitats along the Galician coast (Junoy *et al*., 2005; Sánchez *et al*., 2006; Serrano *et al*., 2006), also reaching other Spanish, French and Portuguese shores (García-Soto, 2004). The high heterogeneity of the Galician coast, comprising extensive rocky intertidal habitats, sandy beaches and mudflats, made it difficult to evaluate in first instance the scope of the impact of the spill (DelValls, 2003). In addition, the lack of previous studies about the biodiversity of many rocky intertidal areas added up to the aforementioned situation.

Benthic assemblages have traditionally been the subject of monitoring studies to detect changes in the environment because of their life span, response to perturbations and their sedentary or sessile nature (Bellan, 1967; Pearson & Rosenberg, 1978; Warwick, 1988; Gómez-Gesteira & Dauvin, 2005). Oil spills constitute a major source of perturbation for both intertidal and subtidal benthic assemblages (Marshall & Edgar, 2003). Benthic fauna may respond differently to these disturbances; some groups such as peracarid crustaceans are greatly affected by fuel and populations can be severely reduced (Dauvin, 1998).

Among the benthic taxa, polychaetous annelids are one of the most important groups in the coastal environment in terms of diversity, abundance and biomass (Belan, 2003) and are well-represented in the lower levels of the tidal zone in the Galician coast (Villalba & Viéitez, 1985, 1988; Parapar *et al*., 2009). Many polychaete species have high tolerance to pollution by organic matter, hydrocarbons and other compounds (Borja *et al*., 2000; Belan, 2003; Faraco & Lana, 2003); some opportunistic species are favoured by perturbations and their presence and relative abundance might be useful to interpret changes in composition and structure of benthic assemblages (Gray & Pearson, 1982; Olsgard & Gray, 1995).

In this paper, we describe the temporal evolution of the polychaete assemblages at two intertidal locations in the West coast of Galicia after the *Prestige* oil spill. One of these locations was strongly affected by the spill and is compared to another location which was not affected; this was done by examining values of abundance, number of species, diversity and by means of multivariate analyses. In addition, we provide the first data on composition and structure of these assemblages at three different tidal levels to serve as baseline data for forthcoming studies.

MATERIALS AND METHODS

Study area

Two study sites, located in the Galician coast (NW Spain), were selected for this study: Punta de Caldebarcos (CA; 42°50′47′′N, 009°07′52′′W), which was highly affected by the spill, and Punta do Segaño in the Ría de Ferrol (OS; 43°27′17′′N, 008°18′38′′W), which was supposedly not affected by the spill and therefore here used as control station. Both locations are exposed to oceanic swell and have extensive intertidal granitic rocky shores with a tidal range of about 3 m. Several benthic assemblages can be distinguished according to the tidal level and dominant sessile organisms in both stations: supralittoral fringe characterized by the presence of the cirripeds, *Chthamalus stellatus* and *C. montagui*; upper eulittoral fringe defined by the mussel *Mytilus galloprovincialis*; and lower eulittoral fringe by sessile assemblages dominated by several foliose algae, mostly *Mastocarpus stellatus.*

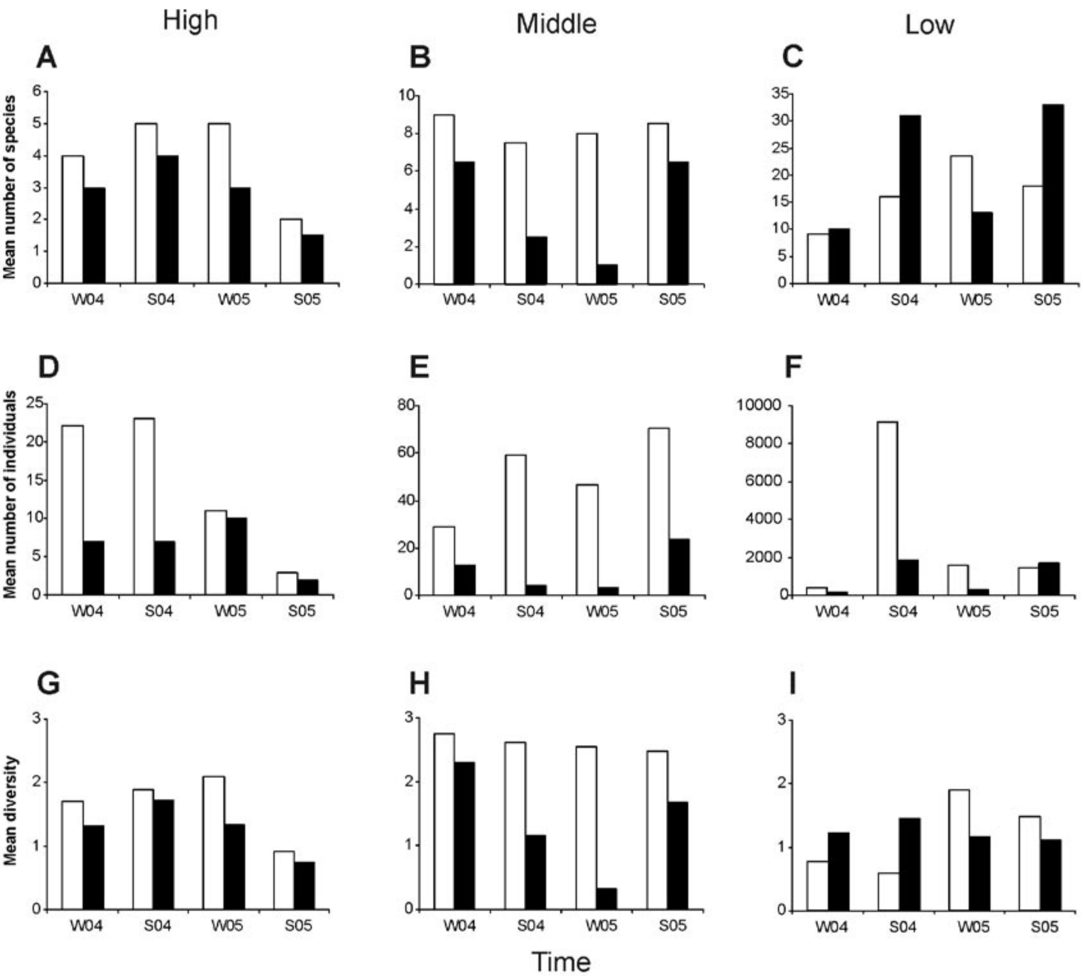

Figure 1:
Temporal variation in mean number of species per sample (A-C), mean number of individuals (D-F) and mean diversity (Shannon-Wiener's index; G-I) at each tidal level (high, middle and low) at O Segaño (control, white bars) and Caldebarcos (affected, black bars).

Sampling

Quantitative sampling was done for two consecutive years (2004 and 2005) twice a year (summer and winter) at three different tidal levels at which polychaetes were present: high, corresponding to upper limit of distribution of *M. galloprovincialis*; middle, where *M. galloprovincialis* had a greater cover on the substratum; low, corresponding to the lower intertidal where algae were the dominant sessile organisms. At each sampling date, two surfaces of 40x40 cm were scraped manually at each tidal level; samples were deposited in plastic bags and fixed in 5% buffered formalin for later sorting and identification of the polychaete fauna.

Data analysis

A matrix of abundance of species was constructed and the following univariate parameters were determined for each sample: total abundance (N), number of species (S) and the Shannon-Wiener's diversity index (H', $\log_2$). Patterns of temporal evolution in the composition of the assemblage were examined by means of multivariate analyses done through the PRIMER 6 software package (Clarke & Gorley, 2006). A similarities matrix between samples was constructed by means of the Bray-Curtis similarity index by first applying square root transformation on species abundance to downweight the contribution of the most abundant species. From the similarities matrix, samples were classified by cluster analysis based on the group-average sorting algorithm. Clusters of samples determined as statistically significant by profile test SIMPROF (alpha<0.05) were considered as having a similar polychaete composition. Non-metric multidimensional scaling (nMDS) was used to provide a visual ordination of the samples. Multivariate analyses were also done based on the similarities matrix calculated after the presence-absence data of species and based on the Sorensen similarity index.

RESULTS

A total of 33,912 polychaetes were found belonging to 104 different taxa, of which 25,640 were collected at OS (54 species) and 8,272 at CA (84 species). Syllidae and Spionidae were the most diverse families in number of species, with 23 and 10, respectively. Spirorbidae with 85.4% of the specimens collected, was by far the most abundant family being followed by Syllidae (1.6%) and Sabellidae (1.2%). Full list of taxa identified to the species/genus level is shown in Appendix I.

High tidal level

Total number of species was smaller in comparison to the other two considered tidal levels (Table 1). Total number of species and mean number of species per sample was greater in OS (13, 4) than in CA (8, 3). The families best represented were Syllidae (5 in OS; 3 in CA) and Nereididae (3, 2). Temporal evolution in number of species was similar at both areas (Figure 1A); numbers were always smaller at CA than at OS. At the control site, maximal numbers were found in summer 2004 and winter 2005, while at CA maximal values were recorded in summer 2004. Minimal values were found in summer 2005 at both areas.

Syllids were the dominant taxa in number of individuals at both areas followed by nereidids at OS and phyllodocids at CA. Total number of individuals was greater at OS (118) than at CA (52); mean number of individuals was, in general, smaller at CA than at OS (Figure 1D). Maximal values were found in 2004 for both sampling sites; number of individuals decreased at OS by the end of the sampling period and increased slightly at CA.

Values of diversity (H') were greater at OS during all the studied period (Figure 1G). At both sites, mean diversity increased from winter 2004 to winter 2005 and then decreased by summer 2005.

Multivariate analyses based on presence-absence and quantitative data did not reveal any significant grouping in the samples (Figures 2A-B, 3A-B). MDS ordinations showed, however, that samples from OS collected in the same year tend to be plotted close to each other.

Middle tidal level

Total number of species was greater at OS than at CA (21 *vs* 17). The polychaete assemblage was at both sites more diverse in number of families and species at this level than at the high level. The most diverse families were Syllidae (8 in OS; 7 in CA) and Nereididae (3, 2). Mean number of species per sample was greater in OS (8) than in CA (4); those numbers were more or less constant at OS while at CA maximal value was recorded in winter 2004 and summer 2005 and the smallest in summer 2005 (Figure 1B).

Total abundance was greater at OS (410 individuals) than at CA (86); the same pattern was

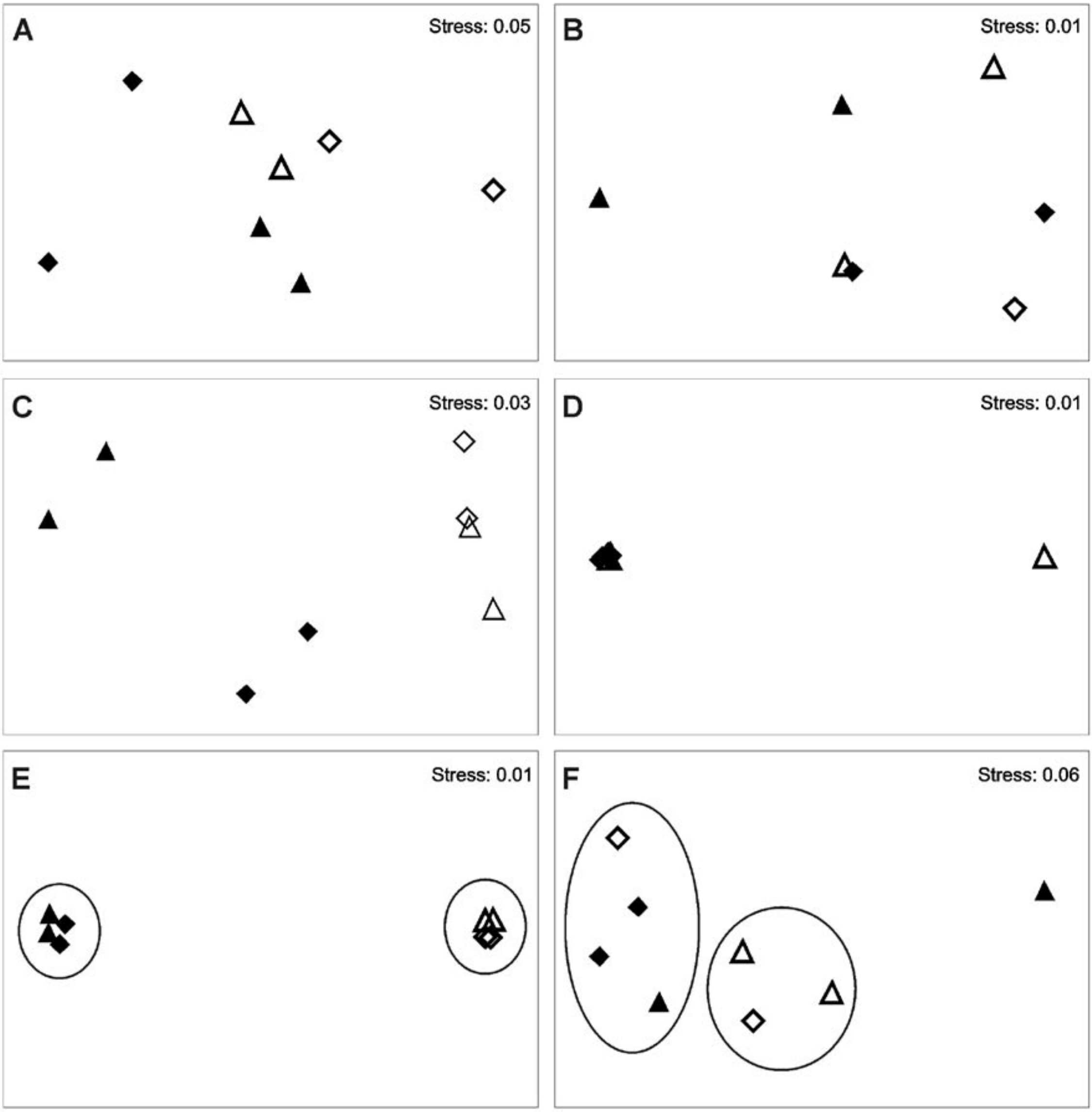

Figure 2:
nMDS ordination of samples based on presence-absence data for each tidal level (high, A-B; middle, C-D; low, E-F) at O Segaño (A, C, E) and Caldebarcos (B, D, F). Groups of samples determined as statiscally significant by the SIMPROF test are also shown.
▲*, winter 2004;* ◆*, summer 2004;* △*, winter 2005;* ◇*, summer 2005.*

observed for the mean number of individuals per sample. Maximal abundance was found at both sites by the end of the sampling period (summer 2005); minimal values were observed in winter (Figure 1E). Syllids and phyllodocids were the numerically dominant taxa at both sampling sites.

Diversity showed at this level the highest values in any given sample in comparison to the other two tidal levels (OS: 2.94; CA: 3.07). Mean diversity was greater at OS than at CA (Figure 1H); values were similar for all the sampling period at OS while at CA showed marked oscillations, with maximal values at winter 2004 followed by a decrease from summer 2004 to winter 2005 and a posterior increase in summer 2005.

SIMPROF analysis did not detected significant groups for samples based on presence-absence data (Figure 2C-D); nevertheless, at OS samples from the same year tend to plot together in the MDS ordination. When considering quantitative data, three different significant groups can be distinguished at OS: samples from winter 2004, those from summer 2004 and a third group composed by all samples from 2005 (Figure 3C-D). No significant groups were detected at CA.

Low tidal level

At this level, the polychaete assemblage was more diverse at CA (81 taxa) than at OS (49); mean number of species per sample was also greater at CA than at OS (22 *vs* 17). Syllids were the most speciose at both sampling sites (OS: 15; CA: 20), followed by Polynoidae (4 and 8, respectively), Spionidae (3, 7) and Phyllodocidae (4, 5). At OS, mean number of taxa increased trough time, showing the maximal value in winter 2005 and then decreasing in summer 2005 (Figure 1C). Values showed a seasonal pattern at CA, with maximal values in both summers and the lowest values in winter.

Total abundance showed the highest values at this tidal level; total number of individuals was greater at OS (25,112) than at CA (8,134). Spirorbids were the dominant taxa at both sites (OS: 88%; CA: 84%), followed by syllids (3% and 7%), sabellids (4% and 2%) and nereidids (3% and 2%). At OS, mean numbers of individuals increased through 2004 and then decreased in 2005 (Figure 1F). On the contrary, at CA there was a seasonal pattern in abundance, with maximal values in summer and a posterior decrease in winter.

Mean values of diversity at OS decreased from summer to winter in both years (Figure 1I). At CA, values of diversity were more or less constant through time; maximal value (1.45) was smaller than that recorded at OS (1.90).

Multivariate analyses based on presence-absence data showed that there were two significant groups of samples at OS: that composed by samples from 2004 and another one comprised of those from 2005 (Figure 2E-F). Samples from CA showed a similar pattern; in this case the group corresponding to 2004 also included a sample from summer 2005. Quantitative analyses determined three significant groups for OS: samples from 2005, samples from summer 2004 and another group composed by samples from winter 2004 (Figure 3E-F). There were no significant groups for samples from CA.

DISCUSSION

The *Prestige* oil spill affected many marine habitats along the Galician coast, from the intertidal areas to bathyal depths (Junoy *et al*., 2005; Serrano *et al*., 2006). Abundance of many species decreased in the impacted areas such as those of some decapods, fishes and birds (Sánchez *et al*., 2006; Martínez-Abraín *et al*., 2006); in some cases, recovery of populations were observed the year after the spill (Sánchez *et al*., 2006). On the other hand, plankton dynamics were not altered in the short term by the spill (Varela *et al*., 2006) and the small differences found could be caused by phenomena of natural variability. Nevertheless, intertidal habitats on hard and soft bottoms were strongly affected and

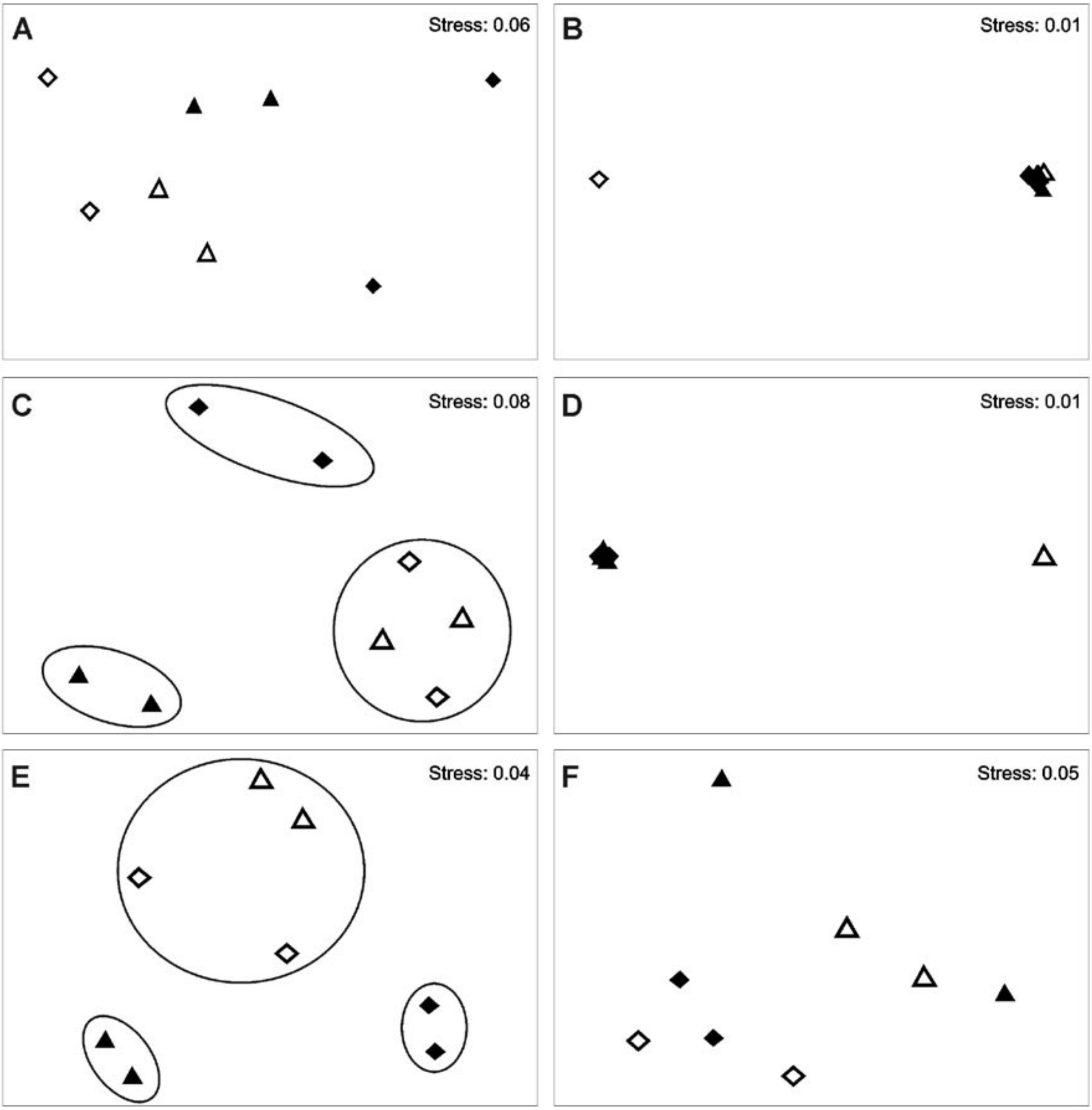

Figure 3:
nMDS ordination of samples based on quantitative data for each tidal level (high, A-B; middle, C-D; low, E-F) at O Segaño (A, C, E) and Caldebarcos (B, D, F). Groups of samples determined as statiscally significant by the SIMPROF test are also shown.
▲, winter 2004; ◆, summer 2004; △, winter 2005; ◇, summer 2005.

Table 1:
Relative abundance (%) and total number of taxa (in brackets) of the polychaete families present at each tidal level adding up all the samples from 2004 and 2005 for each location. OS, O Segaño (control); CA, Caldebarcos (affected); S, total number of species.

	High		Middle		Low	
	OS	CA	OS	CA	OS	CA
Family						
Arenicolidae			0.5 (1)		0.4 (2)	0.2 (2)
Capitellidae						0.2 (1)
Cirratulidae	24.0 (2)		19.8 (1)	1.2 (1)	0.2 (4)	0.4 (6)
Eunicidae						<0.1 (3)
Hesionidae						<0.1 (2)
Lumbrineridae				2.3 (2)	<0.1 (1)	0.6 (3)
Maldanidae					<0.1 (1)	
Nereididae	25.0 (3)	11.5 (2)	8.8 (3)	8.1 (2)	2.8 (3)	2.0 (5)
Opheliidae						0.1 (1)
Orbiniidae						0.1 (3)
Pholoidae					<0.1 (1)	0.4 (1)
Phyllodocidae	2.5 (1)	40.4 (2)	26.6 (2)	48.9 (1)	0.5 (4)	0.3 (5)
Polynoidae	1.7 (1)	5.8 (1)	0.9 (2)	2.3 (1)	0.2 (4)	0.3 (8)
Sabellariidae			0.2 (1)		<0.1 (2)	0.1 (2)
Sabellidae				3.4 (2)	4.0 (3)	2.3 (3)
Serpulidae					<0.1 (2)	0.1 (2)
Sigalionidae						0.1 (3)
Syllidae	46.0 (5)	42.3 (3)	39.0 (8)	31.5 (7)	2.9 (15)	6.9 (20)
Spionidae			0.7 (1)	2.3 (1)	0.4 (3)	1.6 (7)
Spirorbidae			1.0 (1)		88.1 (1)	84.0 (1)
Terebellidae	0.8 (1)		2.5 (1)		0.1 (3)	<0.1 (2)
S (total)	13	8	21	17	49	80

large quantities of fuel reached the Galician shores. In addition, cleaning activities also greatly affected those intertidal habitats (Junoy *et al*., 2005; Rodríguez *et al*., 2007), *i.e.* there was a decrease in populations of some polychaetes and isopods. Studies done on intertidal sediments after the spill pointed out that macrofaunal assemblages also showed differences before-after the spill (de la Huz *et al*., 2005; Junoy *et al*., 2005).

In the case of rocky intertidal habitats, many areas were covered by the fuel after the spill including one of the locations studied here, *i.e.* Caldebarcos. Nevertheless, our results showed that the polychaete assemblage seemed not to be greatly affected by the spill. In fact, total number of species was greater at the affected location than at O Segaño, which did not receive fuel from the spill. At the high tidal level considered here, number of species and diversity were, however, greater at O Segaño than at Caldebarcos but at the end of the period of study mean number of species, abundance and diversity was similar for both locations. In general, the assemblage at both locations was dominated by "errant" families such as syllids, nereidids and phyllodocids (cfr. Table 1). Similarly, studies done on macroalgal assemblages at lowshore along the Galician coast after the spill did not show any significant change in composition of assemblages and abundance of taxa and did not detect proliferation of opportunistic species (Lobón *et al*., 2008). In many cases, the inmediate effects of the spill translate in loss of diversity, decrease in abundance of many taxa and an increase of species which take advantage of the lack of competitors. The overall situation suggests that the impact on the intertidal assemblage at low tidal levels was not so strong as, perhaps, in higher levels where, in addition, aggresive cleaning methods were used in many areas to wash the fuel away; those methods have usually a greater impact on the assemblages than the oil spill (Le Hir & Hily, 2002). Methods using pressurized sea water not only eliminate the fuel but also most of the sessile assemblage, *i.e.*, barnacles, algae and mussels; this might make more difficult for new colonizing organisms to settle there. For example, the presence of barnacles provides refuge at highshore to the periwinkle, *Melaraphe neritoides*, whether the former are alive or dead (Le Hir & Hily, 2002); removal of the barnacle cover prevents the settlement and the survival of the periwinkle, this way delaying the recovery of their populations.

Multivariate analyses did not show, in general, any clear temporal trend between years for samples from Caldebarcos at the three studied tidal levels. At O Segaño, there were, however, differences among samples from 2004 and 2005 mostly at lowshore. This fact might be due to changes induced by the construction of the jetty of the outer harbour at the mouth of the Ría de Ferrol a few years prior to the *Prestige* oil spill. It is likely that the presence of this jetty could have changed the hydrodynamism at the mouth of the ria and therefore this could have translated in changes in composition of assemblages during the last years. In fact, the cover of the substratum at low tidal levels by the alga *Corallina officinalis* decreased from 2004 to 2005 while that of *Mastocarpus stellatus* increased (authors' unpublished data); the former is a typical species from semi-exposed and exposed rocky shores and may be affected by human perturbations (Menconi *et al*., 1999; Le Hir & Hily, 2002) such as those derived from changes in hydrodynamism.

Nevertheless, there was a lack of quantitative data on abundance of benthic species and composition of intertidal assemblages on rocky substrata for many areas of the Galician coast which were impacted by the *Prestige* oil spill, including the two locations studied here. Indeed, baseline data are needed in order to differentiate the variability of the natural systems in normal conditions from that due to the very impact of the spill and to evaluate the eventual recovery of the assemblages and populations (Lobón *et al*., 2008; Veiga *et al*., 2009). In our case, although the overall situation for the affected location suggest a normal situation or, at least, a recovery of the polychaete assemblage, the lack of previous data from the affected areas prevents a full assessment of the possible impact of the *Prestige* oil spill. In addition, it should be taken into account that many areas of the Galician coast are regularly affected by a number of human activities such as sewage disposal, small spills due to ship cleaning, dredging and construction of breakwaters (Alejo & Vilas, 1987; López-Jamar & Mejuto, 1988); these disturbances might induce chronic alterations on the assemblages by increase of pollutants, organic enrichment and alteration of current dynamics and their effects may overlap to those of the oil spills, as it has been pointed out for estuarine areas in Cantabria, N Iberian Peninsula (Puente *et al*., 2009). For instance, the changes observed in the assemblage at O Segaño during the studied period could be related to the construction of the outer harbour. In conclusion, long-term monitoring in areas susceptible to be affected by further oil spills is needed to properly separate their effects from those related to other perturbations.

ACKNOWLEDGEMENTS

The authors want to express their gratitude to all colleagues who collaborated in the field work and the sorting of the samples at the laboratory. Two anonymous referees provided valuable comments which contributed to greatly improve the final version of the manuscript.

REFERENCES

Alejo I, Vilas F (1987). Dinámica litoral y evolución histórica de la Ensenada de Bayona (Pontevedra). Thalassas 5: 21-32.

Belan TA (2003). Marine environmental quality assessment using polychaete taxocene characteristics in Vancouver Harbour. Marine Environmental Research 57: 89-101.

Bellan G (1967). Pollution et peuplements benthiques des substrats meubles de la région de Marseille. Revue Internationale d'Océanographie Médicale 6-7: 53-87.

Borja A, Franco J, Pérez V (2000) A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin 40: 1100-1114.

Clarke KR, Gorley RN (2006). PRIMER V6: user manual/ tutorial. PRIMER-E Ltd, Plymouth, U.K.

Dauvin J-C (1998). The fine sand *Abra alba* community of the Bay of Morlaix twenty years after the Amoco Cadiz oil spill. Marine Pollution Bulletin 36: 669-676.

Dauvin J-C (2000). The muddy fine sand *Abra alba-Melinna palmata* community of the Bay of Morlaix twenty years after the Amoco Cadiz oil spill. Marine Pollution Bulletin 40: 528-536.

de la Huz R, Lastra M, Junoy J, Castellanos C, Viéitez JM (2005). Biological impacts of oil pollution and cleaning in the intertidal zone of exposed sandy beaches: preliminary study of the "*Prestige*" oil spill. Estuarine, Coastal and Shelf Science 65: 19-29.

DelValls A (2003). The oil spill produced by the tanker *Prestige* (13/11/2002): Impact assessment of the northwest coast of the Iberian Peninsula. Ciencias Marinas 29(1): i-iii.

Faraco LFD, Lana PC (2003). Response of polychaetes to oil spills in natural and defaunated subtropical mangrove sediments from Paranaguá bay (SE Brazil). Hydrobiologia 496: 321-328.

García-Soto C (2004). "*Prestige*" oil spill and Navidad flow. Journal of the Marine Biological Association of the United Kingdom 84: 297-300.

Gómez-Gesteira JL, Dauvin J-C (2005). Impact of the *Aegean Sea* oil spill on the subtidal fine sand macrobenthic community of the Ares-Betanzos Ria (Northwest Spain). Marine Environmental Research 60: 289-316.

Gray JS, Pearson TH (1982). Objective selection of sensitive species indicative of pollution induced change in benthic communities 1. Comparative methodology. Marine Ecology Progress Series 9: 111-119.

Jewett SC, Dean TA, Smith RO, Blanchard A (1999). "Exxon Valdez" oil spill: impacts and recovery in the soft-bottom benthic community in and adjacent to eelgrass beds. Marine Ecology Progress Series 185: 59-83.

Junoy J, Castellanos C, Viéitez JM, de la Huz MR, Lastra M (2005). The macroinfauna of the Galician sandy beaches (NW Spain) affected by the *Prestige* oil spill. Marine Pollution Bulletin 50: 526-536.

Le Hir M, Hily C (2002). First observations in a high rocky-shore community after the Erika oil spill (December 1999, Brittany, France). Marine Pollution Bulletin 44: 1243-1252.

Lobón CM, Fernández C, Arrontes J, Rico JM, Acuña JL, Anadón R, Monteoliva JA (2008). Effects of the "*Prestige*" oil spill on macroalgal assemblages: Large-scale comparison. Marine Pollution Bulletin 56: 1192-1200.

López-Jamar E, Mejuto J (1988). Infaunal benthic recolonization after dredging operations in La Coruña Bay, NW Spain. Cahiers de Biologie Marine 29: 37-49.

Marshall PA, Edgar GJ (2003). The effect of the *Jessica* grounding on subtidal invertebrate and plant communities at the Galápagos wreck site. Marine Pollution Bulletin 47: 284-295.

Martínez-Abrain A, Velando A, Oro D, Genovart M, Gerique C, Bartolomé MA, Villuendas E, Sarzo B (2006). Sex-specific mortality of European shags after the *Prestige* oil spill: demographic implications for the recovery of colonies. Marine Ecology Progress Series 318: 271-276.

Menconi M, Benedetti-Cecchi L, Cinelli F (1999). Spatial and temporal variability in the distribution of algae and invertebrates on rocky shores in the northwest Mediterranean. Journal of Experimental Marine Biology and Ecology 233: 1-23.

Olsgard F, Gray JS (1995). A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. Marine Ecology Progress Series 122: 277-306.

Parapar J, Martínez-Ansemil E, Caramelo C, Collado R, Schmelz R (2009). Polychaetes and oligochaetes associated with intertidal rocky shores in a semi-enclosed industrial and urban embayment, with the description of two new species. Helgoland Marine Research. DOI 10.1007/s10152-009-0158-7.

Pearson TH, Rosenberg R (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology: an Annual Review 16: 229-311.

Puente A, Juanes JA, Calderón G, Echavarri-Erasun B, García A, García-Castrillo G (2009). Medium-term assessment of the effects of the *Prestige* oil spill on estuarine benthic communities in Cantabria (Northern Spain, Bay of Biscay). Marine Pollution Bulletin 58: 487-495.

Rodríguez JG, Incera M, de la Huz R, López J, Lastra M (2007). Polycyclic aromatic hydrocarbons (PAHs), organic matter quality and meiofauna in Galician sandy beaches, 6 months after the *Prestige* oil-spill. Marine Pollution Bulletin 54: 1046-1052.

Sánchez F, Velasco F, Cartes JE, Olaso I, Preciado I, Fanelli E, Serrano A, Gutiérrez-Zabala JL (2006). Monitoring the *Prestige* oil spill impacts on some key species of the Northern Iberian shelf. Marine Pollution Bulletin 53: 332-349.

Serrano A, Sánchez F, Preciado I, Parra S, Frutos I (2006). Spatial and temporal changes in benthic communities of the Galician continental shelf after the *Prestige* oil spill. Marine Pollution Bulletin 53: 315-331.

Varela M, Bode A, Lorenzo J, Álvarez-Ossorio MT, Miranda A, Patrocinio T, Anadón R, Viesca L, Rodríguez N, Valdés L, Cabal J, Urrutia A, García-Soto C, Rodríguez M, Álvarez-Salgado XA, Groom S (2006). The effect of the "*Prestige*" oil spill on the plankton of the N–NW Spanish coast. Marine Pollution Bulletin 53: 272-286.

Veiga P, Rubal M, Besteiro C (2009). Shallow sublittoral meiofauna communities and sediment polycyclic aromatic hydrocarbons (PAHs) content on the Galician coast (NW Spain), six months after the *Prestige* oil spill. Marine Pollution Bulletin 58: 581-588.

Villalba A, Viéitez JM (1985). Estudio de la fauna de anélidos poliquetos del substrato rocoso intermareal de una zona contaminada de la Ría de Pontevedra (Galicia). Resultados biocenóticos. Cahiers de Biologie Marine 26: 359-377.

Villalba A, Viéitez JM (1988). Polychaetous annelids from the intertidal rocky substratum of a polluted area of the ría de Pontevedra (Galicia, Spain) 2. Taxonomic aspects with the description of Lugia atlantica, n. sp. Proceedings of the Biological Society of Washington 101: 176-182.

Warwick RM (1988). The level of taxonomic discrimination required to detect pollution effects on marine benthic communities. Marine Pollution Bulletin 19: 259-268.

APPENDIX I

List of polychaete species found at Caldebarcos and/or O Segaño.

Class POLYCHAETA
Order PHYLLODOCIDA
Family Phyllodocidae Örsted, 1843

Eteone picta Quatrefages, 1866
Eteone sp.
Eulalia aurea Gravier, 1896
Eumida sanguinea (Örsted, 1843)
Nereiphylla parietti Blainville, 1828
Phyllodoce laminosa Lamarck, 1818

Family Hesionidae Grube, 1850

Psamathe fusca Johnston, 1836
Syllidia armata Quatrefages, 1866

Family Nereididae Savigny, 1822

Eunereis longissima (Johnston, 1840)
Nereis pelagica Linnaeus, 1758
Perinereis cultrifera (Grube, 1840)
Perinereis oliveirae (Horst, 1889)
Platynereis dumerilii (Audouin & Milne-Edwards, 1833)

Family Syllidae Grube, 1850

Exogone naidina Örsted, 1845
Odontosyllis ctenostoma Claparède 1868
Salvatoria clavata (Claparède, 1863)
Sphaerosyllis histrix Claparède 1863
Sphaerosyllis pirifera Claparède 1868
Syllides edentatus Westheide, 1974
Syllis alternata Moore 1908
Syllis amica Quatrefages, 1865
Syllis armillaris (O.F. Müller, 1771)
Syllis columbretensis (Campoy, 1982)
Syllis corallicola Verrill, 1900
Syllis gerlachi (Hartmann-Schröder, 1960)
Syllis gracilis Grube, 1840
Syllis kabilica Ben-Eliahu, 1977
Syllis krohni Ehlers, 1864
Syllis pectinans Haswell, 1920
Syllis prolifera Krohn, 1852
Syllis variegata Grube, 1860
Syllis vivipara Krohn, 1869

Family Polynoidae Malmgren, 1867

Harmothoe areolata (Grube, 1860)
Harmothoe cf. *antilopes* McIntosh, 1876
Harmothoe sp.
Lepidonotus clava (Montagu, 1808)
Malmgreniella sp.

Family Pholoidae Kinberg, 1858

Pholoe synophtalmica Claparède 1868

Family Sigalionidae Malmgren, 1857

Sthenelais boa (Johnston, 1839)

Order EUNICIDA

Family Eunicidae Savigny, 1818

Eunice harassii Audouin & Milne-Edwards, 1834
Lysidice ninetta Audouin & Milne-Edwards, 1833

Family Lumbrineridae Schmarda, 1861

Lumbrinereis coccinea (Renier, 1804)
Lumbrineris gracilis (Ehlers, 1868)
Scoletoma funchalensis (Kinberg, 1865)
Scoletoma impatiens (Claparède, 1868)

Order ORBINIDA

Family Orbiniidae Hartman, 1942

Phylo norvegicus (M. Sars in G.O. Sars, 1872)
Protoaricia oerstedii (Claparède, 1864)

Order SPIONIDA

Family Spionidae Grube, 1850

Aonides oxycephala (Sars, 1862)
Dipolydora giardi (Mesnil, 1896)
Malacoceros girardi (Quatrefages, 1843)
Polydora caeca (Örsted, 1879)
Polydora hoplura Claparède, 1869
Scolelepis tridentata (Southern, 1914)

Order CIRRATULIDA

Family Cirratulidae Ryckholdt, 1851

Aphelochaeta marioni (de Saint Joseph, 1894)
Caulleriella bioculata (Keferstein, 1862)
Cirratulus cirratus (O.F. Müller, 1776)
Cirriformia tentaculata (Montagu, 1808)
Dodecaceria concharum Örsted, 1843

Order OPHELIIDA

Family Opheliidae Malmgren, 1867

Polyophthalmus pictus (Dujardin, 1839)

Order CAPITELLIDA

Family Capitellidae Grube, 1862

Capitella capitata (Fabricius, 1780)

Family Arenicolidae Johnston, 1835

Arenicolides ecaudata (Johnston, 1835)
Branchiomaldane vincenti Langerhans, 1881

Order TEREBELLIDA

Family Sabellariidae Johnston, 1865

Sabellaria alveolata (Linnaeus, 1767)
Sabellaria spinulosa Leuckart, 1849

Family Terebellidae Malmgren, 1867

Amphitritides gracilis (Grube, 1860)
Nicolea venustula (Montagu, 1818)
Terebella lapidaria Linnaeus, 1767

Order SABELLIDA

Family Sabellidae Malmgren, 1866

Amphiglena mediterranea (Leydig, 1851)
Branchiomma lucullana (Delle Chiaje, 1828)
Fabricia sabella (Ehrenberg, 1836)

Family Serpulidae Johnston,1865

Pomatoceros lamarcki (Quatrefages, 1865)
Pomatoceros triqueter (Linnaeus, 1767)

Family Spirorbidae Pillai, 1970

Spirorbis sp.