BOTTLENOSE DOLPHINS *(TURSIOPS TRUNCATUS)* IN SLOVENIAN AND ADJACENT WATERS (NORTHERN ADRIATIC SEA)

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ABSTRACT

A local population of bottlenose dolphins (Tursiops truncatus*) in Slovenian and adjacent waters (northern Adriatic Sea) was studied between 2002 and 2008. Boat-based surveys, land-based surveys and standard photo-identification procedures were carried out. A total of 120 sightings were recorded and 101 well-marked dolphins photo-identified. Resighting rates within and between years showed a relatively high rate of site fidelity for some individuals. The group size ranged from 1 to 43. Offspring were present in 53.3% of the groups. Annual mark-recapture density esti-mates of 0.069 dolphins/km^2 seem to be good baseline information for conservation management.*

Key words: bottlenose dolphin, *Tursiops truncatus*, ecology, photo-identification, Slovenia, northern Adriatic

TURSIOPI *(TURSIOPS TRUNCATUS)* IN ACQUE SLOVENE E ADIACENTI (ADRIATICO SETTENTRIONALE)

SINTESI

Una popolazione locale di tursiopi (Tursiops truncatus) *in acque slovene e adiacenti (Adriatico settentrionale) è stata studiata nel periodo dal 2002 al 2008. La ricerca è stata condotta tramite avvistamenti da imbarcazioni e da stazioni d'osservazione da terra, nonché con le procedure standard di foto-identificazione. In totale sono stati effet-tuati 120 avvistamenti ed identificati 101 individui. Il tasso di riavvistamento dei singoli delfini nell'arco dell'anno e fra anni diversi indica un alto grado di frequenza di determinati individui nell'area. La grandezza dei gruppi variava da 1 a 43 individui. I cuccioli erano presenti nel 53,3% dei gruppi. La valutazione annuale della densità è pari a 0,069 tursiopi / km^2, il che rappresenta un'informazione di base importante nella tutela e gestione dei tursiopi.*

Parole chiave: tursiopi, *Tursiops truncatus*, ecologia, foto-identificazione, Slovenia, Adriatico settentrionale

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INTRODUCTION

The bottlenose dolphin *(Tursiops truncatus*, Montagu, 1821) is one of the best studied cetacean species in the world (Shane *et al.*, 1986; Leatherwood & Reeves, 1990; Connor *et al.*, 2000; Bearzi *et al.*, 2008b) and one of the most common and widespread cetacean species in the Mediterranean Sea (Notarbartolo di Sciara *et al.*, 1993; Reeves & Notarbartolo di Sciara, 2006; Bearzi *et al.*, 2008b). Today, the Mediterranean subpopulation is proposed for being listed as "Vulnerable" under IUCN (World Conservation Union) criterion A2d, c, e and its present distribution is considered to be fragmented into units with relatively low densities (Reeves & Notarbartolo di Sciara, 2006).

No consistent and systematic research on this species had been carried out in Slovenian waters and adjacent waters of Italy and Croatia (Gulf of Trieste and western Istria, northern Adriatic Sea) prior to this study. The only long-term study of free ranging bottlenose dolphins in the Adriatic prior to this study started in 1987 and is being carried out in Kvarnerić, Croatia (Bearzi *et al.*, 1997, 1999; Mackelworth *et al.*, 2003; Fortuna, 2006; Rako, 2006).

The bottlenose dolphin is the only cetacean species regularly observed in the northern Adriatic Sea in the last 20 years (Kryštufek & Lipej, 1993; Notarbartolo di Sciara *et al.*, 1993; Bearzi & Notarbartolo di Sciara, 1995; Bearzi *et al.*, 2004).

By studying bottlenose dolphin populations in different areas we can gain insight into their habitat use and the way in which varying environmental factors shape their behaviour and population dynamics (Wilson, 1995). By understanding these processes, we can try to make predictions or generalisations about the ecology of the marine ecosystem as a whole and attempt to evaluate the effects that natural and human-induced changes in the environment might have on the status of the ecosystem and species (Wilson, 1995).

The area where this study was carried out is the northernmost part of both the Adriatic Sea and the Mediterranean Sea as a whole. It is a semi-enclosed and shallow area, shared among three countries (Croatia, Italy and Slovenia). Human activities, such as urbanisation, maritime transport, fishery, mariculture and tourism, are very intense. For these reasons, the area is of particular interest for studying bottlenose dolphins in relation to natural and anthropogenic variations in the ecosystem.

The mainly coastal nature of bottlenose dolphins exposes them to a wide variety of human activities and potential threats. Careful evaluation and consistent monitoring of the status of this species and the extent of human impacts are therefore essential. This is emphasised by national legislation *(e.g.* the Nature Conservation Act), international conventions *(e.g.* the Convention on Migratory Species), European directions and regulations *(e.g.* the Habitats Directive and Council Regulation (EC) No. 812/2004) and regional conservation agreements, such as the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), ratified by Croatia, Italy and Slovenia.

This paper presents some preliminary results of a long-term study having been carried out since 2002 to investigate the ecology of bottlenose dolphins inhabiting Slovenian waters and adjacent areas of Croatia and Italy. Part of the data from this research was already presented in various sources (Genov *et al.*, 2004; Genov & Fortuna, 2005; Genov & Wiemann, 2005; Genov & Furlan, 2006). This work is the first attempt to provide data on bottlenose dolphin ecology in this area and baseline information for future studies and effective conservation of this species in the region.

MATERIAL AND METHODS

Study area

The whole study area covers roughly 1,200 km^2, including Slovenian territorial waters, as well as portions of adjacent Italian and Croatian territorial waters of the Gulf of Trieste and the waters off north-western Istria (Fig. 1). The real size of the study area varied between years, due to budgetary and logistic reasons, increasing from about 260 km^2 up to 1,600 km^2.

This area is mostly characterised by muddy and sandy bottoms, with occasional hard rock bottoms and seagrass meadows of *Posidonia oceanica* and *Cymodocea nodosa* (Lipej *et al.*, 2000). The average depth is 20 m, while the maximum depth is 38 m. The area is inhabited by high biomass benthic communities and characterised by high variations of salinity (32–39 PSU) and water temperature (6–26°C), high riverine output, strong stratification, occasional oxygen depletion and occasional mucous aggregate phenomena (Lipej *et al.*, 2000).

Due to its natural characteristics and the degree of anthropogenic pressure, the area can be considered very sensitive. The Gulf of Trieste, in particular, is subject to substantial chemical, industrial and sewage pollution and is considered one of the most heavily polluted areas in the Mediterranean (Horvat *et al.*, 1999). All the necessary scientific permits for studying dolphins in all parts of the area have been acquired by competent authorities.
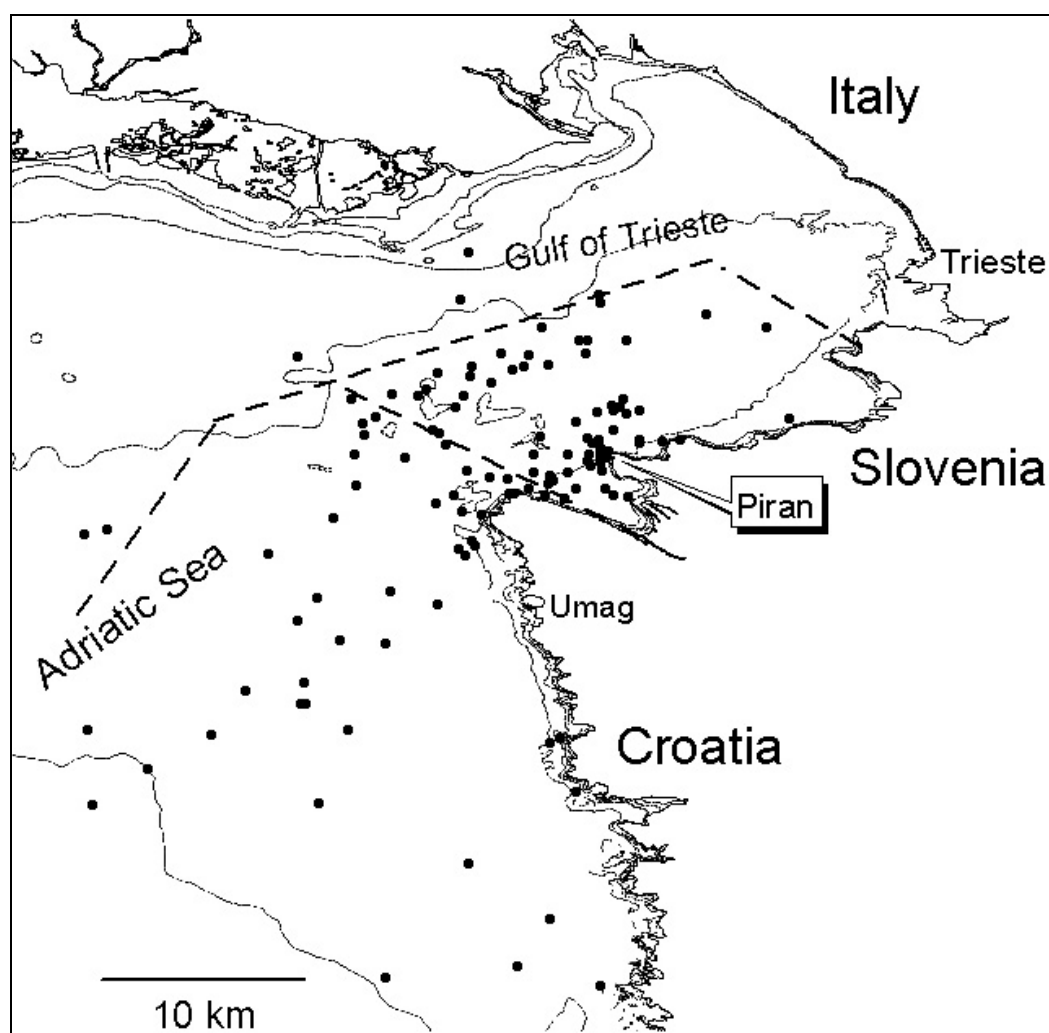
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Fig. 1: *Locations of dolphin sightings.* The dashed lines represent national borders.
Sl. 1: Lokacije opažanj delfinov. Črtkana linija ponazarja državne meje.

Field procedures

Boat-based and land-based surveys were carried out between July 2002 and September 2008. Two teams often operated simultaneously, one from land and the other from a boat. An attempt was made to keep the search effort of both teams independent. Although surveys were conducted in all seasons, they were mostly concentrated during summer months (July-September), given better general weather conditions and logistic reasons (Tab. 1). Boat-based surveys were carried out using various types of small vessels, mainly rigid inflatable boats with outboard engines. A relatively constant search speed of 25–30 km/h was maintained. An attempt was made to cover all parts of the study area in a given period. However, this was not always possible, given that the effort could vary due to weather conditions, logistic reasons, dolphin sighting frequency and sighting locations, which could have attracted our attention. Land-based surveys were undertaken from 10–50 m high observation points (mostly cliffs), using binoculars. The first two years of the study (2002–2003) were different from the remaining years both in type (mostly land-based observations were carried out) and the amount of survey effort. From 2004 to 2008, the survey effort was more systematic and involved a greater amount of boat-based effort.

The position of the boat and dolphin groups was determined using a GPS (Global Positioning System) in most cases. At times, when this was not possible due to sightings from land or unavailability of GPS, the position was determined with a compass or using local land marks. The analysis of dolphin distribution was based on the positions obtained at the beginning of each sighting, to avoid the possibility that positions at the end of the

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sighting may have been biased by the presence of the research boat. Sightings data were analysed with GIS software ArcView 3.2 and GPS software MapSource 6.13.7.

"Sighting" was defined as an uninterrupted continuous observation of a dolphin focal group. A dolphin focal group was considered any number of dolphins in visual range of the researchers, observed in apparent association, moving in the same direction or staying in the same area and often, but not always, engaged in the same activity. Sightings were subdivided into "sets" (Notarbartolo di Sciara, 1994; Bearzi *et al.*, 1997), in order to account for any change in group size or composition during each sighting. Each set was determined by a change in group size and composition. The mean and median group size and the proportion of groups with offspring were calculated accordingly.
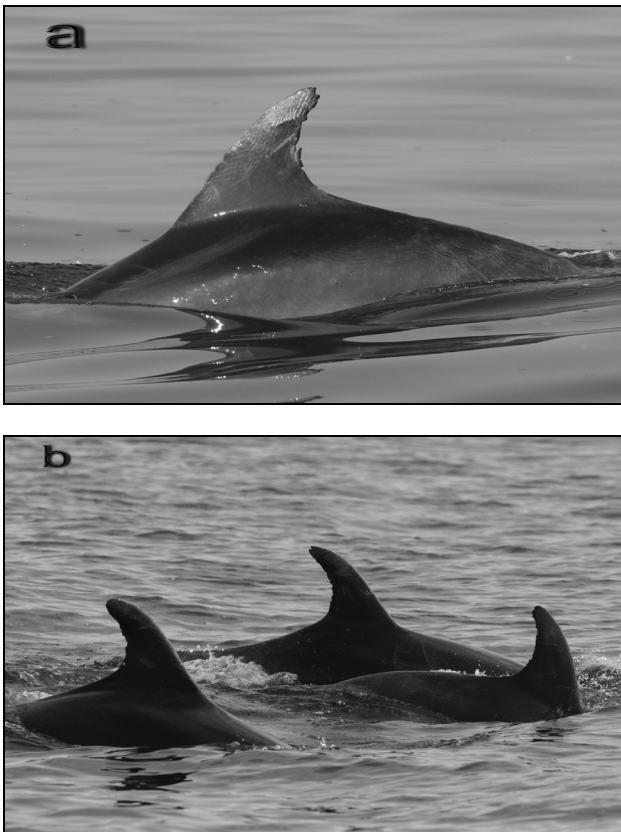

Fig. 2: Natural marks used for photo-identification. a) Individual Fok, with visible nicks, notches and tooth rakes. b) Individuals Kai, Pao and Lov, showing individual mark differences. (Photo: T. Genov)
Sl. 2: Naravne oznake za foto-identifikacijo. a) Osebek Fok, z vidnimi zarezami, brazgotinami ter sledmi zob. b) Osebki Kai, Pao in Lov kažejo individualne razlike v oznakah. (Foto: T. Genov)

Survey conditions were considered good if a) the sea state of Beaufort scale was 2 or less; b) at least one experienced observer searched for dolphins (usually 2–5 other observers could participate in the search); c) visibility was not reduced by heavy fog or precipitation. If survey conditions did not match these criteria, no systematic search for dolphins was carried out.

During each survey, navigation and environmental data (time, position, sea state, etc.) were collected every 15 minutes or whenever the direction or conditions of the search changed.

When a dolphin group (or an individual) was found at sea, focal group/individual follow protocol was applied (Mann, 1999, 2000). The group was slowly approached and followed in a way that was believed to cause minimal disturbance to the animals (Wilson, 1995). If a dolphin group was spotted from land, it was either observed from there or subsequently approached with a boat. Dolphins were followed for variable periods of time, usually between 30 minutes and 2 hours, to allow photo-identification of all individuals in the group. Although the time spent following dolphins could vary due to group size and behaviour, an attempt was made to keep it at a minimum to reduce possible disturbance. Standard photo-identification procedures (Würsig & Jefferson, 1990) were carried out during most sightings. Natural marks on dorsal fins, such as nicks, notches, scars, tooth rakes and fin shape were used to identify individual animals (Figs. 2, 3). An attempt was made to photograph both sides of dorsal fins of all members of a dolphin group. Photographs were taken using a SLR camera Nikon F80D equipped with zoom lens Sigma 70–300 mm and ISO 100 or 200 colour transparency films and a digital SLR camera Canon 30D equipped with zoom lens Canon L USM 70–200 mm. More than 10.000 photographs were taken, analysed, labelled and sorted into photo-identification catalogues. New photographs were visually examined and compared to those taken during previous sightings. Two catalogues were compiled: one containing all photographs in chronological order and one containing only the best photographs of each identified individual. To avoid potential bias in the analyses of site fidelity and dolphin abundance, only well-marked animals recognizable from fair and high quality photographs were considered identified. All identified animals were given names as a reference. Poorly-marked or unmarked animals were not considered identified for these analyses. Furthermore, well-marked individuals for which only poor quality photographs were acquired were not considered identified either. These poorly-marked dolphins and those from poor quality photographs were, however, used for group size analysis and kept in the photographic record for possible future re-identifications. Based on capture histories of well-marked animals, we applied mark-recapture models (Otis *et al.*, 1978) for closed popula-

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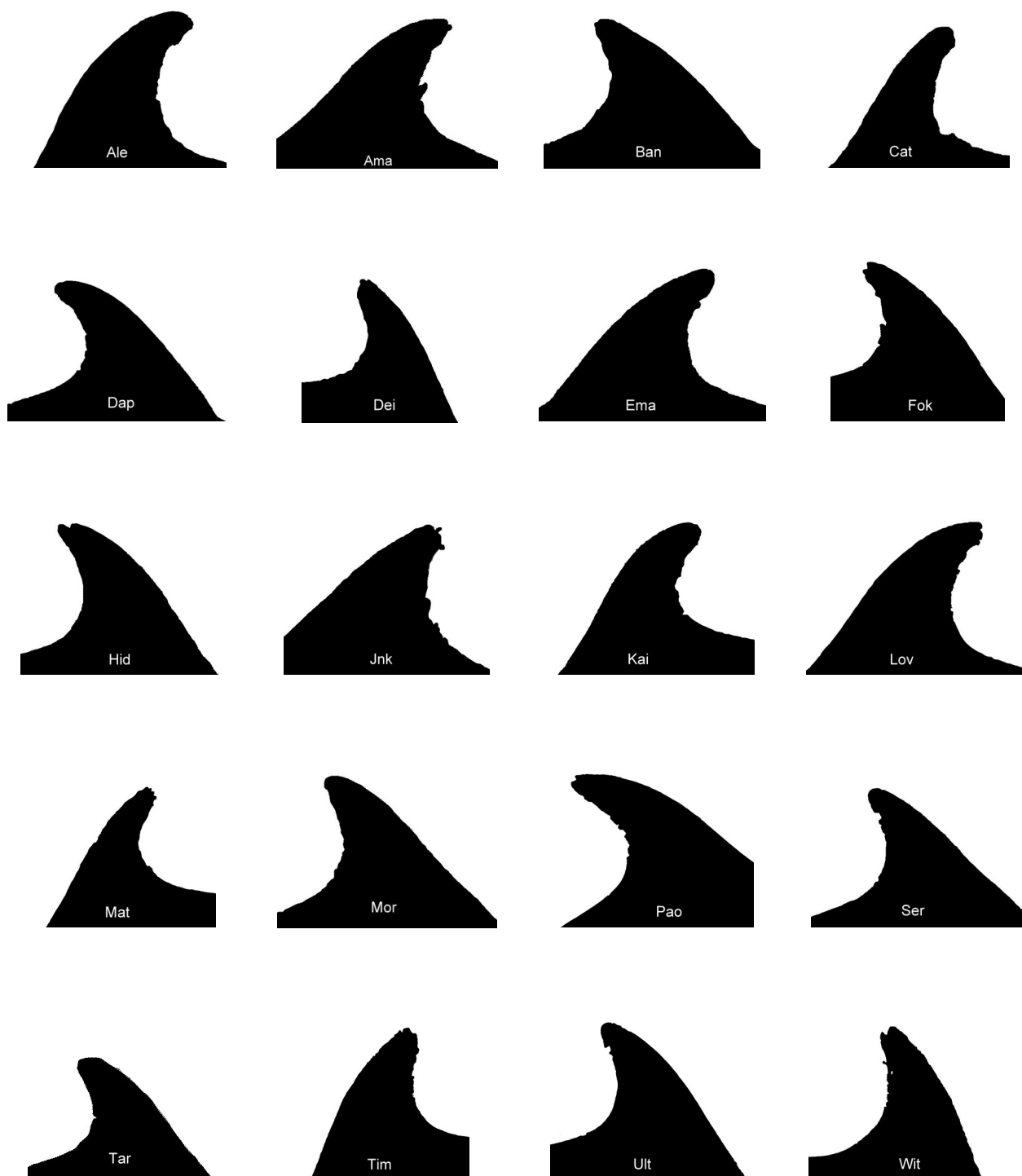
Fig. 3: Dorsal fins of 20 photo-identified bottlenose dolphins. These dolphins represent some of the first identified animals in the study area, as well as some of the most well-marked and most resident individuals.
Sl. 3: Hrbtne plavuti 20 foto-identificiranih velikih pliskavk. Ti delfini predstavljajo nekatere izmed prvih identificiranih živali na območju raziskave in tudi nekatere izmed najbolj prepoznavnih in stalnih osebkov na tem območju.

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tions to estimate the annual abundance of well-marked dolphins frequenting our study area, using the CAPTURE program, run from MARK 4.3 program (http://www. phi-dot.org/software/mark/). In order to build individual capture histories, photo-identification data from sightings were pooled into two different "capture occasion" bouts: one lasting 15 days and the other one month. These two time frames were considered a fair compromise between maintaining a reasonable number of capture occasions per year and the need to allow the necessary remixing of "marked" animals with the rest of the animals using the area. The most appropriate among different annual models was selected using the chi-square test of explained deviance implemented in MARK. Annual estimates of the total number of animals, including offspring, were then calculated by taking into account the estimates of marked animals and the annual proportion of unmarked animals (Wilson *et al.*, 1999). Confidence limits were calculated after Fortuna (2006).

Information on sighting position, time, group size, presence of offspring, behaviour, respiration patterns and interactions with fisheries or maritime traffic was recorded during each sighting. *Ad libitum* behavioural observations (Altmann, 1974; Mann, 1999, 2000) were made throughout the sighting, in order to get an insight into the behaviour of the local population. From 2006 onwards, in addition to *ad libitum* behavioural sampling, a single behavioural sample was taken at the beginning of each sighting, before approaching the focal group (Chilvers *et al.*, 2003). The sample represented the behaviour of ≥50% of the individuals in each group. Groups were scanned to determine behavioural state. This procedure was applied in order to ensure independence of data and avoid pseudoreplication (Chilvers *et al.*, 2003). Behavioural states (travel, dive, dive/travel, active trawler follow, passive trawler follow, socializing, social travel, surface feeding, milling and mixed behaviour) were defined according to objective parameters, following Bearzi *et al.* (1999) and Lusseau (2006).

Group size was assessed in the field and later confirmed through photo-identification. Only sightings where group size could be accurately determined and/or confirmed through photo-identification were used for the analysis of group size.

Offspring were identified according to size, colouration, overall appearance, behaviour and association with adults (for description see Bearzi *et al.*, 1997). Three age classes were used: "adult", "calf" (an offspring more than 1 year old) and "newborn" (an offspring in the first year of its life). Alloparental association ("babysitting") in which offspring associate with individuals other than

their mother (Whitehead, 1996; Mann & Smuts, 1998; Simard & Gowans, 2004), was also recorded.

Gender could opportunistically be determined from photographs of the genital area during aerial behaviour or bowriding (Smolker *et al.*, 1992) or through the identification of mother-offspring pair. Adults consistently and closely accompanied by an offspring were assumed to be females.

Operating trawlers were often opportunistically approached and inspected for possible dolphin presence. All the data such as date and time, position, effort, research platform, number of observers, sea state, dolphin group size, behaviour, presence of offspring, visibility, etc. were recorded onto specifically designed research forms.

Reports of dolphin sightings by fishermen, divers, tourists, local people and other members of the public were collected as an additional source of information. However, such reports were not treated as scientific data and were not included in the analyses, nor merged with the data collected with procedures outlined above, as taking such data into account could lead to significant bias (Zanardelli *et al.*, 1992). If a report of a dolphin sighting resulted in a documented sighting by the research team, however, data from the documented sighting was considered in certain analyses, such as distribution of sighting locations, individual resighting frequencies, group size, presence of offspring, behaviour, interactions with fishery, etc.

RESULTS

Distribution, abundance, site fidelity and ranging patterns

Throughout the study period, 258 systematic boat trips, typically lasting 3–6 hours, and 419 systematic land observation sessions, typically lasting 30 minutes to 2 hours, were carried out (Tab. 1). July, August and September were the only months with consistent survey effort. The time spent to find the dolphins ranged from a few minutes to several consecutive days of search. A total of 120 sightings of bottlenose dolphins were recorded (Tab. 1, Fig. 1). Of these, 68 were recorded as a result of boat-based survey effort and 38 as a result of land-based survey effort. The remaining sightings were either a result of opportunistic sightings or successful responses to sighting reports by local people and fishermen. No other cetacean species were encountered during the study.

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Tab. 1: Systematic survey effort.
Tab. 1: Sistematično pregledovanje območja.

Year	Month	No. boat surveys	No. land-observation sessions	No. sightings
2002	Jul-Sep	9	0	1
	Oct-Dec	0	0	0
	Year total	**9**	**0**	**1**
2003	Jan-Mar	3	6	8
	Apr-Jun	5	4	5
	Jul-Sep	0	49	8
	Oct-Dec	0	4	0
	Year total	**8**	**63**	**21**
2004	Jan-Mar	0	11	1
	Apr-Jun	1	12	3
	Jul-Sep	20	54	5
	Oct-Dec	2	5	1
	Year total	**23**	**82**	**10**
2005	Jan-Mar	4	2	3
	Apr-Jun	3	12	1
	Jul-Sep	44	54	16
	Oct-Dec	3	0	0
	Year total	**54**	**68**	**20**
2006	Jan-Mar	5	2	1
	Apr-Jun	0	10	0
	Jul-Sep	58	55	26
	Oct-Dec	0	1	0
	Year total	**63**	**68**	**27**
2007	Jan-Mar	0	3	0
	Apr-Jun	5	7	1
	Jul-Sep	41	61	15
	Oct-Dec	0	0	0
	Year total	**46**	**71**	**16**
2008	Jan-Mar	0	0	0
	Apr-Jun	1	0	1
	Jul-Sep	54	67	24
	Year total	**55**	**67**	**25**
TOTAL		**258**	**419**	**120**

Dolphins were seen in the study area in every month of the year except November and December, but survey effort in these two months was very low. The maximum linear distance between two sighting locations of an identified individual was 39 km. Several individuals displayed similar maximum distances between their sighting locations, both within and between years.

A total of 101 well-marked individual dolphins were photo-identified (Figs. 2, 3). Photo-identification data showed that 75% of all dolphins encountered in fully photographed groups were well-marked and could be identified in the long-term. The rate at which new dolphins were identified throughout the study period is shown in figure 4.

The frequency with which identified dolphins were seen in the study area varied greatly (Tab. 2, Fig. 5). Some were seen very often. For example, one adult animal was encountered on 36 occasions (30% of all sightings). Others were observed occasionally and almost half (48%) were seen only once (Fig. 5). Mean frequency of resightings was 5.0 (SD = 7.92, n = 101, mode = 1, median = 2). The maximum number of times any individual was seen within any given month was 9. A maximum of 27 different individuals were identified in any one month and a maximum of 51 different individuals were identified in any one year. Although there were great differences in the degree of residency among different individuals, some animals displayed a high rate of

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Tab. 2: Residency pattern of 35 selected identified individuals. Black cells represent presence of individuals documented through photo-identification. "Days" represent the total number of days in which photo-identification was carried out in a given month.

Tab. 2: Vzorec rezidentnosti 35 izbranih identificiranih osebkov. Črna polja ponazarjajo pojavljanje osebkov v preučevanem območju, "days" (dnevi) pa skupno število dni, v katerih je potekala foto-identifikacija v določenem mesecu.

ID	Sex	2003				2004			2005					2006			2007				2008			
		Feb	Mar	May	Jun	Apr	Jul	Aug	Feb	May	Jul	Aug	Sep	Jul	Aug	Sep	May	Jul	Aug	Sep	Jun	Jul	Aug	Sep
Days		2	1	1	1	2	3	2	3	1	9	3	1	9	6	7	1	3	4	1	1	11	4	6
Aar												■		■			■					■		■
Ale			■			■									■							■		■
Ama	m						■	■		■	■			■	■				■			■	■	■
Ban							■	■			■			■				■	■					■
Cat	f		■																					■
DaH															■			■		■				
Dan													■				■			■				
Dap	f						■	■		■	■	■		■	■							■	■	
Dei			■				■				■			■	■			■				■	■	
Dor					■				■										■		■			■
Ema							■	■			■			■	■	■						■	■	■
Fok			■				■				■						■	■				■	■	
Gal										■														
Gro										■					■									
Hid		■																				■	■	
Hru																					■	■		
Jan						■										■								
Jnk	m						■	■		■	■			■				■	■			■	■	
Kai							■							■				■				■		
Lin						■								■										
Lov														■					■				■	
Mat			■				■	■											■			■	■	
Mor							■				■	■		■	■		■							
Nep					■				■		■			■	■				■					
Pao						■						■		■					■				■	
Ser								■			■								■			■	■	
Sne	f									■				■									■	
Tar	f						■								■	■							■	
Tim											■								■			■	■	
Ult														■										
Ves	f						■			■	■				■							■		
Vio	f		■			■								■										
VSR									■					■				■	■					
Wes										■														
Wit			■			■			■					■				■			■		■	

site fidelity and appeared to use the area often and on a yearly basis (Tab. 2). Four individuals were seen in every year from 2003 to 2008, while 8 others were seen in 5 different years (Tab. 2, Fig. 6).

Based on their sighting frequency, individual dolphins could be divided into four arbitrary categories: "common" (20 or more sightings), "frequent" (11–19 sightings), "occasional" (4–10 sightings) and "rare" (fewer than 4 sightings). Individual dolphins could therefore also be divided into three arbitrary categories based on years of resightings: "common" (seen in 5 different years or more), "occasional" (seen in 3 or 4 years) and "rare"

(seen in 2 years or less). The frequency distribution of the number of years in which each individual was seen is shown in figure 6.

In mark-recapture analyses, no significant differences were found between models run on the two different annual datasets: the 15 days *vs.* one month sampling bout. Results from mark-recapture analyses, based on 15 days datasets, are summarised in Table 3. Estimates from 2003 are not presented, given their extremely high coefficient of variation (>0.92). No statistical inter-annual differences were found among estimates (p>0.05), except for year 2004, which was different to the remaining years.

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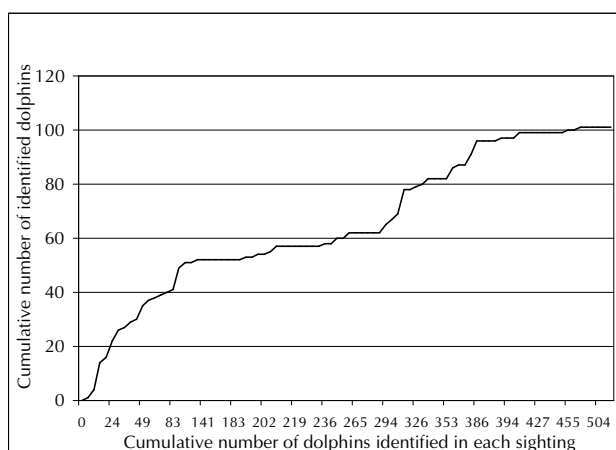
Fig. 4: Discovery curve showing the number of identified dolphins against the cumulative number of identifiable dolphins encountered during the study.
Sl. 4: Krivulja odkrivanja novih delfinov, ki kaže število identificiranih delfinov v primerjavi s kumulativnim številom prepoznavnih delfinov, opaženih v času raziskave.

Social structure, behaviour and interactions with fishery

The size of dolphins groups ranged from 1 to 43 (Fig. 7). The mean group size calculated from sets was 8 (SD = 7.35, n = 90, mode = 1, median = 5). Most groups (88.9%) included 15 individuals or less, with a mode of 1 (Fig. 7). Single individuals were represented in 13.3% of the sample, but they did not always seem to represent solitary animals. One adult, for example, was observed following a bottom trawler alone, only to be joined later by 5 other dolphins. Another resident dolphin sighted on two consecutive days in groups of 11 and 13 dolphins, was seen alone the very next day and then sighted in a group of 19 individuals a few days later. On the other hand, one identified adult was only observed once in 2004 and once in 2006. No other dolphins were observed on those days.

Although changes in group size and composition between sightings occurred regularly, with individuals leaving and joining groups, some identified individuals seemed to form relatively stable groups over the study period.

Changes of group size and composition within sightings (a change of set) were observed on only 5 occasions.

Out of 101 photo-identified dolphins, 18 were classified as females, 2 as males and 81 as unknown sex. The most commonly observed groups of identified individuals contained both sexes.
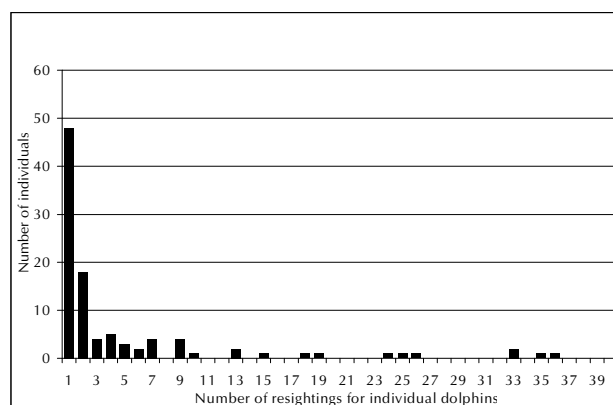
Fig. 5: Frequency distribution of the number of times each individual was seen.
Sl. 5: Frekvenčna porazdelitev števila opažanj posameznih osebkov.

More than 50 different mother-offspring pairs were observed during the study. Offspring were present in 53.3% of the 105 dolphin groups in which presence or absence of the offspring could be determined. Between 0 and 4 newborns were observed each year: 2 in 2003, 1 in 2004, 1 in 2005, 4 in 2006, 1 in 2007 and 0 in 2008. The year 2002 is excluded due to a small number of sightings. Alloparental associations between offspring and non-mothers were observed on several occasions. Two apparent cases of offspring mortality were observed. Two photo-identified females, which were accompanied by offspring in one year, were seen without one in the next year. Given the size, overall appearance and the estimated age of the offspring (one was a newborn), it is highly unlikely that the offspring had already been weaned. One of the two females was observed with a newborn two years after being sighted without the first calf for the first time.

Some offspring, however, appeared to have survived their first few years. One photo-identified female that was first seen with a newborn in 2004, was still accompanied by a calf in 2006 and 2008. Due to the size and overall appearance of the observed calf, it is believed to be the same individual born in 2004.

Dolphins were observed in all main behavioural states: travel, dive, dive/travel, trawler follow, socializing, social travel, surface feeding and milling.

The behavioural sampling resulted in 61 cases in which behaviour was determined at the beginning of each sighting. Behavioural budget based on this sample is shown in Table 4. Most common behavioural state was "dive-travel" (34.4%), followed by the "active trawler follow" (21.3%) and "travel" (18.1%). Although surface feeding was never recorded at the beginning of the sighting and is therefore not represented in the sample, it was observed during focal group follows in at least 17% of all sightings.

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Tab. 3: Summary of mark-recapture analyses.
Legend: N_{hat} = Annual estimate for Well-Marked (WM) animals only; SE = Standard Error; N_{TOT} = Annual estimate for marked and unmarked animals; D_{TOT} = Annual density for marked and unmarked animals (number of animals / size of the study area in km^2); CV = Coefficient of Variation; 95% CI = Log-normal confidence intervals.
Tab. 3: Povzetek analiz z metodo "lova in ponovnega ulova".
Legenda: N_{hat} =letna ocena števila označenih živali (WM) živali; SE = standardna napaka; N_{TOT} = letna ocena števila označenih in neoznačenih živali; D_{TOT} = letna gostota označenih in neoznačenih živali (število živali / velikost raziskovalnega območja v km^2); CV = koeficient variacije; 95% CI = Log-normalni interval zaupanja.

Dataset	Study area (km^2)	Model	N_{hat}	SE	Capture occasions	Identified dolphins	Capture probability	%WM	N_{TOT}	D_{TOT} (n/km^2)	CV	95% CI
2003	260	-	-	-	4	22	0.03	0.56	-	-	-	-
2004	550	M(o)	29	3.49	4	24	0.35	0.77	38	0.069	0.17	34-47
2005	1,000	M(th)	41	5.12	6	33	0.23	0.60	68	0.068	0.18	62-81
2006	1,200	M(o)	82	11.97	5	51	0.18	0.76	108	0.090	0.24	84-163
2007	1,400	M(t)	64	13.02	5	36	0.15	0.94	68	0.049	0.36	46-152
2008	1,000	M(t)	42	0.94	7	41	0.37	0.61	69	0.069	0.08	68-70

A relatively high percentage of all dolphin sightings (31.7%) involved an interaction with some type of fishery. In 3.3% of all sightings, interaction was considered likely, but was not confirmed. Known cases of interactions (n=39) could further be divided according to gear type: most interactions occurred with pelagic pair trawlers (59%), followed by interactions with bottom trawlers (38.4%). One sighting involved two separate types of interaction (one with pelagic pair trawlers and one with a bottom trawler). Only one case was classified as an interaction with a bottom-set gill net, involving one identified individual.

A group of particular identified individuals resident in the area often followed the same pair of pelagic pair-trawlers. These dolphins often swam rapidly towards the operating trawlers, in order to start following their wake (and presumably to feed). During haul-out of the nets the dolphins sometimes left shortly after, but they often milled in the area, following the trawlers passively. It is not clear whether dolphins also fed on discarded fish. Sometimes the trawlers would move more than 1 km away at normal travel speed and the dolphins would follow. Once the trawlers started trawling again, the dolphins resumed the active follow, which lasted until the next haul-out. At that point, the dolphins milled in the area for a while and then travelled away, usually towards the open sea. The details of how exactly dolphins fed in association with pelagic pair trawlers is yet to be determined.

In contrast, other identified individuals were sighted in the vicinity of the same pelagic pair trawlers, but they did not engage in any type of interactions. Instead, they continued diving in the same area even after the trawlers had passed them.
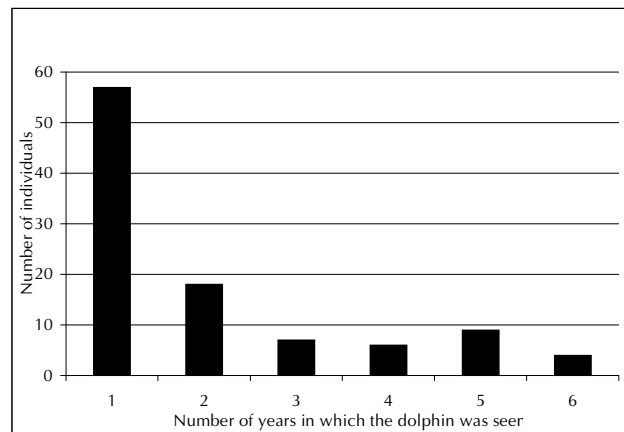

Fig. 6: Frequency distribution of the number of years in which each individual was seen.
Sl. 6: Frekvenčna porazdelitev števila let, v katerih je bil opažen vsak osebek.

No incidental mortality in fishing gear (bycatch) was recorded during direct observations of dolphin-fishery interactions; however, one case of bycatch, involving an adult female entangled in a bottom-set gill net, was reported by a local fisherman.

DISCUSSION

Distribution, abundance, site fidelity and ranging patterns

Sightings of dolphins seemed to be distributed unevenly across the study area (Fig. 1). Several factors may have contributed to this finding. Firstly, the sightings

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distribution was not weighted by effort distribution. Therefore the location of the most suitable and most commonly used land observation point surely affected the distribution of recorded sightings. Furthermore, the starting harbours of boat surveys made areas closer to them more surveyed than those on the outskirts of the study area. Secondly, the study area was continuously expanding from 2003 to 2005, after which it became of a constant size. New sightings were therefore recorded in previously unsurveyed areas. Thirdly, surveys were conducted in a non-systematic way because they were more focused on photo-identification rather than detecting spatial distribution patterns. Furthermore, operating trawlers often attracted our attention. It is therefore clear that a completely equal coverage was not achieved. Nevertheless, some of the most surveyed areas appeared to be used less frequently by the dolphins. Possible bias resulting from differences in dolphin detectability is not likely, because surveys were only carried out in good survey conditions, following the same protocols.

Temporal distribution of survey effort did not allow for comparisons between seasons. There were some differences in distribution between certain years, but that was likely an artefact of the different sampling regime between years, especially in the first few years of the study (land *vs.* boat surveys, coverage of adjacent areas as the study progressed, etc.).

Dolphin distribution overlapped with areas used intensively by fishermen and many sightings were recorded during interactions with fishery (Genov, 2006a; Genov & Kotnjek, 2007). Dolphins were observed following pelagic pair trawlers actively during trawling and passively during haul-out. Therefore, it is reasonable to assume that fishing operations must have had at least some effect on small-scale movement patterns of dolphins.

Tab. 4: Behavioural budget, based on 61 behavioural samples taken at the beginning of each sighting.
Tab. 4: Deleži vedenjskih kategorij glede na 61 vedenjskih vzorcev, ki so bili zbrani ob začetku vsakega opažanja.

Behavioural state	Frequency	%
Dive travel	21	34.4
Active trawler follow	13	21.3
Travel	11	18.1
Dive	5	8.2
Passive trawler follow	2	3.3
Socializing	2	3.3
Social travel	1	1.6
Mixed	6	9.8
Total	**61**	**100**

Dolphins often approached the coast to as little as 30 m from shore and entered bays which are used intensively by humans (Fig. 1). It is worth noting that the coastal waters of the study area are used intensively by recreational boats in summer (Morigenos, *unpubl. data*). It has been demonstrated that recreational boating can have strong adverse impacts on dolphins using coastal habitats, affecting their distribution, behaviour and vocalisations and increasing the risk of collisions (Janik & Thompson, 1996; Wells & Scott, 1997; Hastie *et al.*, 2003; Buckstaff, 2004; Fortuna, 2006; Genov, 2006b; Lemon *et al.*, 2006; Lusseau, 2006; Rako, 2006). Preliminary analysis of summer distribution data suggests that dolphins avoid areas close to shore during the day (between 10:00 and 18:00 hrs), heading out to the open sea in the morning when the number of boats increases and approaching the coast again to less than 3 km from shore in late afternoon when the number of boats at sea decreases.

The distances between sighting locations of identified dolphins showed that dolphins are not confined to one small area, but can travel considerable distances in relatively short time, as was demonstrated in other inshore populations of bottlenose dolphins (Würsig, 1978; Bearzi *et al.*, 1997; Wilson *et al.*, 1997, 2004). The maximum recorded linear distance between two sighting locations of several identified individuals was between 30 and 40 km. Two adults, for example, were photographed in waters off Piran on 8 September 2006 and then again on 11 September 2006 more than 30 km away. However, these distances are likely an artefact of the size of the study area and therefore underestimate the dolphins' true ranging limits. Moreover, great differences were observed in time spent to find the animals. Sometimes dolphins could not be seen on several consecutive surveys, while they could often be found within minutes or hours of search on several other consecutive days. This suggests that dolphin distribution was highly variable and that dolphins ranged within an area much greater than the chosen study area. Dolphins' relatively large ranges, like those recorded in Moray Firth in Scotland (Wilson, 1995; Wilson *et al.*, 1997, 2004), may suggest that the dolphins feed on patchy and unpredictably distributed prey (Wilson, 1995). Additional survey effort in non-summer months is needed in order to acquire insights into distribution patterns in other seasons of the year and to enable comparisons between seasons. Furthermore, this is needed to determine whether dolphin distribution in summer is indeed traffic-related or if it simply reflects dolphins' natural movement patterns.
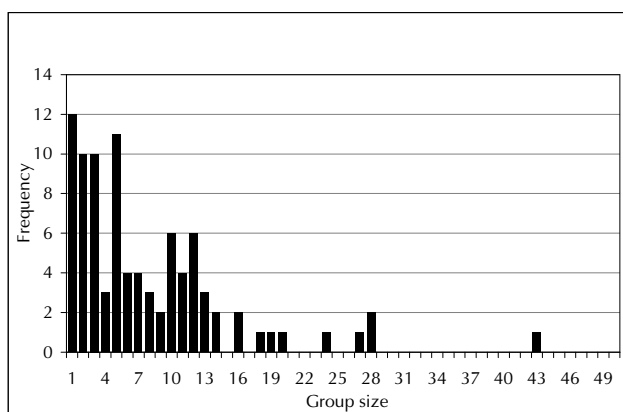
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Fig. 7: Frequency distribution of group size.
Sl. 7: Frekvenčna porazdelitev velikosti skupin.

The size of the home range of identified individuals remains unknown; however, a comparison with the photo-identification catalogue of the local population in Kvarnerić, Croatia (Bearzi *et al.*, 1997; Bearzi *et al.*, 1999; Mackelworth *et al.*, 2003; Fortuna, 2006), less than 200 km away, did not yield a single match (Genov & Fortuna, 2005; Genov & Wiemann, 2005).

Resighting rates within and between years have shown a relatively high rate of site fidelity for some individuals (Tab. 2, Fig. 5) although a large number of individuals were sighted only once. In Kvarnerić, only a few animals were sighted once (Bearzi *et al.*, 1997). The discovery curve (Fig. 4) suggests that most dolphins using Slovenian waters on a regular basis have likely been identified. After an initial steep rise (as first dolphins were being identified, resulting in many new dolphins in each photo-identification session), the curve slowly started levelling out, with fewer newly identified animals added to the catalogue. However, given the fact that the study area was probably smaller than the population range, the animals encountered regularly are likely a part of a bigger population. This is supported by the fact that once the curve had started approaching a horizontal asymptote for the first time, it has risen once more in 2006, which corresponds to two sightings of large dolphin groups at the outer edge of the study area, resulting in newly identified dolphins. The previously known dolphins were identified in these two sightings as well. Nevertheless, some recruitment of new animals into the catalogue still occurred even in the original study area alone. For example, two sightings of large groups of dolphins in Piran Bay in summer 2008 resulted in several new identified individuals and therefore a steeper slope of the curve in that period. After this rise, the curve started levelling out again by the end of the study period.

Based on resighting frequencies, 31 dolphins appeared to use the area on a relatively regular basis.

However, the cumulative number of resightings should be interpreted with care, as the number of resightings alone might not necessarily reflect true residency. For example, one particular female and her identifiable calf were seen 9 times in 2005, but were never observed again. In contrast, another individual was "only" observed 7 times: once in 2004, 2005, 2006 and 2007 each and twice in 2008. Another female was seen a few times every second year. All of these individuals were observed in association with highly resident dolphins (those that had the highest resighting rates both within and between years). Is a dolphin sighted several times in a single year more resident than a dolphin that was seen only a few times, but appears to use the area on a yearly basis? For this reason, resighting rates both within and between years should be considered in interpreting these data. In this respect, residency should be regarded as the frequent and long-term use of the area by the animals. When resightings with years as sampling occasions are considered, 26 dolphins appeared to use the area on a relatively regular yearly basis.

Subsequently, those dolphins that matched the categories "common", "frequent" and "occasional" based on their overall resighting frequency and the category "common" and "occasional" based on the number of years in which they were seen were considered resident. This resulted in 25 well-marked dolphins being true residents in the area. This of course does not reflect the total number of animals using the area. Rarely encountered well-marked animals, poorly-marked animals and the lack of survey effort in non-summer months all need to be taken into account.

Mark-recapture estimates (Tab. 3) showed temporal variability of dolphin density and area use, but this could also potentially be due to variation of our spatial and temporal coverage of the study area. Concerning the number of animals frequenting Slovenian territorial waters, the annual density estimates for 2004 and 2008 seem to be good baseline information for conservation management. The annual abundance estimates between these two years are different, but densities are the same. The differences in abundance estimates seem to reflect differences in the size of the study area and the distribution of effort. It should be noted that the amount of effort in 2004 was lower than in 2008, possibly making the estimate for 2008 more reliable. Furthermore, the model M_t for 2008 allows capture probabilities to vary by time (sampling occasion) and thus possibly making the use of this model more appropriate than the null estimator (model M_0) used for 2004 (Wilson *et al.*, 1999). The year 2005 gives good approximation of the number of animals using not only Slovenian territorial waters, but the whole study area. The model M_{th} used for 2005 allows capture probabilities to vary by time and by individual animal, thus making this model preferable for bottlenose dolphins (Wilson *et al.*, 1999; Bearzi *et al.*, 2008a). The

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year 2006 resulted in higher abundance and density estimates, but before any speculation can be made on the possible reasons, more attention should be given to the spatial distribution of the searching effort. As noted above, the estimates for 2006 most likely correspond to two sightings of large dolphin groups at the outer edge of the study area, resulting in higher number of identified dolphins. In 2007, dolphin density was lower compared to other years. This reflects a relatively low number of dolphin sightings in this particular year, despite the wide coverage of the study area. This further suggests variability in dolphin density and the number of animals using the area. The abundance estimate for 2007 is the same for 2005 and 2008. However, the confidence interval for this year is rather wide, which makes this year inappropriate for baseline information.

In general, even though these estimates should be considered only preliminary, since more thorough evaluation should be given to the annual spatial distribution of effort, all estimates showed good coefficients of variation and a strong consistency among them. The only exception is the estimate for 2003, which is probably biased by the low number of sampling occasions and therefore low number of resightings. Interestingly, annual densities were highly consistent, at least between 2004–2005, despite the strong increase in the size of study area.

Social structure, behaviour and interactions with fishery

The differences in ecology of different populations and the differences in the definitions of a dolphin group by different authors (these two factors are inherently linked) make it difficult to compare mean group sizes between this and other populations worldwide. Another problem in comparing mean values is in the values themselves. Although most studies provide information on the mean values of group size, these values are poor at describing highly skewed data, as it is often the case with group size data (Wilson, 1995). Median and inter-quartile range statistics are less influenced by outliers and are therefore better suited to such data (Wilson, 1995).

Both mean and median values of group size from this study, calculated from sets, can however be compared to a study in the same geographical region (the northern Adriatic Sea), using the same methodology and group size definition (Bearzi *et al.*, 1997). The mean group size of 8 is comparable to the mean group size of 7.4 (based on a large sample size of 3-min samples) and the mean group size of 6.75 (obtained by averaging all set sizes, regardless of their duration, which was also a method in the present study) recorded by Bearzi *et al.* (1997) in Kvarnerić, Croatia. This value is also comparable to other populations of inshore bottlenose dolphins, for ex-

ample in Scotland and Florida (Wilson, 1995; Connor *et al.*, 2000). The median value of 5, however, which is often better suited to group size data, was identical to the median value 5 in Kvarnerić (Bearzi *et al.*, 1997) and almost the same as the median value 4.5 in Moray Firth, Scotland (Wilson, 1995). The group size range (1–43) is also very similar to that reported by Wilson (1995) in Moray Firth, Scotland (1–46). However, single animals were not commonly observed in Moray Firth, as they represented 6.3% of the sample (Wilson, 1995), while they represented the modal class and 13.3% of the sample in the present study (Fig. 7).

The size of bottlenose dolphin groups usually increases with the increasing distance from shore (Shane *et al.*, 1986; Connor *et al.*, 2000). Given the characteristics of the northern Adriatic Sea in general and the common use of areas close to shore by the dolphins, this is consistent with relatively small sizes of groups in this study, as they mainly contained less than 15 individuals (Fig. 7). The composition of dolphin groups indicated that, although changes in group size and composition, typical for the fission-fusion societies of bottlenose dolphins (Wilson, 1995; Bearzi *et al.*, 1997; Connor *et al.*, 2000), do occur, some group stability was present. Direct observations of intermixing of dolphin groups within sightings was much less frequent than in Kvarnerić, where a change in group size and composition (a change of set) occurred on average every hour (Bearzi *et al.*, 1997). This could possibly be related to lower dolphin density in the present study area and/or to differences in ecology, social structure and habitat use.

No evidence of sexual or age segregation was found. Frequent observation of mother-offspring pairs (including newborns) and repeated sightings of the same mother-offspring pairs over several years indicate that bottlenose dolphins are breeding and nursing in the area.

No evidence of shark predation was observed. The only species of sharks known to have occasionally fed on bottlenose dolphins in the Adriatic is the great white shark *(Carcharodon carcharias),* which is considered rare in the region at present times (De Maddalena, 2000; Lipej *et al.*, 2004).

Although the sampling techniques and sample size did not allow for any behavioural budget analysis, an useful initial insight was gained into the behaviour of bottlenose dolphins in the study area. Behavioural states dive travel, dive, surface feeding and trawler follow are thought to be linked to foraging or food search (Bearzi *et al.*, 1999). In the present study dive travel, dive, active trawler follow and passive trawler follow (foraging-related behaviours) constitute 67.2% of the total sample size (Tab. 4). Bearzi *et al.* (1999) reported 82% of the behavioural budget to be foraging-related. However, the small sample size in the present study as well as differences in methodology make further comparisons diffi-

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cult. Surface feeding, which was not included in the sample, but was observed during at least 17% of the sightings, was reported as rare in Kvarnerić (Bearzi et al., 1999). Dolphin feeding behaviour observed during the study suggests that the study area contains some important habitats for feeding of bottlenose dolphins. Photographs of dolphins tossing mullet (Mugil sp.) out of the water during surface feeding were taken. Furthermore, as described above, dolphins often followed pelagic pair trawlers that typically target anchovies (Engraulis sp.) and sardines (Sardina sp.). This evidence suggests that local bottlenose dolphins regularly feed on mullet, sardines and anchovies, although probably not exclusively. These species are considered a typical part of the diet of bottlenose dolphins in several places in the world, including the Mediterranean Sea (dos Santos & Lacerda, 1987; Barros & Odell, 1990; Blanco et al., 2001; Bearzi et al., 2008b).

A high proportion of sightings involved interactions with fisheries, particularly trawlers, indicating an overlap of target/prey species of fishermen and dolphins. As suggested elsewhere, both fishermen and dolphins are probably drawn to areas of high prey density (Fertl & Leatherwood, 1997). In Kvarnerić, bottlenose dolphins have been estimated to spend around 5% of their time following bottom trawlers (Bearzi et al., 1999), and in some areas of the Mediterranean they have been observed feeding on discarded fish as well (Bearzi et al., 2008b). Such interactions often have negative consequences for at least one party involved. These consequences include dolphin mortality through bycatch, gear damage (either through entanglement of the animals or in the form of holes torn in the net as the dolphins attempt to remove fish), depredation (reduction in the amount or value of the catch as the dolphins mutilate or remove caught fish from the net) and catch loss as the dolphins' presence causes fish to flee from the vicinity of the nets (Reeves et al., 2001; Lauriano et al., 2004). The local fishermen of the pelagic pair trawlers claimed that dolphins caused reduced catches when they followed the trawlers, while gill netters often claimed that dolphins damage their nets and reduce catch. Data collected so far appear to indicate that incidental mortality in fishing gear does not represent a major source of concern for this particular area. However, further systematic studies, possibly based on direct observations onboard fishing boats, should be carried out, as bycatch could also go unreported.

There is also often a positive side to the situation when interactions are concerned, at least for one party. Bottlenose dolphins, which are known for their behavioural adaptability (Shane et al., 1986; Bearzi et al., 2008b), are probably attracted to trawling (and other fishing) activities because they make it easier for the animals to exploit a concentrated food source (Fertl & Leatherwood, 1997). Dolphin distribution might have been influenced simply by the distribution of their prey, which is also targeted by the fishery, but observations of direct interactions suggest that they were indeed taking advantage of the fishing activities. In contrast, other dolphins seemed less interested in such alternative food sources. It is therefore possible that different groups of dolphins in this population implement different foraging strategies. A study of foraging ecology of Indo-Pacific bottlenose dolphins (Tursiops aduncus) by Sargeant et al. (2007) showed that various factors such as environmental heterogeneity, demographic and social factors and differences in ecological, genetic and phenotypic differences can shape individual variation in foraging tactics.

The movement patterns and behaviour of at least some dolphin groups appeared to be influenced by fishing activity. Chilvers & Corkeron (2001) and Chilvers et al. (2003) found similar results in Moreton Bay, Australia.

CONCLUSIONS

This study has shown that bottlenose dolphins are a regular, year-round component of the fauna of Slovenian waters, Italian waters of the Gulf of Trieste, and the Croatian waters of north-western Istria. The study has revealed the presence of a resident local population or population segment in these waters, where dolphins were considered rare or occasional visitors. This is the second documented resident local population (or population segment) of bottlenose dolphins in the Adriatic Sea. Moreover, the study has shown that the area likely contains important habitats for bottlenose dolphins inhabiting these waters. These dolphins are part of a larger sub-population of the northern Adriatic Sea, shared by Croatia, Italy and Slovenia. This sub-population therefore needs well-coordinated conservation actions, based on sound science, to ensure its well-being. Bottlenose dolphins under this study have shown that they do not know national borders, as they constantly moved from territorial waters of one country to waters of another. The same is true for human-related threats facing not only dolphins, but the whole northern Adriatic Sea. International collaboration in research, conservation and management of the northern Adriatic ecosystems is therefore fundamental.

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VELIKA PLISKAVKA *(TURSIOPS TRUNCATUS)* V SLOVENSKIH IN OKOLIŠKIH VODAH SEVERNEGA JADRANA

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POVZETEK

*Med letoma 2002 in 2008 smo avtorji pričujočega prispevka preučevali lokalno populacijo delfinov vrste velika pliskavka (*Tursiops truncatus*) v slovenskih in okoliških vodah (severno Jadransko morje). Raziskovanje je potekalo s plovil in kopenskih opazovalnih točk ter s standardnimi postopki foto-identifikacije. Zabeleženo je bilo 120 opažanj, identificiranih pa 101 osebkov. Stopnja opažanj posameznih delfinov v posameznih letih ter med leti kaže na razmeroma visoko stopnjo pogostosti nekaterih osebkov. Velikost skupin je nihala med 1 in 43. Mladiči so bili zabeleženi v 53,3% skupin. Pogosto so bile opažene matere z mladiči različnih starosti, kar kaže na razmnoževanje vrste in vzrejanje mladičev v preučevanem območju. Zabeleženo vedenje velikih pliskavk je zajemalo vse od dejavnosti, povezanih s hranjenjem, do njihovega potovanja po morju in druženja. Neposredna opažanja njihovih prehranjevalnih dejavnosti dajejo slutiti, da se delfini v tem območju redno hranijo. Opaziti je bilo tudi, da se ribolovna območja ribičev in delfinov pogosto prekrivajo. Sicer pa je letna ocena gostote 0,069 delfina / km^2 verjetno dober osnovni podatek za varstvo in upravljanje velikih pliskavk.*

Ključne besede: velika pliskavka, *Tursiops truncatus*, ekologija, foto-identifikacija, Slovenija, severni Jadran

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