Aquatic Mammals 2001, **27.2,** 172–182

Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) with anomalous colour patterns in Volcano Bay, Hokkaido, Japan

Shigeyuki Tsutsui[1,3], Miho Tanaka[1,4], Nobuyuki Miyazaki[1] and Tadao Furuya[2]

[1]*Otsuchi Marine Research Center, Ocean Research Institute, The University of Tokyo, Akahama, Otsuchi, Iwate 028-1102, Japan*
[2]*ELM Co., Ltd. Saiwai-cho, Muroran, Hokkaido 051-0016, Japan*

Abstract

Fourteen individuals of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) having anomalous colour patterns were identified from 154 photographs taken in Volcano Bay, Hokkaido, Japan. This is believed to be the only study that made individual identifications with anomalous white animals in this species, as well as the first record of them in the West Pacific Ocean. They were not true albinos, but anomalous white individuals, and showed various degrees of lack of pigmentation. Five dolphins repeatedly occurred in the area for two years or more, and two individuals were sighted twice a year in summer and late autumn. From their sighting records, the following three possibilities were suggested: (1) the same population of this species migrates into Volcano Bay every year, (2) the population that occurs in late autumn in the area is the same as that found in the summer, or (3) they stay around the area for six months or more from spring to late autumn. These fourteen dolphins are considered to be important individuals because they are naturally marked to study the population structure and migration of the species.

Key words: Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, anomalous colour pattern, Volcano Bay, population, migration.

Introduction

Anomalous colour patterns in cetaceans have been reported by several scientists (Brown & Norris, 1956; Scheffer, 1950; Hain & Leatherwood, 1982; Fertl *et al*., 1999). Hain & Leatherwood (1982) described two sightings of white pilot whales, *Globicephala melas*, and summarized records of anomalous white colouration in cetaceans of 13 species. Fertl *et al*. (1999) reported sighting an albino bottlenose dolphin, *Tursiops truncatus*, and reviewed the occurrence of anomalous white cetaceans in 20 species.

Normal colour pattern (Fig. 1) of the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*, Gill, 1865) has the following characteristics: (1) dark gray back and sides are distinctly set-off from the white belly by a black border, (2) light gray streaks beginning on the side of the melon sweep downward behind eye and expand into large gray thoracic patches, (3) gray 'suspender stripes', which include a blowhole chevron starting above eyes and followed by a dorsal flank blaze, ventral flank blaze, and flank patch widens to bands on the sides of the tail stock, (4) dorsal fin is darker anteriorly, and the posterior two-thirds is a variable light gray patch, and (5) flukes are completely dark (Scheffer, 1950; Michell, 1970; Jefferson *et al*., 1993; Brownell *et al*., 1999). In this species, eight records of anomalous colour patterns have been reported (Brown & Norris, 1956; Brownell, 1965; Hain & Leatherwood, 1982; Walker *et al*., 1986; Black, 1989) (Table 1). These sightings suggest that there are at least two types of anomalous colour patterns in this species; one is 'anomalous white' and the other is 'anomalous design'. Brown & Norris (1956) reported an anecdotal fisherman's record of one individual with snow white colour. They also reported the sighting of a large adult dolphin being mottled gray dorsally from the snout to the tail stock in the mixed species school of 200 individuals of both *Delphinus delphis* and *L. obliquidens*. Hain & Leatherwood (1982), Black (1982), and Stacey & Baird (1991) also reported similar anomalous white dolphins. On the other hand, Brownell (1965) described another type of anomalous colour pattern of the species, which had a large lateral thoracic

[3]Present address: Fisheries Laboratory, Faculty of Agriculture, The University of Tokyo, Maisaka, Hamana, Shizuoka 431-0211, Japan.

[4]Present address: Port of Nagoya Public Aquarium, Minato-machi, Minatoku, Nagoya, Aichi 455-0033, Japan.

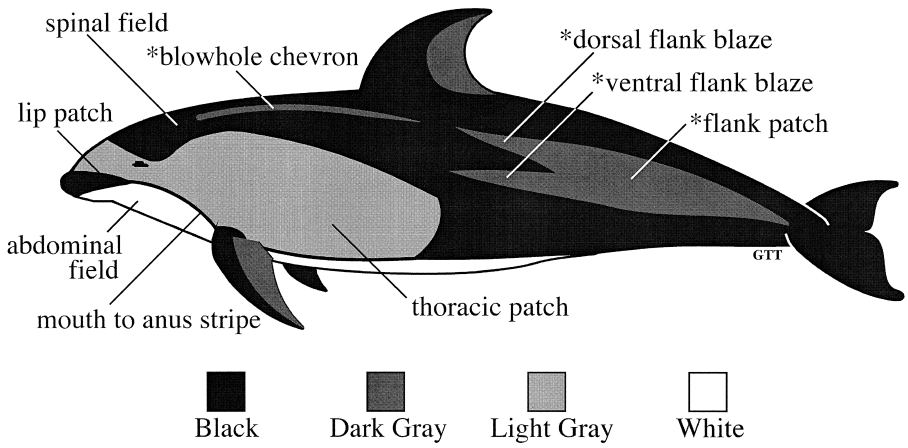


Figure 1. Schematic interpretation of the normal colour pattern in the Pacific white-sided dolphin. The dark gray areas include a *dorsal and *ventral flank blaze, *flank patch, and *blowhole chevron called 'suspender stripes'.

Table 1. Records of anomalous colour patterns in the Pacific white-sided dolphin.

Date	Location	Remarks	Reference
12 July 1954	Between San Martin Island and Guadalupe Island, Baja California, Mexico.	Fisherman's report of a snow white animal, except for small black eyebrows.	Brown & Norris, 1956
13 April 1955	6 miles NE of White' Landing, Santa Catalina Island, California.	Sighted, unpigmented except for a mottled gray area running dorsally from snout onto the tail stock.	Brown & Norris, 1956
4 May 1955	6 miles S of San Pedro Lighthouse.	Sighted, markedly faded pattern and its dorsal surface was covered with dirty gray spots.	Brown & Norris, 1956
4 July 1963	Outside the Farallon Island, off San Francisco Bay, California. (37°41′N, 123°45′W)	Sighted and photographed, a large lateral thoracic black area, a white line that is distinct and higher on the body, and a strong anterior white extension over the eye.	Brownell, 1965
25 Feb. 1966	37°46′N, 124°30′W	An anomalous coloured specimen collected.	Walker *et al.*, 1986
Nov. 1967	3 miles E of Pedro Point, Santa Cruz Island, California.	Photograph of an anomalous coloured white individual reported.	Stacey & Baird, 1991
Sept. 1968	4 miles E of Pedro Point, Santa Cruz Island, California.	Sighted in a group of 12–15, basically cream white with regions of gray around blowhole, at several locations on the back, on the leading edge of dorsal fin and on dorsal surface of tail stock.	Hain & Leatherwood, 1982
1987	Monterey Bay, California.	Some animals were predominately white with some black areas on their sides and extremities were sighted, and an anomalous white female with her normal coloured calf was photographed.	Black, 1989

black area, a very distinct white line that was higher on the body than normal, and a strong anterior white extension over the eye. A similar specimen with an unusual white stripe was collected from the North Pacific area at 37°46′N, 124°30′W on 25 February 1966 (Walker *et al.*, 1986). According to Stacey & Baird (1991), all-black individuals also have been observed.

Pacific white-sided dolphins are widely distributed in the North Pacific Ocean. The distribution

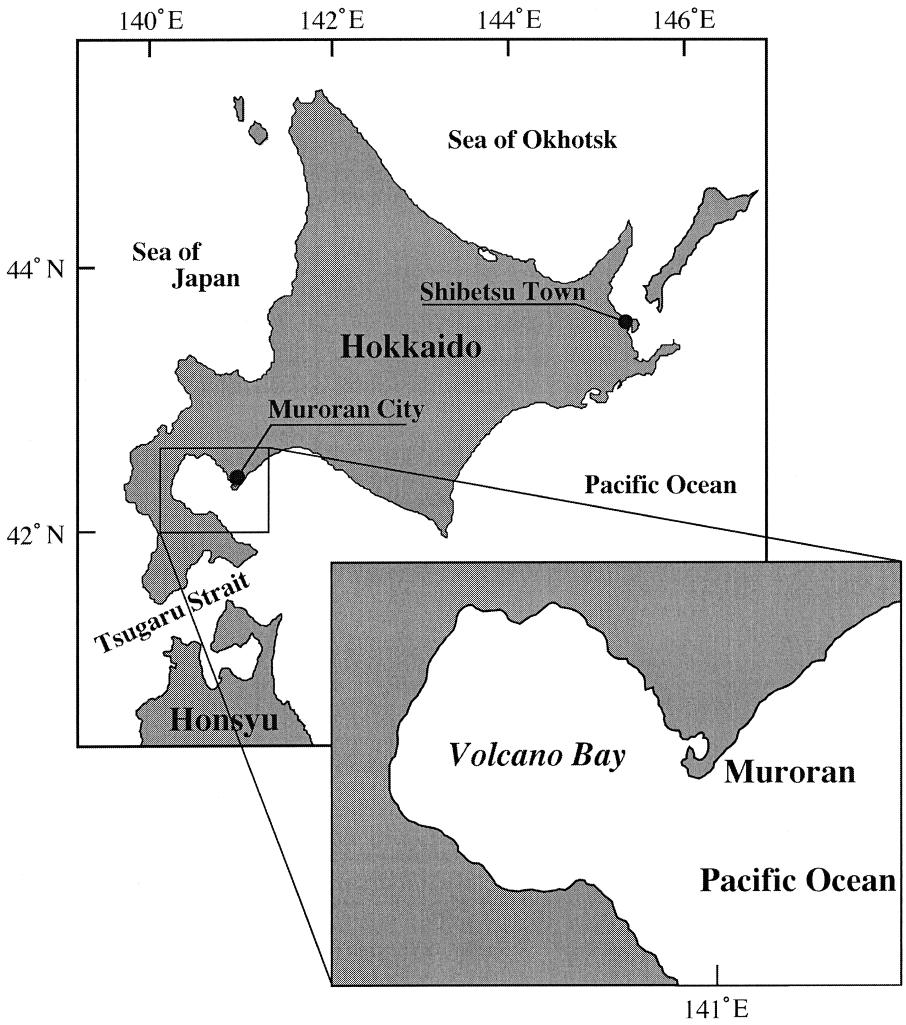


Figure 2. Map of Volcano Bay, Hokkaido, Japan.

has been reported from temperate waters between the 20th to 60th parallels in the eastern North Pacific (Mitchell, 1975; Leatherwood & Walker, 1982; Leatherwood *et al.*, 1984), and in the western North Pacific from Taiwan in the south to the Sea of Japan, off the Pacific coast of Japan, and the Kuril and Commander Islands in the north (Matsuura, 1943; Nishiwaki, 1967; Yang, 1976; Kasuya, 1981). Miyazaki & Shikano (1997) and Miyazaki *et al.* (1991) reported that there might be at least two populations for the species around Japanese waters; one population in the Sea of Japan and the other in the western-north North Pacific. Little is known about the migration of this species in the western-north North Pacific. Ohsumi (1986) and Miyashita (1986) expected the Pacific white-sided dolphin in the Sea of Japan migrated northward along the coast of Japan in spring, and reversed the direction in late autumn. The species was sighted in Tsugaru Strait from May to June and was speculated to travel to the Pacific Ocean through the strait (Kawamura *et al.*, 1983). This migration pattern appeared to be similar to that of Dall's porpoises (*Phocoenoides dalli*) in the Sea of Japan (Miyashita & Kasuya, 1988; Amano & Kuramochi, 1992). Tanaka (1998) reported that Pacific white-sided dolphins were observed in Volcano Bay, Hokkaido, Japan, during late May and the end of August, and Miyashita (1986) also reported sighting records of the species in the area in summer. However, there is no direct evidence from where the species comes to Volcano Bay. We

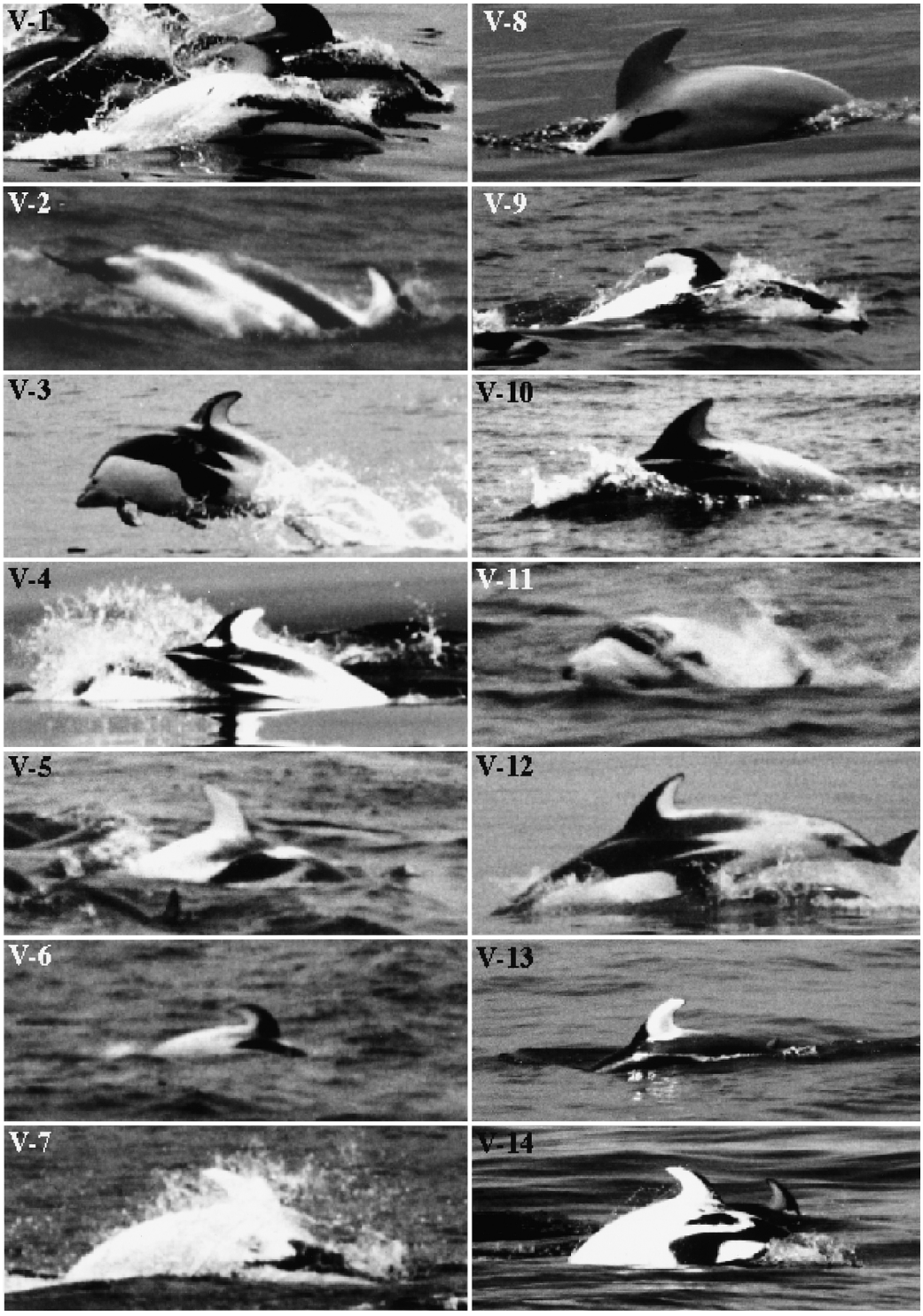


Figure 3. Best photographs of 14 Pacific white-sided dolphins having anomalous colour patterns. Photographs of V-1 taken by Seiji Yoshida; of V-2 by Miho Tanaka; of V-3, 6, 7, 8, 9, 11 and 13 by Takaya Yoshida; and of V-4, 5, 10, 12, and 14 by Kotoe Sasamori.

Table 2. Comparison of 14 dolphins' anomalous colour pattern; sighting side, degree of pigmentation, design of lateral body side, sex, and age.

		Body*		Dorsal fin*			
	Sighting side	anterior half	posterior half	anterior half	posterior half	Suspender stripes y/n**	Sex/Age***
Normal	−	+	+	+	+	yes	−
V-1	Right and Left	+	−	+	−	no	Adult male
V-2	Right and Left	+	+	+	−	yes	Possible adult male
V-3	Left	+	+	+	−	yes	Adult female or immature
V-4	Right and Left	+	+	+	−	yes	Adult female or immature
V-5	Right and Left	+	−	+	−	no	Adult female or immature
V-6	Right	unknown	−	+	−	no	Possible adult male
V-7	Right	+	−	−	−	no	Adult female or immature
V-8	Left	+	−	−	−	no	Possible adult male
V-9	Right	+	−	+	−	unknown	Possible adult male
V-10	Left	+	−	+	−	yes	Adult female or immature
V-11	Left	+	−	−	−	no	Adult male
V-12	Left	+	+	+	−	yes	Adult female or immature
V-13	Right and Left	+	+	−	−	yes	Possible adult male
V-14	Right	+	−	+	−	no	Adult female or immature

*The occurrence of pigmentation in four main body parts is expressed as +=pigmentation, −=unpigmentation, or unknown; the photograph of the part was not obtained. **Whether the dolphin had a standard design of 'suspender stripes' (flank patch, dorsal flank blaze, and ventral flank blaze). ***Sex was judged from the shape of dorsal fin.

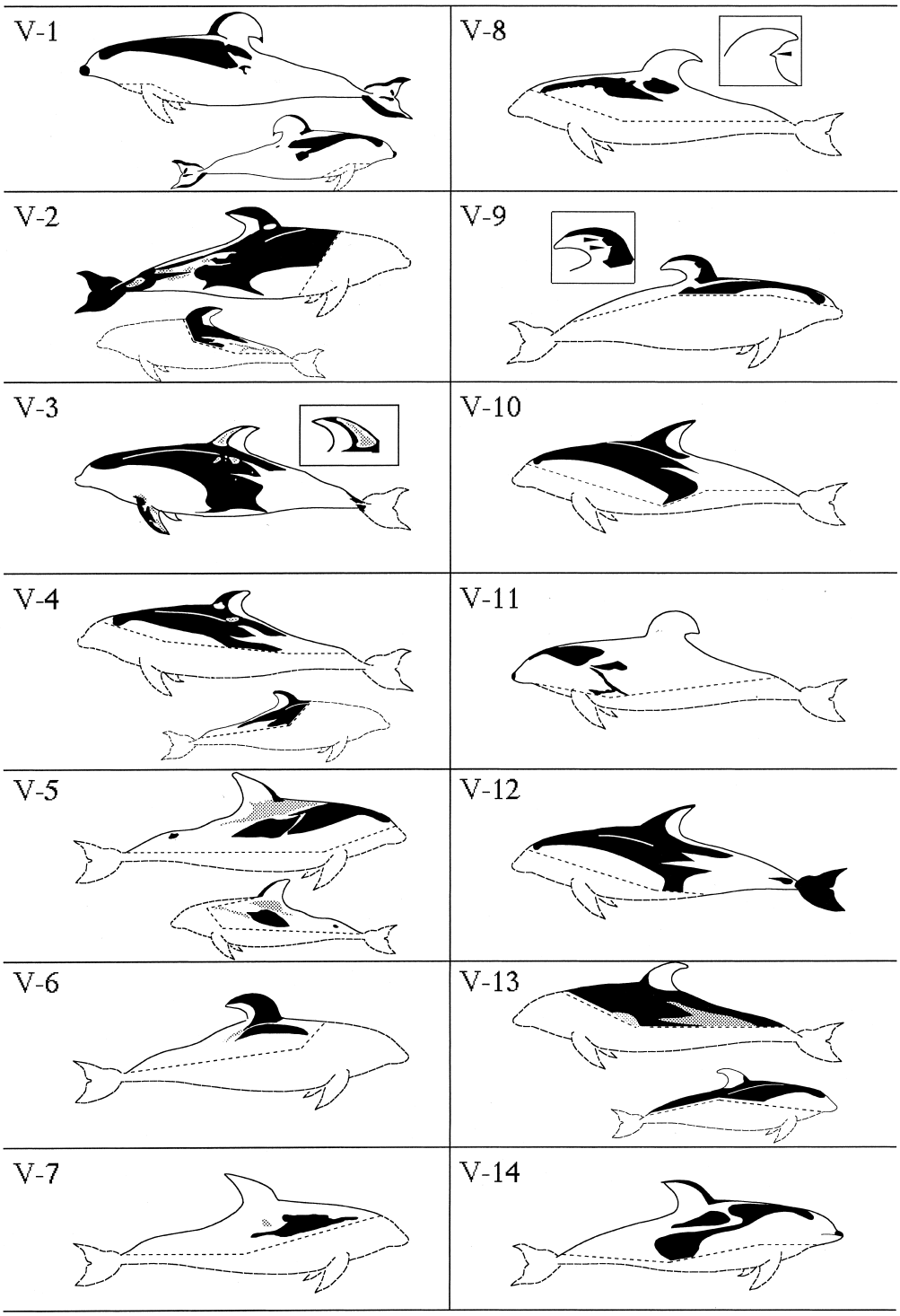
have confirmed that Pacific white-sided dolphins are almost absent in autumn from September to October and occur again for about a month in late autumn (November) in Volcano Bay (Tsutsui, 2001). It has never been clear whether animals that occur in summer and late autumn in Volcano Bay belong to the same population.

Since 1994, our research team has studied behavior of the species in Volcano Bay, Hokkaido, Japan, using dolphin-watching boats belonging to the Dolphin Watching Company, *ELM Co., Ltd.* in Muroran City (Fig. 2). In the past six years, we observed various types of the anomalous colour patterns in individual dolphins. However, in the West Pacific Ocean, no sighting records of dolphins having anomalous colour pattern have been published. In this study, we made individual identification of Pacific white-sided dolphins with anomalous colour patterns, and discussed the migration and population of the species into Volcano Bay based on their sighting records.

Materials and Methods

Since 1994, we have observed Pacific white-sided dolphins in Volcano Bay, Hokkaido, Japan (Fig. 2), from the beginning of May through August by using 2–4 dolphin watching boats (4.9–17 in tonnage, 14–15 m in length). These boats left Volcano

Figure 4. Illustrations of 14 Pacific white-sided dolphins having anomalous colour patterns. Solid and dotted-line show the recognized and the uncertain parts, respectively. Characteristics of 14 anomalous colour patterns were described as follows; V-1: a strongly hooked dorsal fin with black patch at the tip, mottled flukes, and black snout; V-2: two horizontal lines in the posterior-half of the right side of the body and a white patch on the right side of the base of the dorsal fin; V-3: mottled area in both sides of the dorsal fin and on outer side of the left flipper, and some mosaic patches on the left side of the body below the dorsal fin; V-4: a white patch at the left side of the base of the dorsal fin and one mottled patch below; V-5: distinctively different colouration between right and left sides of the body, and a black area on the right side of the body separated by line like a reverse letter 'Z'; V-6: right side of dorsal fin with wider black area compared with the others; V-7: a relatively erect and completely white dorsal fin; V-8: one gap at the posterior edge of completely white dorsal fin; V-9: two white gaps on black outline in the anterior part of the right side of the dorsal fin; V-10: white area on the left side of posterior body similar to 'suspender stripes'; V-11: a white dorsal fin with a strongly hooked shape; V-12: a white area on the left side of posterior body similar to suspender stripes and black flukes; V-13: normal colour pattern in the body with gray colour and anomalous white dorsal fin; V-14: separate black area on the right side by white line like letter 'S'.


V-1
V-8
V-2
V-9
V-3
V-10
V-4
V-11
V-5
V-12
V-6
V-13
V-7
V-14

Bay twice a day in the morning (10:00 a.m.–3:00 p.m.) and afternoon (14:00 p.m.–17:00 p.m.), respectively, as far as weather conditions were permitted (< Beaufort 4 in wind force scale). In addition, in five days in November 1999, we used a special research boat to search for the species all day long. When an anomalous white dolphin was found, we followed it, took photographs, and collected behavioural information. The photographs analyzed in this study were taken at 1–3 m above sea level by 35-mm cameras (*Nikon F5, Canon EOS-1N RS, EOS-1N HS*, and *EOS-5*) with a zoom telephoto lens of 80–300 mm.

During our observation, we collected 154 photographs of dolphins with an anomalous colour pattern. In the laboratory, photo-identification was made based on the differences in pigmentation. Then, we categorized each individual by the sex (determined by visual inspection of the dorsal fin as by Kasuya, 1995), and its approximate age (adult vs immature). Sighting dates of each individual were also summarized.

Results

Characteristics of anomalous colour patterns

We collected 154 photographs with multiple resightings of 14 identified individuals (V-1 to V-14) having specific white colour patterns (Fig. 3). In six dolphins (V-1, V-2, V-3, V-4, V-5, and V-13), we took photographs of body and dorsal fin from both the right and left side (Table 2). On the basis of multiple photographs of each individual, the colour patterns of 14 individuals were illustrated in Figure 4. These 14 dolphins showed anomalous white colour patterns to various degrees in several areas of the body, dorsal fin, and dorsal side of the tail. Thirteen individuals (all except for V-13) had a common point; they lacked the gray colour of normal individuals.

To learn about the formation of anomalous white colour, we compared its occurrence in four parts, the anterior and the posterior half of both body and dorsal fin, respectively (Table 2). Anomalous white colour patterns were found most frequently in the posterior half of the dorsal fin, and followed by the posterior half of the body, the anterior half of the dorsal fin, and the anterior half of the body. As for designs of lateral body pigmentation, these 14 dolphins were divided into two types: (1) dolphins having a common design; the 6 dolphins (V- 2, V-3, V-4, V-10, V-12, and V-13) had suspender stripes, although the colour was not gray, but white, except for V-13, (2) dolphins which had no suspender stripes, but had their own designs.

Sex and approximate age of these 14 dolphins were analyzed. Among them, five animals (V-1, V-2, V-7, V-8, and V-11), which occupied 36% of the total, appeared to be adult males because of strongly hooked dorsal fin (Kasuya, 1995), while the other 9 ones (64%) were either immature animals or adult females (Table 2).

Sighting records

When the 14 animals with the anomalous colour pattern were sighted in a school, they were likely to behave with the normally pigmented dolphins accompanying them. There was no abnormal behavior in the school.

Sighting records of 14 dolphins were summarized by year (Table 3). Five dolphins (V-1, V-2, V-3, V-6, and V-10) were sighted repeatedly in Volcano Bay for 2 years or more. V-1 was observed annually in July–August from 1994 to 1998. Among 6 seasons from 1994 to 1999, we observed 8 anomalous white colour dolphins in 1998, and followed 6 in 1997 and 1999, 2 in 1995 and 1996, and 1 in 1994. Moreover, V-3 and V-12 were sighted not only during the summer season, but also in late autumn (Fig. 5). Especially, V-12 was sighted in both summer and late autumn seasons in 1999. Almost all animals with anomalous colour patterns were recorded for the three months from June to August, which was the main migration season into Volcano Bay. Their sighting numbers were higher in 1997 and 1998, when much sighting effort was spent for observation.

There were nine cases where two dolphins were sighted in the same day (Table 3). V-8 and V-11, and V-3 and V-12 were found in the same school on 27 July 1998 and 24 November 1999, respectively. In the other seven cases, they belonged to different schools.

Discussion

Records of anomalously coloured Pacific white-sided dolphins were obtained only from the East Pacific Ocean (Table 1). Thus, this is the first record in the western Pacific Ocean. Moreover, most of the past records were about single dolphins; although Black (1989) reported 'some' white dolphins, she did not show the accurate figures. So, it is very rare that 14 dolphins with anomalous colour were observed in an area.

In addition to these 14 dolphins, an anomalous white animal was sighted and photographed on 5 August and 12 October off Shibetsu (Fig. 2) in western Hokkaido, which is about 500 km NW of Volcano Bay (H. Sato, personal communication). Judging from the photograph, the animal was different from the reported 14 dolphins in Volcano Bay. Thus, it is suggested that a larger number of Pacific white-sided dolphins with an anomalous colour pattern are present in the western North Pacific Ocean, and new anomalous colour patterns in this species may be recorded in the future.

Table 3. Sighting dates of 14 Pacific white-sided dolphins with anomalous colour pattern in Volcano Bay, Hokkaido, Japan during 1994 and 1999.

Year	V-1	V-2	V-3	V-4	V-5	V-6	V-7	V-8	V-9	V-10	V-11	V-12	V-13	V-14
1994	+	–	–	–	–	–	–	–	–	–	–	–	–	–
1995	29 July	+	–	–	–	–	–	–	–	–	–	–	–	–
1996	+	11 June 11 Aug.	–	–	–	–	–	–	–	–	–	–	–	–
1997	31 Aug.	sight	2 Aug. 4 Aug. 6 Aug. 31 Aug.	13 July	15 June 25 July 2 Aug.	13 July	–	–	–	–	–	–	–	–
1998	14 July	–	24 June	–	–	24 June	9 July 10 Aug.	27 July 26 Aug.	18 Aug.	14 July 10 Aug. 22 Aug.	27 July	–	–	–
1999	–	20 June	24 Nov.	–	–	–	–	–	–	12 Aug.	–	4 Aug. 24 Nov.	4 Aug.	29 July

+=photographed but no date recorded, –=not sighted, or sight=sighted but not photographed and no date recorded.

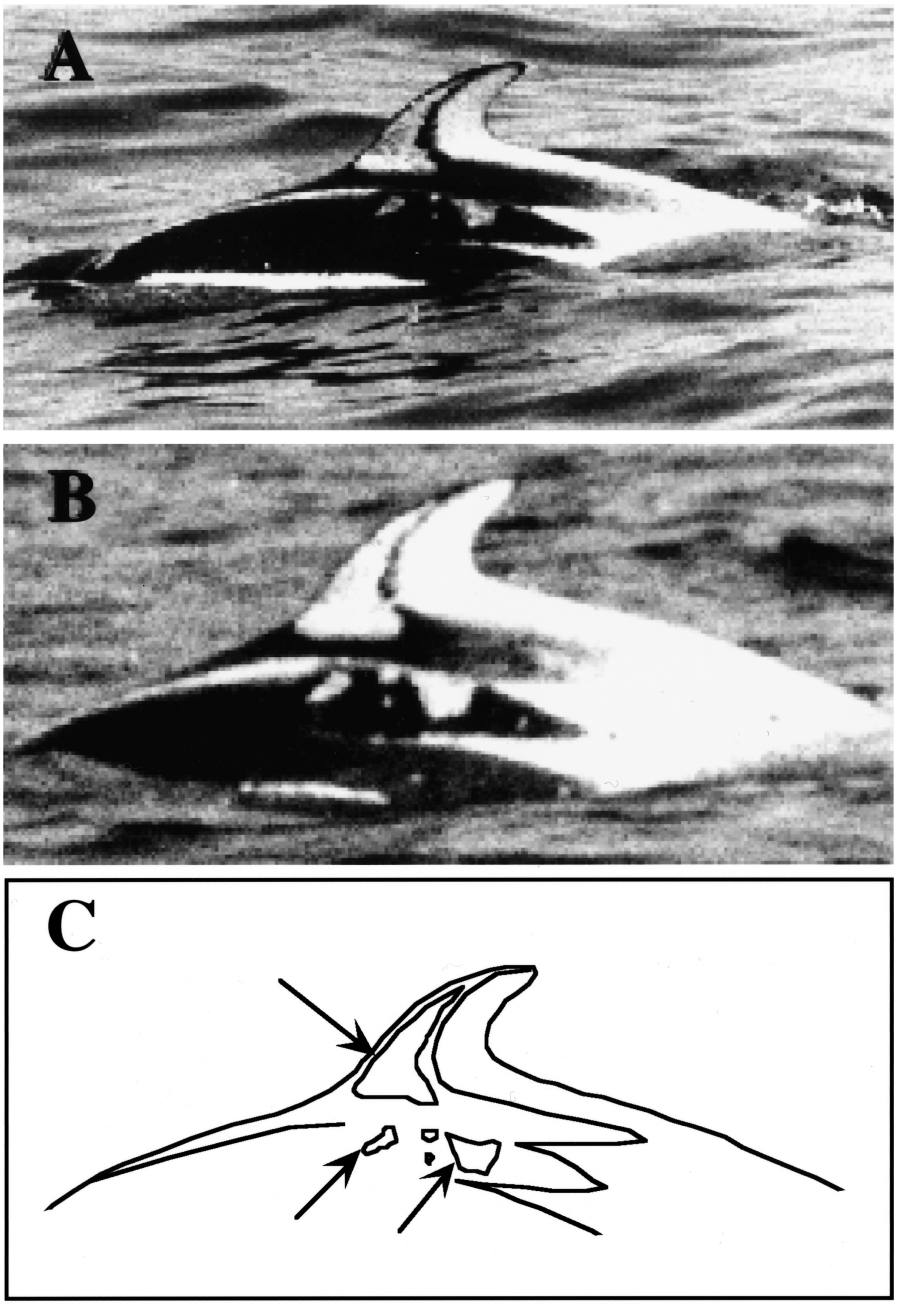


Figure 5. Photographs and sketch of V-3 (Courtesy by Takaya Yoshida). A: On 4 August, 1997. B: On 24 November, 1999. C: Arrows indicate characteristic white patches.

There were adult males and females and immatures present among the 14 anomalous white dolphins (Table 2). In addition, the anomalous white Pacific white sided-dolphin described by Brown & Norris (1956) was likely to be a mature male judging from information on its dorsal fin Black (1989) also photographed a white female. Thus, these anomalous colour patterns in Pacific white-sided dolphins were distinctly different from the white colour pattern found in old adult male sperm

whales (*Physeter catodon*) and the scratched white wound found in adult Risso's dolphins (*Grampus griseus*), suggesting they were not formed as sexual characteristics and did not change with age.

An albino individual, that is completely white with reddish eyes, was reported in the bottlenose dolphin (Fertl *et al*., 1999) and the sperm whale (Ohsumi, 1958; Berzin, 1971), but not in the Pacific white sided-dolphin. All of the present 14 anomalous white dolphins were partly white in the normally-pigmented areas, but not completely absence of pigmentation. Thus, they were not true albinos due to a simple autosomal recessive condition at a particular gene locus, but they might be close to the phenotypic 'partial albino' or 'pseudo-albino', which is due to a number of genetic and biochemical factors (Searle, 1968; Hain & Leatherwood, 1982). The possibility that anomalous colour patterns are caused by disease or scars may be rejected on two accounts; the present 14 Pacific white sided-dolphins appeared to behave normally, and no change of their pigmentation was confirmed (Fig. 5).

To identify populations of cetaceans, photographic identification is considered to be one of the most useful methods. Information on colour pattern and body shape, dorsal fin and fluke are useful for individual identification as natural markers. Hamond *et al*. (1990) summarized the extent of such studies in 17 cetacean species, e.g. right (*Eubalaena glacialis*), humpback (*Megaptera novaeangliae*), and killer whales (*Orcinus orca*). In the Pacific white-sided dolphin; however, we were not able to find any useful external characters, except for the presence of anomalous colour patterns. These 14 dolphins are considered to be useful tools for improving biological knowledge of the species in the future.

The fact that some individuals were annually sighted in the Volcano Bay for some years suggests that these Pacific white-sided dolphins belong to the same population and migrate to the area every year. To clarify whether the Pacific white-sided dolphins annually observed in Volcano Bay come from the population of the Sea of Japan or from that of the western-north Pacific, present anomalous colour patterns are considered to be very useful as natural markers. If some of these 14 identified individuals are confirmed in either the Sea of Japan or western-north North Pacific in the season when they are absent from Volcano Bay, the origin and migration route of these Pacific white-sided dolphins to Volcano Bay will be resolved.

Sighting records of V-3 and V-12 indicated that at least these animals occur twice a year (in both spring-summer and late autumn) in Volcano Bay. This information suggests that Pacific white-sided dolphins sighted in late autumn in the area belong to the same population sighted during the spring and summer, and they travel elsewhere outside Volcano Bay during only a few months (September–October). It is hardly possible that they travel far away from the area in September and October, and then come back to the area in November. Therefore, they are considered residents in waters off Hokkaido near Volcano Bay for more than half a year from late May to November.

Acknowledgments

We express our thanks to three Captains: H. Kimura, T. Mukai, S. Hiratsuka, and other workers of the *ELM Co., Ltd.* for cooperation with our research. S. Yoshida, K. Sasamori, and T. Yoshida in Muroran City helped us with taking photographs. H. Sato also gave us useful information and photographs. Dr James G. Mead (National Museum of Natural History Smithsonian Institution) critically read the manuscript and gave us valuable comments.

Literature Cited

Amano, M. & Kuramochi, T. (1992) Segregative migration of Dall's porpoise (*Phocoenoides Dalli*) in the Sea of Japan and Sea of Okhotsk. *Mar. Mamm. Sci.* **8,** 143–151.

Berzin, A. A. (1971) Kashalot. Izdatel'stvo pishchevaya promyshlennost, Moskva (English translation, 394 pp.). *Smithsonian Inst*. 1972.

Black, N. A. (1989) Pacific white-sided dolphins in Monterey Bay. *Whalewatcher* (*Journal of American Cetacean Society*) **23,** 5–8.

Brownell, R. L., Jr. (1965) An anomalous color pattern on a Pacific striped dolphin. *Bulletin of the Southern California Academy of Sciences* **64,** 242–243.

Brownell, R. L., Jr., Walker, W. A. & Forney, K. A. (1999) Pacific White-sided Dolphin *Lagenorhynchus obliquidens* Gill, 1865. In: S. H. Ridgway & Sir R. Harrison (eds.) *Handbook of Marine Mammals*, *Vol. 6*: *The Second Book of Dolphins and the Porpoises*. pp. 57–84. Academic Press: Florida.

Brown, D. H. & Norris, K. S. (1956) Observations of captive and wild cetaceans. *J. Mammal.* **37,** 311–326.

Fertl, D., Pusser, L. T. & Long, J. J. (1999) First record of an albino Bottlenose dolphin (*Tursiops truncatus*) in the Gulf of Mexico, with a review of anomalously white cetaceans. *Mar. Mamm. Sci.* **15,** 227–234.

Hain, J. H. W. & Leatherwood, S. (1982) Two sightings of white pilot whales, *Globicepbala melaena*, and summarized records of anomalously white cetaceans. *J. Mammal.* **63**, 338–343.

Hammond, P. S., Mizroch, S. A. & Donovan, G. P. (1990) Report of the Workshop on Individual Recognition and the Estimation of Cetacean Population Parameters. In: *Individual Recognition of Cetaceans. Rep. Int. Whal. Commn*. (**Special Issue 12**), 3–7.

Jefferson, T. A., Leatherwood, S. & Webber, M. A. (1993) *FAO Species Identification Guide. Marine Mammals of the World*. FAO: Rome, 320 pp.

Kasuya, T. (1981) Identification manual of dolphins and porpoises in the Japanese waters. The Research Division, Fisheries Agency of Japan, 41 (in Japanese).

Kasuya, T. (1995) Dorsal fin of *Lagenorhynchus obliquidens*: an indicator of male sexual maturity. Abstract for the 11th biennial conference on the biology of marine mammal, Orlando, Florida, U.S.A.

Kawamura, A., Nakano, H., Tanaka, H., Sato, M., Fujise, Y. & Nishida, K. (1983) Sighting survey of dolphins in the Thugaru Strait by the Sei-kan ferry-boats (Result). *Geiken-Tsushin* 351–352, 29–52 (in Japanese).

Leatherwood, S. & Walker, W. A. (1982) Population biology and ecology of the *Lagenorhynchus obliquidens* in the northeastern Pacific. Part I: distribution, seasonal movements and abundance with a bibliography and summary of specimens materials. *SWFC Admin. Rep*. LJ82–18C, 76 pp.

Leatherwood, S., Reeves, R. R., Bowles, A. E., Stewart, B. S. & Goodrich, K. R (1984) Distribution, seasonal movements, and abundance of Pacific white-sided dolphins in the eastern North Pacific. *Sci. Rep. Whales Res. Inst.* **35**, 129–157.

Matsuura, Y. (1943) *Marine Mammals*. Tennen-sha, Tokyo. 298 pp. (in Japanese).

Mitchell, E. (1970) Pigmentation pattern evolution in delphinid cetaceans: An essay in adaptive colorations. *Can. J. Zool.* **48**, 717–740.

Mitchell, E. (1975) Review of small cetacea, identity and status of species and stocks. In: *Report on the Meeting on Smaller Cetaceans, April 1–11, 1974, Montreal. Journal of Fisheries Research Board of Canada* **32,** 899–983

Miyazaki, N. & Shikano, C. (1997) Comparison of growth and skull morphology of Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, between the coastal waters of Iki Island and the oceanic waters of the western North Pacific. *Mammalia* **4**, 561–572.

Miyazaki, N., Kuramochi, T. & Amano, M. (1991) Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) off northern Hokkaido. *Memoirs of the National Science Museum*, *Tokyo* **24**, 131–139.

Miyashita, T. (1986) Investigation by research vessels. In: T. Tamura, S. Ohsumi & S. Arai (eds.) *Report of Fishery Pollution Measures Trust Enterprise Investigation (1981–1985)*. pp. 78–82. Fishery pollution measures investigation and examination committee, Fishery Agency of Japan (in Japanese).

Miyashita, T. & Kasuya, T. (1988) Distribution and abundance of Dall's porpoise off Japan. *Sci. Rep. Whales Res. Inst.* **39**, 121–150.

Nishiwaki, M. (1967) Distribution and migration of marine animals in the North Pacific area. *Bulletin of the Ocean Research Institute*, *University of Tokyo* **1**, 1–49.

Ohsumi, S. (1958) A descendant of Moby Dick, or a white sperm whale. *Sci. Rep. Whales Res. Inst.* **13**, 207–209.

Ohsumi, S. (1986) Synthetic analysis. In: T. Tamura, S. Ohsumi & S. Arai (eds.) *Report of Fishery Pollution Measures Trust Enterprise Investigation* (*1981–1985*). pp. 82–87. Fishery pollution measures investigation and examination committee, Fishery Agency of Japan (in Japanese).

Scheffer, V. B. (1950) The striped dolphin, *Lagenorhynchus obliquidens* Gill 1865, on the coast of North America. *Amer. Midland Nat.* **44,** 750–758.

Searle, A. B. (1968) *Comparative Genetics of Coat Colour in Mammals*. Logos Press Ltd., London, 308 pp.

Stacey, P. J. & Baird, R. W. (1991) Status of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in Canada. *Canadian Field-Naturalist* **105**, 219–232.

Tanaka, M. (1998) Biological study on Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) off Muroran, Hokkaido, Japan. M.S. thesis, Univ. of Tokyo, 58 pp. (in Japanese).

Tsutsui, S. (2001) Acoustic study of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in Volcano Bay, Hokkaido, Japan. M.S. thesis, Univ. of Tokyo, 74 pp. (in Japanese).

Walker, W. A., Leatherwood, S., Goodrich, K. R., Perrin, W. F. & Stroud, R. K. (1986) Geographical variation and biology of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in the north-eastern Pacific. In: M. M. Bryden & R. Harrison (eds.) *Research on Dolphins*. pp. 441–465. Oxford University Press, Oxford.

Yang, H. (1976) Studies on the whales, porpoises and dolphins of Taiwan, *Annual Report of Science*, *Taiwan Museum*, Taipei **19**, 131–178.