

Applying the phylogeographic concept to identify franciscana dolphin stocks: implications to meet management objectives

EDUARDO R. SECCHI*, DANIEL DANILEWICZ⁺ AND PAULO H. OTT[#]

Contact e-mail: edu.secchi@xtra.co.nz or seced001@student.otago.ac.nz

ABSTRACT

High numbers of franciscanas (*Pontoporia blainvillei*) have been bycaught in gillnets for at least four decades. The impact is strong but not homogeneous along the species distribution range, and there is evidence that at least one local population is declining. Reliable stock determination is important to evaluate how bycatch affects stocks so that they can be preserved through local management actions. Following the phylogeographic approach of Dizon *et al.* (1992), which applies a hierarchical classification scheme to stock designations, available information relevant for franciscana stock discreteness was reviewed, including data on distribution, population response, phenotype and genotype. Data on mtDNA, morphometrics and population parameters all together provide evidence for splitting the species into four management stocks: two inhabiting coastal waters of Brazil; the third occurring in Rio Grande do Sul State (southern Brazil) and Uruguay, and the fourth inhabiting coastal Argentine waters. The areas where these stocks occur are herein called Franciscana Management Areas or FMA I to IV. Although in some cases the evidence for such sub-division into four stocks is weak due to lack of data, the use of the proposed classification into four FMAs is recommended to warrant effective management on a local scale.

KEYWORDS: FRANCISCANA; CONSERVATION; MANAGEMENT STOCK; SOUTH AMERICA; ATLANTIC OCEAN; DISTRIBUTION; GENETICS; MORPHOMETRICS; POPULATION PARAMETERS; PHYLOGEOGRAPHY; INCIDENTAL CATCHES

INTRODUCTION

Conservation concern for the franciscana

The franciscana (*Pontoporia blainvillei*) receives legal protection from direct catch in Brazil, Uruguay and Argentina. However, the greatest threat to the species' survival is incidental catches in coastal gillnets throughout most of its range (Praderi *et al.*, 1989; UNEP/CMS, 2000). Incidental catches reported for most of the areas along its distribution (e.g. Perez-Macri and Crespo, 1989; Praderi, 1997; Secchi *et al.*, 1997; Di Benedetto *et al.*, 1998; Kinan and Secchi, 1998; Ott, 1998; Bertozzi and Zerbini, 2002; Ott *et al.*, 2002; Rosas *et al.*, 2002) are apparently high. However, the full impact of these catches, even on a local scale, remains unclear mainly because the identity of stocks is not understood and because effort to estimate abundance has been low and limited to only a few areas (e.g. Secchi *et al.*, 2001).

It is important to determine stock discreteness in order to guide conservation and management procedures at a local level. Despite some progress in understanding stock structure, the stocks upon which management should be applied still remain unknown. Parasite loads have been used to identify ecological stocks of franciscana in the southern portion of its distribution (southern Brazil, Uruguay and Argentina – see Aznar *et al.*, 1995; Andrade *et al.*, 1997; 2000). Differences in the displacement loop (D-loop) region of the mitochondrial DNA (mtDNA) between the two geographic forms of franciscana (proposed by Pinedo, 1991) were found, suggesting the existence of at least two genetic populations or management stocks (Secchi *et al.*, 1998; Lázaro, 2000). Given the high monetary and ecological interests involved in the management of endangered species, it would seem prudent to base taxonomic decisions on broad

and reliable information (Awise, 1989). Secchi (1999) emphasised that an adequate management of coastal gillnet fisheries could be reached by defining franciscana stocks using analyses of a variety of *proxies* and the phylogeographic concept of stock proposed by Dizon *et al.* (1992).

Stock characterisation for conservation purposes

According to Moritz (1994), two main types of conservation units are recognised, both important for management purposes: the Evolutionarily Significant Unit (ESU) and the Management Unit (MU). ESUs are concerned with historical population structure, mtDNA phylogeny and long-term conservation needs. MUs address current population structure, allele frequencies and short-term management issues.

Dizon *et al.* (1992) proposed a phylogeographic concept based on a hierarchical classification scheme to define stocks. Their scheme classifies populations into four categories: (1) those having the highest probability of being ESUs, characterised by geographic separation and significant genetic distances; (2) populations which are similarly characterised by significant genetic diversity, but with weak geographic partitioning; (3) populations which are the converse of category (2) (i.e. having little genetic differentiation between assemblages that are clearly separate and likely to be reproductively isolated); and (4) assemblages having the lowest probability of being ESUs, characterised by extensive gene flow and no division by extrinsic barriers. In addition to phylogeographic designation, the following information is also used in the classification, as indicated by single-letter abbreviations: distribution (a), population response (b), phenotypic data (c)

* Laboratório de Mamíferos Marinhos, Museu Oceanográfico 'Prof. Eliezer C. Rios', Fundação Universidade Federal do Rio Grande, Cx.P. 379, Rio Grande, RS 96200-970 Brasil. Current address: Marine Mammal Research Group, University of Otago, PO Box 56, Dunedin, New Zealand.

⁺ Grupo de Estudos de Mamíferos Aquáticos de Rio Grande do Sul-GEMARS, R. Felipe Neri, 382 s. 203, Porto Alegre, RS 90440-150 Brasil.

[#] Centro de Estudos Costeiros, Limnológicos e Marinhos, Universidade Federal do Rio Grande do Sul – CECLIMAR/UFGRS, Av. Tramandai, 976, Praia do Imbé, RS 95625-000 Brasil.

and genotypic data (d). Evidence both for and against designating a population as a separate stock is included. For example, in the designation *Type III cd/a*, information to the left of the solidus would be evidence for 'lumping', to the right would be for 'splitting'. Missing letter abbreviations mean lack of reliable data (for further details see Dizon *et al.*, 1992).

Moritz (1994, p.374) acknowledged that the Dizon *et al.* scheme is explicit but argued that '...it remained unwieldy and did not recognise different conservation goals'. Thus, Moritz suggested that the term stock be restricted to short-term management issues and, in relation to genetics, be treated as synonymous with management units. Therefore, this study tentatively applied the stock concept of Dizon *et al.* to the franciscana with the aim of identifying units upon which short-term management actions (e.g. bycatch monitoring, setting catch limits, monitoring of demographic trends) should take place promptly.

Applying Dizon *et al.*'s approach

Taxonomy

SPECIES: *PONTOPORIA BLAINVILLEI*

Intraspecific sub-division: geographic forms North and South (Pinedo, 1991); genetic populations North and South (Secchi *et al.*, 1998).

Provisional proposed management sub-divisions

- (1) Northern population: occurring to the North of Santa Catarina State, Brazil,
 - (a) animals from Espírito Santo to Northern Rio de Janeiro;
 - (b) animals from São Paulo to Santa Catarina.
- (2) Southern population: occurring to the South of Santa Catarina State,
 - (a) animals from Rio Grande do Sul (southern Brazil) and Uruguay;
 - (b) animals from Argentina.

Evidence

DISTRIBUTION

GEOGRAPHIC DISTRIBUTION AND ABUNDANCE DATA

Information on distribution and abundance could be used as the basic criteria for splitting stocks and, when additional data is lacking, disjunct populations might be considered different stocks for conservative management purposes (Dizon *et al.*, 1992). The franciscana is endemic to the western South Atlantic, ranging from Itaúnas (18°25'S-30°42'W), Espírito Santo, Brazil (Siciliano, 1994) to Golfo Nuevo (42°35'S-64°48'W), Península Valdés, Argentina (Crespo *et al.*, 1998). Based on morphological differences, Pinedo (1991) proposed two different forms of franciscana, one found to the north and the other to the south of Santa Catarina State, southern Brazil. Sequence differences in the displacement loop (D-loop) region of the mtDNA between these geographic forms of franciscana were found, suggesting the existence of at least two genetic populations or management stocks (Secchi *et al.*, 1998). This finding was further supported by analyses of many more samples from the southern population (Hamilton *et al.*, 2000; Lázaro, 2000; 2001).

A hypothesis of disjunct populations has been proposed based on two gaps observed in the distribution of the northern population (Siciliano and Santos, 1994; Siciliano *et al.*, 2002). Information on the hiatus between Regênciã, Espírito Santo State (19°40'S) and north of Atafona, northern Rio de Janeiro State (21°37'S) is incipient. However, continued effort for monitoring strandings and

incidental captures confirms the second gap between southern Macaé, Rio de Janeiro State (22°25'S) and Ubatuba, northern São Paulo State (23°18'S). Siciliano *et al.*'s (2002) findings suggest the existence of two isolated populations, one in northern Espírito Santo and the other in northern Rio de Janeiro State. According to the authors, the populations are associated with the runoffs of the Doce and Paraíba do Sul rivers due to the favourable conditions for feeding and protection against natural predators.

Although data on abundance exist only at a local level (Secchi *et al.*, 2001), empirical evidence suggests that the southern population is larger than the northern one. Relative abundance of franciscanas is suspected, based on Catch per Unit of Effort (CPUE) data, to be considerably higher to the south (e.g. Crespo *et al.*, 1986; Corcuera, 1994; Praderi, 1997; Secchi *et al.*, 1997; Ott, 1998; Secchi and Ott, 2000; Ott *et al.*, 2002), than to the north of Santa Catarina (e.g. Di Benedetto *et al.*, 1998; Di Benedetto and Ramos, 2001a; Bertozzi and Zerbini, 2002; Rosas *et al.*, 2002). This suspicion is supported by comparing data from systematic surveys of stranded animals to the south (Pinedo and Polacheck, 1999) and north (Schmiegelow, 1990; Santos *et al.*, 2002) of Santa Catarina.

Furthermore, the abundance of franciscana might be limited to the north by the presence of an abundant sympatric species (i.e. the tucuxi *Sotalia fluviatilis*, which has its southern limit at Santa Catarina — see Flores, 2002 and Borobia *et al.*, 1991) and other less abundant or occasionally sympatric species (e.g. Atlantic spotted dolphins (*Stenella frontalis*); rough-toothed dolphin (*Steno bredanensis*) and bottlenose dolphin (*Tursiops truncatus*)). If these sympatric species compete in some way for the same or similar resources (habitat or food) and it may be reasonable to believe that the northern population is less abundant and more specialised than the southern one. However, in northern Rio de Janeiro, franciscana and tucuxi showed a low degree of competition for the same resources (Di Benedetto, 2000).

The southern population may be a single and widely distributed population ranging from northern Argentina to Santa Catarina (as suggested by genetic data). The only cetaceans that are sympatric with the southern population year-round are the highly estuary-dependent local populations of bottlenose dolphins. Moreover, Secchi *et al.* (1998) found that genetic diversity was greater within samples collected from animals of Rio Grande (southern population) than within the samples of franciscanas caught off Rio de Janeiro (northern population).

Data on fishing characteristics and areas of incidental catches are also useful when defining stocks for management. Management action involves changes to the fishing fleet effort, and the ability to do this is easier when fisheries are homogeneous or similar. Fisheries experiencing franciscana bycatch in Rio Grande do Sul and Uruguay are apparently more similar compared with those in Argentina or areas to the north of Santa Catarina. However, further investigation is necessary to support this argument.

CONTAMINANT LOADS

Castello *et al.* (2000) found that female franciscanas from northern Argentina had a slightly higher mean concentration of PCBs (3.35ppm; SE = 1.95) than those from Rio Grande do Sul, southern Brazil (1.69ppm; SE = 1.61), while concentrations in males were similar. However, no statistical analyses were conducted by the authors. Borrel *et al.* (1997) analysed 17 females from Argentine waters and found PCB concentrations to be similar to those found by O'Shea *et al.*

(1980) in animals caught off Uruguay. DDTs and heavy metal studies are insufficient for comparative analyses (e.g. see Borrell and Aguilar, 1999). Although PCB contamination seems to indicate no stock sub-division between southern Brazil, Uruguay and northern Argentina, temporal and methodological differences as well as the lack of data limit the usefulness of contamination loads for stock definition.

PARASITE LOADS

Some considerations are important when using parasite loads as biological markers for defining stocks. Parasites must present a relatively long lifetime and a high specificity to their intermediate hosts, so that their occurrence would be limited to areas where these hosts are present. Also, the infection levels must be significantly different between areas, but not lethal to the host (for details see Mackenzie, 1987).

Andrade *et al.* (2000) stated that the distribution pattern of franciscana's gastrointestinal helminths was similar among individuals sampled in Rio Grande do Sul and Uruguay. Franciscanas sampled in these areas were infected lightly by the acanthocephalan worm *Polymorphus cetaceum* whilst in Argentina, all the sampled franciscanas experienced high levels of infection. The dominant parasites were also different between animals from Rio Grande do Sul and Argentina. The trematode *Hadwenius pontoporiae* was present in 83% of the dolphins sampled in Rio Grande do Sul and *P. cetaceum* was found in 63% of the franciscana from Argentina. Aznar *et al.* (1995) compared the helminthofauna of franciscana between samples from Uruguay and Argentina and suggested some degree of stock segregation according to differences in dominance and infection levels by *P. cetaceum*, *Anisakis simplex* and *H. pontoporiae*.

The studies of Aznar *et al.* (1994; 1995) and Andrade *et al.* (2000), showed that the parasite infection levels in franciscanas from Rio Grande do Sul and Uruguay were similar but considerably different from those sampled in Argentina. These findings suggest the existence of two ecologically distinct stocks: one comprising franciscanas from Rio Grande do Sul and Uruguay and the other comprising the animals of Argentine waters. However, since data on parasites infecting franciscana from Rio Grande do Sul (Andrade *et al.*, 1997; 2000) are limited seasonally to spring, further studies are needed to strengthen the proposed sub-division.

These parasitic data were also consistent with information on franciscana diet. Diet was more similar among individuals inhabiting adjacent areas of Rio Grande do Sul and Uruguay (see Pinedo, 1982; Pinedo *et al.*, 1989; Ott, 1994; Bassoi, 1997) than between these two areas and Argentina (Perez *et al.*, 1996; 2000; Rodríguez *et al.*, 2002). The La Plata River is the only physical barrier between these supposed stocks and is probably the reason for the difference in feeding habits. Diet composition of individuals from the northern population is considerably different (see Di Benedetto, 2000; Di Benedetto and Ramos, 2001b). Franciscanas from the southern population feed essentially on benthic species while franciscanas from the northern population (at least those from northern Rio de Janeiro) tend to forage more on pelagic species. These differences may reflect prey availability but also evolving behavioural adaptation to local niches.

Marigo *et al.* (2002) found a significant difference in the occurrence of *H. pontoporiae* between the intestines of franciscanas from Paraná and São Paulo (prevalence = 68.4%, this study) and those of franciscanas from Rio

Grande do Sul (prevalence = 97.7%, Andrade *et al.*, 1997). In this context, the intestines of franciscanas from Rio de Janeiro could also indicate population differences when compared with the population of São Paulo, Paraná and Rio Grande do Sul States. Therefore, it remains as a recommendation for further studies.

POPULATION RESPONSE

Southern and northern populations exhibit different reproductive strategies. According to Di Benedetto and Ramos (2001), franciscanas in the northern distribution reproduce year-round whilst the southern population has marked seasonal reproduction, with the birth pulse spanning from approximately late austral spring to late summer (e.g. Kasuya and Brownell, 1979; Harrison *et al.*, 1981; Pinedo *et al.*, 1989; Corcuera, 1996; Danilewicz *et al.*, 2000; In press). Differences in reproductive timing represent an important line of evidence upon which stock structure can be based due to the implicit ecological or behavioural constraints that might limit gene flow between the two populations (Secchi, 1999).

Although differences in deposition patterns of dentine and cementum in teeth may indicate clinal variation in water temperature, food availability and energetics, the growth layer groups (GLGs) for both the northern and southern populations seem to correspond to one annual cycle of deposition (Pinedo and Hohn, 2000; Ramos *et al.*, 2002). Therefore, inter-population comparisons of any age-related parameter are possible.

Danilewicz *et al.* (2000) compared estimates of age at sexual maturity (ASM) of animals incidentally caught in gillnets in Rio Grande do Sul State with estimates from Uruguay (adapting data from Kasuya and Brownell, 1979) and from northern Argentina (Corcuera, 1996). Using the DeMaster method (DeMaster, 1978; 1984), the resulting ASM was 3.7 years (95% CI = 3.0-4.4) in Rio Grande do Sul, 2.8 years (95% CI = 2.5-3.1) in Uruguay and 4.5 years in Argentina. The ASM of females from Rio Grande do Sul was significantly higher than females from Uruguay ($t = 2.3$; $p < 0.01$) but lower than those from Argentina. It should be noted that mature females only two years old were observed in Uruguay but not in Rio Grande do Sul. These low-aged adult females contributed to the difference in the ASM from these two adjacent regions.

The findings of this comparative study are tentative; any conclusions at the population and ecosystem level should be avoided until a more representative sample from Rio Grande do Sul and Argentina, and more recent samples from Uruguay are available. Data from Uruguay were collected about 25-30 years ago (which corresponds to about three to four generations for franciscana) and the reproductive biology of the animals of the region may have changed substantially. It is tempting to explain the differences in ASM between the study regions as density-dependence. It could be hypothesised, for example, that the lower ASM in female franciscanas from Uruguay is a compensatory effect in response to a decrease in the population density due to high levels of removals from past fishing effort. Likewise, the higher mean age of sexual maturity estimated for franciscanas from Argentina could be a reflection of the lower impact of incidental catches in the area over the last three decades or other density-dependent reasons. However, it is worthwhile to state that comparative studies on the life history of exploited marine mammal populations have failed to detect evidence of density-dependence or have produced contradictory results, even when sample sizes were very large and the history of exploitation well known (see Chivers

and Myrick, 1993). Nevertheless, the difference of about one year in ASM between the three areas requires further comparative investigations of the reproductive biology of the franciscana between southern Brazil and Argentina and encourages the collection of recent reproductive data from Uruguay. These differences may still be considered important in supporting the option of splitting the southern population into more than one management stock.

Little information on size/age at sexual maturity is available for most of the distribution of the northern population. The size at sexual maturity of males from the northern population was estimated between 112-116cm for southern São Paulo/northern Paraná States (Rosas, 2000) and 115cm for northern Rio de Janeiro (Ramos *et al.*, 2000). Females from São Paulo/Paraná attain sexual maturity at 122cm, while the smallest sexually mature female from northern Rio de Janeiro was 130cm long. The differences could be related to distinct somatic patterns between the regions. However, the sample size presented in Rosas (2000) was very small and any conclusions must be made cautiously.

Comparisons of age at sexual maturity between the southern and northern population are limited because of the relatively small sample size available for the northern population and because of methodological differences in the analyses. Individuals from the southern population seem to be much larger at sexual maturity (see Kasuya and Brownell, 1979; Danilewicz and Secchi, 2000; Danilewicz *et al.*, 2000) than individuals from the northern population (see Ramos *et al.*, 2000; Rosas, 2000).

PHENOTYPIC DATA

The intra-specific variation in size, shape and colour in cetaceans may be as great as or greater than in terrestrial mammals. This is most likely due to the high diversity of habitat and local pressure selection (Perrin, 1991). Analysis of morphological variation is useful for understanding how much individuals or populations change their phenotype along time and space. It may also be useful for understanding micro-evolutionary processes within a species. Therefore, knowledge of the degree of morphological variation found along the distribution of the franciscana is an alternative way for determining stock structure and, perhaps, movement patterns of the species (Pinedo, 1991).

Based on osteological differences, Pinedo (1991) proposed two different forms of franciscana, one found to the north and the other to the south of Santa Catarina State, southern Brazil. This study showed that the animals from the north are smaller than animals from the south. The author also demonstrated that the two forms exhibited marked morphological differences that were not observed among individuals sampled from Rio Grande do Sul, Uruguay and Argentina. However, some differences were observed between individuals from Argentina and those from Uruguay and Rio Grande do Sul. Some of the conclusions from Pinedo (1991), relevant to stock characterisation, include: (1) no difference was observed in the measurement of the first GLG in the dentine and cementum among samples from Rio Grande do Sul and Uruguay; and (2) craniometrical analysis and measurements in the axial skeleton revealed the existence of two different geographic forms (one smaller found to the north and the other larger to the south of Santa Catarina State) that should be recognised separately for management and conservation purposes.

Corroborating findings are presented by Ramos *et al.* (2000). They presented data on age and growth for individuals from northern Rio de Janeiro and found

asymptotic lengths (for both males and females) were smaller than those found by Kasuya and Brownell (1979) for franciscanas from Uruguay. No differences were observed in the growth curves among individuals from Uruguay (recalculated from age and length data supplied by T. Kasuya to ERS) and from Rio Grande do Sul (Walter *et al.*, 1998). Although this information is closely related to the work of Pinedo (1991), it may be used as a supporting criterion for better definition of a stock as a management unit.

Ramos *et al.* (2002) presented data on growth for the northern population and found that the growth parameters for individuals from São Paulo were smaller than the values obtained for individuals from northern Rio de Janeiro. The phenotypic difference between two geographic areas could be a reflection of distinct local adaptations. In addition, the asymptotic lengths presented by Rosas (2000) for São Paulo were also smaller than those found by Ramos *et al.* (2000) for northern Rio de Janeiro, corroborating this evidence. Differences in the somatic pattern represent important aspects supporting the hypothesis of distinct stocks within the northern population.

Inter-population analysis on franciscana's growth was conducted by Barreto *et al.* (2000). They used the Von Bertalanffy growth model to compare data on animals collected from Rio Grande do Sul with data from Paraná/São Paulo. The asymptotic lengths of individuals from Rio Grande do Sul were significantly larger than individuals from Paraná/São Paulo ($p < 0.05$, maximum-likelihood test).

GENOTYPIC DATA

Hoelzel (1992, p.119) states that, '...for cetacean populations, perhaps the most essential and immediate application for genetic analyses will be the identification of which populations should be recognized as distinct entities (stocks)'. According to this author, the genetic variation within a species needs to be conserved to allow continuing adaptation to a changing environment. Since the franciscana might be separated into genetically distinct demes, the high incidental fishing mortality of local populations could adversely affect the evolutionary potential of the species.

From 10 franciscanas from each geographic form proposed by Pinedo (1991), 486 base pairs (bp) of the mtDNA (68bp of proline tRNA and 418bp control region) were analysed. Samples from Atafona (Rio de Janeiro State) and Rio Grande (Rio Grande do Sul State) provided direct genetic evidence for at least two genetic populations (Secchi *et al.*, 1998). The phylogeny of the haplotypes, two substitutional differences (sites 202 and 356), network of haplotype inter-relationships, and analysis of molecular variance showed that the franciscana samples are separated into two distinct lineages.

Lázaro (2000) and Hamilton *et al.* (2000) provided recent information on mtDNA analyses for franciscanas from Uruguay and Argentina. The two studies compared their results with those published by Secchi *et al.* (1998) and suggested the existence of one genetic population involving animals from Rio Grande do Sul, Uruguay and Argentina. No haplotypes from these three locations were shared with animals from Rio de Janeiro, corroborating the hypothesis of at least two genetic populations of franciscana. Although data comparisons amongst the three studies do not support further division of franciscanas from Rio Grande do Sul, Uruguay and Claromecú (Argentina), a pairwise analysis of haplotype distances between different geographic locations showed increasing differentiation in the haplotype

frequencies with increasing geographic distance, following an isolation by distance pattern (Lázaro, 2001). Moreover, recent analysis showed that haplotypic frequencies of samples from Claromecó were significantly different from the rest of the southern population (Lázaro, 2001). This finding supports the proposed division of the southern population into different management stocks.

Valsecchi and Zanelatto (2003) presented preliminary results on the analysis of the mtDNA obtained from individuals collected in Paraná State, an intermediate region between Rio Grande and Atafona. The results were also compared with the results published by Secchi *et al.* (1998) and suggested that individuals from Paraná are more similar to those from Rio Grande do Sul than to those from Rio de Janeiro. Not surprisingly, Secchi *et al.* (1998) had observed significantly lower nucleotide diversity in the Rio de Janeiro area.

The results of these studies provide direct genetic support for population distinctions that are critical for conservation. Management-decision makers should recognise at least two (potentially more according to the findings of Valsecchi and Zanelatto, 2003) genetically distinct populations.

Classification

The crude separation of franciscana into northern and southern genetic populations may not be sufficient for effective conservation of this species. When genetic data fail to indicate sub-division it is not necessarily evidence of the lack of genetic structuring. Most genetic analysis performed so far for franciscana have little statistical power due to small sample sizes relative to the population. Even after a distribution-wide genetic survey is complete, information on differences in population distribution, demography, morphology, incidental mortality and as many other criteria as possible must be integrated and considered when conservation strategies are designed. Obviously, when significant genetic structuring is found, there is very strong evidence that the tested populations should be managed separately.

The provisionally proposed stocks could be classified according to the hierarchical approach of Dizon *et al.* (1992). Data on genetics (Secchi *et al.*, 1998; Hamilton *et al.*, 2000; Lázaro, 2001), morphology and growth (Pinedo, 1991; Barreto *et al.*, 2000; Ramos *et al.*, 2000; 2002; Rosas, 2000), suspected abundance based on genetic variability and co-existence with sympatric species (Secchi *et al.*, 1998), interaction with fisheries and fishing fleet characteristics (Praderi, 1997; Secchi *et al.*, 1997; Di Benedetto *et al.*, 1998; Ott, 1998), parasite loads (Aznar *et al.*, 1995; Andrade *et al.*, 2000; Marigo *et al.*, 2002), feeding habits/behaviour (Pinedo, 1982; Ott, 1994; Perez *et al.*, 1996; 2000; Bassoi, 1997; Di Benedetto, 2000; Di Benedetto and Ramos, 2001; Rodríguez *et al.*, 2002) and population response (Kasuya and Brownell, 1979; Danilewicz and Secchi, 2000; Danilewicz *et al.*, 2000; In press; Rosas, 2000; Di Benedetto and Ramos, 2001) indicate that the proposed northern and southern populations should be recognised as different stocks for management purposes. According to the phylogeographic approach these stocks should be classified as: *Type II –/abcd* meaning that all existing data support the existence of these two management stocks.

Regarding the proposed division of the southern population/stock in two stocks, data on genetics (Secchi *et al.*, 1998; Hamilton *et al.*, 2000; Lázaro, 2000; 2001), morphology and growth (Pinedo, 1991; Walter *et al.*, 1998), suspected abundance based on genetic variability (Secchi *et al.*, 1998; Hamilton *et al.*, 2000; Lázaro, 2001), supports the

lumping of franciscanas from Rio Grande do Sul, Uruguay and Argentina into one large stock. However, data on haplotypic frequencies (Lázaro, 2001), parasite load (Aznar *et al.*, 1995; Andrade *et al.*, 2000), feeding habits/behaviour (Pinedo, 1982; Ott, 1994; Perez *et al.*, 1996; 2000; Bassoi, 1997; Rodríguez *et al.*, 2002), population response (Kasuya and Brownell, 1979; Corcuera, 1996; Danilewicz *et al.*, 2000; In press) and fishing fleet characteristics, fishing dynamics and characteristics of incidental captures (Perez-Macri and Crespo, 1989; Praderi *et al.*, 1989; Corcuera, 1994; Praderi, 1997; Secchi *et al.*, 1997; Ott, 1998; Capozzo *et al.*, 2000; Ott *et al.*, 2002) suggest splitting the southern population into two smaller stocks: one including animals from Rio Grande do Sul and Uruguay; and the other including franciscanas inhabiting Argentine waters. These stocks are, therefore, classified as *Type IV acd/abd* suggesting that the evidence for the splitting is weaker. The Southwest Fisheries Science Center recommends an averse-to-risk strategy (see Dizon *et al.*, 1997, p.11), to consider a population as a different stock whenever any evidence suggest distinctiveness (e.g. genetic, morphology, population parameters or ecology). Despite the lack of more data to strongly support the splitting, it is recommended to recognise this classification for applying management action on a local basis. Even though the La Plata estuary would be the most appropriate ecological boundary for the two stocks, for management purposes, the most pragmatic separation between the stocks is the geopolitical border between Uruguay and Argentina.

For the proposed division of the northern population into two stocks, information on distribution (Siciliano and Santos, 1994; Siciliano *et al.*, 2002), size at sexual maturity (Rosas, 2000; Di Benedetto and Ramos, 2001), growth (Ramos *et al.*, 2000; 2002; Rosas, 2000) and genetics (Valsecchi and Zanelatto, 2003), suggest the splitting of the northern population into two stocks of *Type II –/abcd*: one occurring from Espírito Santo to Rio de Janeiro states and the other from São Paulo to Santa Catarina states.

Small-scale management is likely to be more effective and highly relevant in countries where resources are limited by the dominating economical situation to preventing the waste of limited resources in management actions that may have little chance to be effective. This is the case for the three countries where franciscana occur. Management actions will always affect the people direct or indirectly. Any management action to mitigate the bycatch problem will unavoidably result in changes to current fishing practices and in turn, have socio-economic consequences. Management actions could have a wide range of possible effects. In the best-case scenario, the government could afford to subsidise and promote changes to fishing gear for at least part of the fleet. Alternately, restrictions on fishing effort may lead to increased unemployment and compromise the quality of life of many fishers. It is recommended that states/provinces and/or Federal Governments share responsibility to find suitable conservation action within their Franciscana Management Areas.

CONCLUDING REMARKS AND RECOMMENDATIONS

Data presented here suggest splitting the southern and the northern franciscana populations into two management stocks each. The establishment of four FMAs along its range is proposed: FMA I includes the coastal waters of Espírito Santo and Rio de Janeiro; FMA II covers São Paulo to Santa Catarina states; FMA III is comprised of the coastal waters

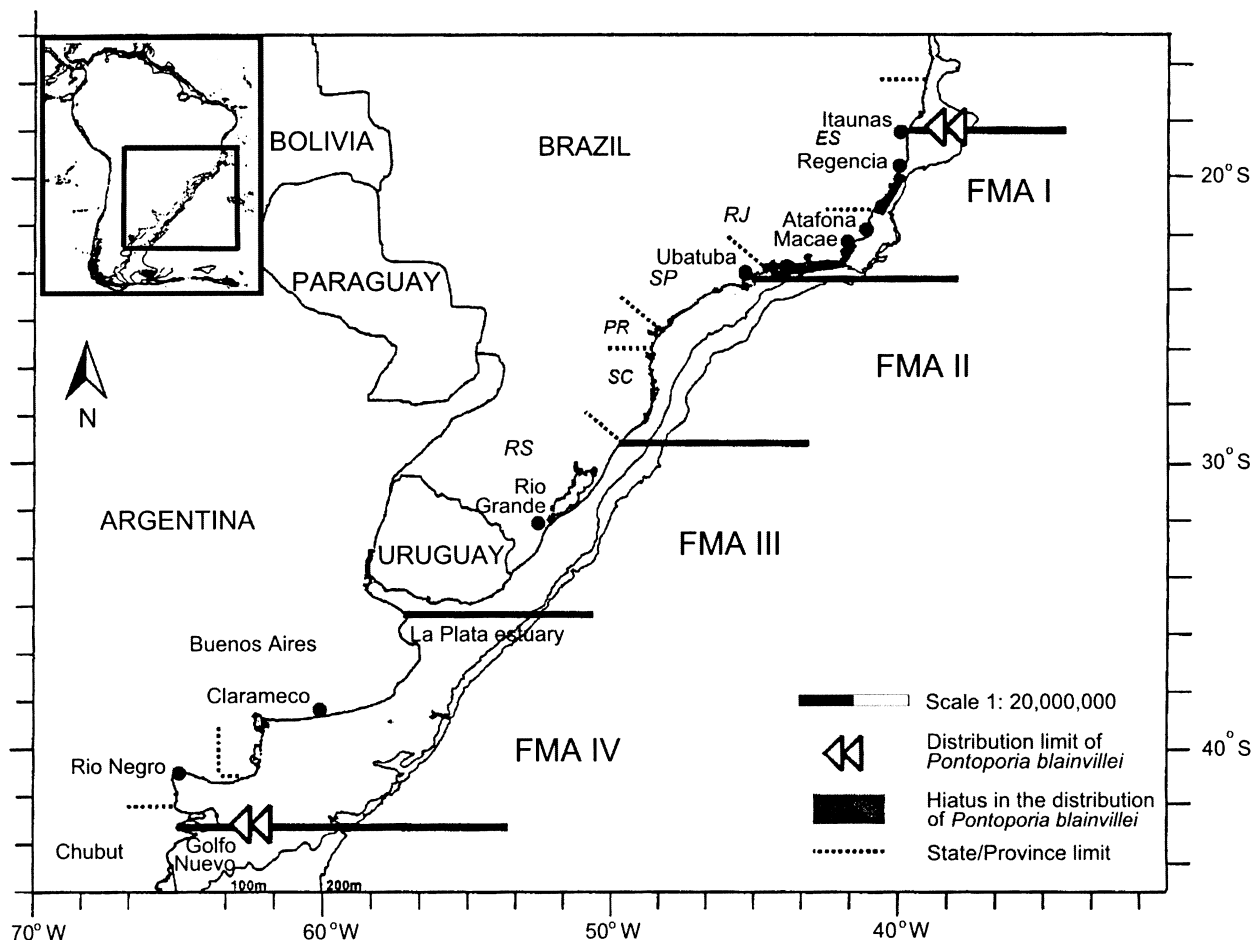


Fig. 1. Map showing the southern and northern limits¹ of the franciscana range and the four proposed Franciscana Management Areas (FMA). Brazilian states and Argentine provinces are shown in italics. RS - Rio Grande do Sul; SC - Santa Catarina; PR - Paraná; SP - São Paulo; RJ - Rio de Janeiro; ES - Espírito Santo.

of Rio Grande do Sul and Uruguay; and FMA IV represents the coastal waters of Argentina (including the Provinces of Buenos Aires, Rio Negro and Chubut) (see Fig. 1). However, it is worthwhile to emphasise that arguments presented for the proposed divisions are not immutable. Intra-specific populations are dynamic and, therefore, the proposed classification should be flexible and subject to changes as new data are obtained. As stated by Dizon *et al.* (1992), the approach allows preliminary and conservative splitting of assemblages where data are lacking without the risk that these divisions become biological dogmas. Moreover, this hierarchical procedure for defining stocks permits managers and decision-makers to direct limited resources to those stocks most likely in need of protection and also, it increases the chance of any management action to be effective.

For further improving our understanding of stock identity for franciscana, the following are recommended: (1) conduct temporally and methodologically synchronised comparative studies on reproductive biology, parasite and contamination loads along the species distribution range; (2) conduct genetic analyses for samples from areas between Rio de Janeiro and Rio Grande do Sul states and also from the northern and southern limits of the species distribution range; (3) increase effort to estimate population parameters all along the species distribution range; and (4) reconsider the provisional stock sub-divisions as new data are obtained.

¹ Limits here are considered the southern and northernmost records of the species.

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