International Whale Comission

Migration of a humpback whale between the Cape Verde Islands and Iceland.

Jann, B.[1], J. Allen [2], M. Carrillo [3], S. Hanquet [4], S.K. Katona [2], T. Martin[5], R. Seton [2], R. Reeves [6], P.T. Stevick [2], and F. W. Wenzel [7]

[1] Swiss Whale Society, via Nolgio 3, CH-6900 Massagno, Switzerland
[2] College of the Atlantic, 105 Eden St., Bar Harbor, Maine 04609, USA
[3] **Canariasconservacion.org** La Laguna, Tenerife, Canaries, Spain
[4] Los Cristianos, Tenerife, Canaries, Spain
[5] British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 OET, UK
[6] Okapi Wildlife Assoc. 27 Chandler Lane, Hudson, Quebec, Canada J0P 1H0
[7] National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water St., Woods Hole, Ma. 02543 USA.

ABSTRACT

Migratory destinations of humpback whales (*Megaptera novaeangliae)* can be determined by using natural markings of the ventral fluke patterns of individuals. During the winter-spring seasons of 1990, 1991, 1995, 1996 and 1999 to 2002 a total of 42 individual humpbacks were identified by fluke photographs from the waters of the Cape Verde Islands. These fluke photographs were compared with other individual photographs taken from throughout the North Atlantic in an attempt to identify resightings. One individual had been previously photographed in the Denmark Strait off Iceland. This is the first photographic match of a humpback fluke from the tropical waters of the eastern North Atlantic to the high latitude feeding grounds, thus providing an insight into migratory patterns for this species.

Our findings in the Cape Verde Islands are consistent with the theory that a second breeding stock of humpbacks exists in the eastern North Atlantic. The presence of cows with young calves, presence of singers, distribution and residency during the mating and calving season, combined, this information implies that these waters surrounding the Cape Verde Island archipelago probably represents a breeding and calving ground for the eastern North Atlantic humpback whales.

INTRODUCTION

The North Atlantic humpback whale (*Megaptera novaeangliae*) is among the best studied of large whale populations in the world. Since the 1970's, the use of photo-identification has provided extensive information on population structure and migratory movements from tropical waters north to the arctic ice pack of whales in this ocean basin (Katona and Whitehead 1981; Katona and Beard 1991; Clapham and Mead 1999; Smith et al. 1999). More recently, genetic tagging has yielded additional data on the connections between whales from different areas of the North Atlantic (Palsbøll et al. 1995; 1997; Larsen et al. 1996).

It is clear from these previous studies that humpback whales feed in a number of relatively discrete sub-populations including; the Gulf of Maine, Newfoundland/ Labrador, Gulf of St. Lawrence, Greenland, Iceland and Norway. Fidelity to these summer feeding areas is strong and apparently maternally directed and genetic analysis has suggested that this fidelity is maintained on an evolutionary timescale (Larsen et al. 1996; Palsbøll et al. 1997). Despite the low level of movement among these feeding habitats, photo-id and genotyping has clearly shown that some individual whales from these high-latitude areas will migrate over 8,000 km in winter to a common breeding ground in the West Indies (Martin et al. 1984; Stevick et al. 1998; 1999a) where they mix spatially and genetically. The great majority of humpback whales from the North Atlantic appear to utilize this West Indies wintering area, with large concentrations found in the northern Antilles, on or near Silver Bank (Winn et al. 1975; Clapham and Mead 1999; Smith et al. 1999).

However, during the 19th century Yankee whalers were rarely recorded taking humpbacks in the northern Antilles, but instead exploited what were apparently large populations in the southeastern Caribbean and Cape Verde Islands (Mitchell and Reeves, 1983; Reeves et al. 2001; 2002; Reeves and Smith 2002). Today, densities of humpbacks in these two historic breeding areas are comparatively low. Recently, one photographic match was made from the southeastern Caribbean to Fyllas Bank, Greenland (western North Atlantic feeding grounds) **(**Stevick et al. 1999b**)** suggesting that the whales in this lower portion of the West Indies wintering area are similar in their migratory movements to those found in the main breeding grounds in the northern Antilles. However, the origin of humpback whales in the Cape Verde Islands has remained unknown.

Here, we report the first match of an individually identified humpback whale from the Cape Verde Islands to a eastern feeding ground (Iceland), and discuss the implications for population structure in the North Atlantic population.

METHODS AND MATERIALS

Study area

The Cape Verde Islands are situated in the eastern North Atlantic between 14^{0}48' - 17^{0}22'N and 22^{0}44'-25^{0}22'W, 460 to 830 km west of Senegal (Hazevoet 1995). The 10 islands and several islets are of volcanic origin, with steep shores, arising from a marine bottom of more than 3000m depth. Only the islands of Maio, Boavista and Sal have a continental platform, while in the north-western part the group of Sao Vicente, Santa Lucia, Branco and Raso presents to some extent shallow waters, of less than 100m depth (Fig.1). The main study area during these research seasons (1990 to 2002) is situated on the western side of this archipelago among the islands of Sal, Boavista and Maio.

These waters are also known for strong trade winds, rough seas, presence of sand storms, often making navigation around the Cape Verde islands difficult and hazardous and producing less than ideal conditions for mariners and whale researchers. This explains in part, the low number of flukes obtained from this region and limited information about cetaceans occurring in the archipelago (Reiner et al. 1996; Hazevoet and Wenzel 2000).

Data collection

Sighting effort during 1990, 1991, 1995 and 1996 took place from February to May aboard a 5 m inflatable boat from the islands of Sal and Boavista (Reiner et al. 1996; Hazevoet and Wenzel 2000).

Sighting effort in 1999 took place aboard a 50m steel hull motor ship, from 26 February to 8 April. In 2000 (27 to 29 of February and 30 March to 4 April) and 2001 (31 March to 2 May) the observations were made from a 37m schooner. During 2002, a 20 m sailboat was utilized from 22 March to 2 May. During 2000 – 2002, a 5 meter inflatable boat was deployed from these larger vessels when humpbacks were observed and sea state permitted. More humpback fluke photographs were obtained during the 1999 – 2002 seasons than previous years, demonstrating greater success using larger vessels in poor sea state conditions which prevail in these waters.

For each cetacean sighting the time, GPS position, group size and composition, behaviour were noted. Photographs for identification purposes and acoustic recordings were made during approaches of humpback whales.

The photographs were shot with a 35 mm single lens reflex camera with a 75-300mm zoom using 400 ASA black and white print film.

Photo Comparison

There are two major projects involving individual identification of humpback whales that include geographical coverage over much of the North Atlantic Ocean: the North Atlantic Humpback Whale Catalogue (NAHWC) and the collection from the Years of the North Atlantic Humpback Whale (YoNAH) project. Both humpback catalogues (NAHWC and YoNAH) are maintained at Allied Whale, College of the Atlantic, 105 Eden St., Bar Harbor, Maine 04609, USA.

The NAHWC is a central curator facility for identification fluke photographs of humpback whales from throughout the North Atlantic Ocean. Photographs date from 1952 to 2002, though few data are available before 1978, and analysis subsequent to 1994 is not completed. The project is collaborative and photographs were submitted by more than 350 contributors. Samples were collected opportunistically, so temporal and spatial coverage is highly variable. Most samples were collected from the feeding grounds of the western North Atlantic (Table 1 and 2).

The YoNAH project, an ocean-basin-wide study of humpback whales, was conducted during 1992 and 1993. As part of this study, identification photographs were collected from humpback whales in all of the major feeding grounds and in the West Indies, the principal breeding ground in the western North Atlantic, using standardized protocols. Due to logistical considerations, sampling intensity in Icelandic and Norwegian waters, while considerably greater than during any previous effort, however it was not as high as that in the western North Atlantic feeding areas (i.e., Greenland, eastern Canadian waters and northwestern United States (Gulf of Maine) (Smith et al. 1999). No YoNAH sampling was conducted in the Cape Verde Islands (Table 1 and 2).

Collection	NAHWC	YoNAH
Feeding grounds, Western	3,431	1,398
Feeding grounds, Eastern	158	260
West Indies	1,647	1,324
Cape Verde Is.	22	0
Non-feeding/breeding regions: US Coast So. of Cape Cod, Bermuda and Mediterranean	122	0
TOTAL	5,380	2,982

Table 1. Numbers of individuals identified in the two photographic collections (as of 31 Dec. 2002) to which the Cape Verde Islands photographs were compared. Individuals identified in both feeding and breeding regions are only included in the number for the feeding area they were associated with. Western and eastern feeding areas are divided at Cape Farewell, Greenland. No photographic matches have been identified between the western and eastern feeding areas.

NAHWC	West Indies	Cape Verde Is.
Feeding grounds, Western	564	0
Feeding grounds, Eastern	15	1
YoNAH		
Feeding grounds, Western	163	0
Feeding grounds, Eastern	21	0

Table 2. Numbers of individuals in the NAHWC and the YoNAH collections identified in both feeding and breeding grounds.

While the YoNAH collection has not been methodically compared to the NAHWC, due to resource and time limitations, to date nearly eight hundred individuals have been identified in common to the two collections (J. Allen pers. comm.). All identification photographs from the Cape Verde Islands were compared to both collections to identify re-sightings using methods described in Katona and Whitehead 1981; Katona and Beard 1990 and Smith *et al*. 1999.

RESULTS

A total of 42 individual humpbacks have been identified thus far within the waters of the Cape Verde Islands. The first Cape Verde humpback whale fluke photographs were obtained in 1991 (n=2); 1995 (n=1), in 1999 (n=22), in 2001 (n=1) and during 2002 (n=16). No individuals were identified in more than one year in the Cape Verde Islands.

A single individual, NAHWC#4504, photographed on 10 March 1999 in the Bay of Sal Rei, Boavista, Cape Verde Islands at 16° 02'N, 23° 02'W. and had previously been identified in the Denmark Strait west of Iceland at 65° 66'N, 27° 30'W in July of 1982. No additional resightings of this animal were recorded during the 18 year lapse between sightings. (Figures 2 and 3 – the two matching flukes)

No individual from the Cape Verde Islands was identified in the feeding ground sample from the YoNAH collection. No individual from the Cape Verde Islands was identified in the breeding grounds of the West Indies, utilizing both the YoNAH and

NAHWC Collections.

Presence of mother calf pairs

Humpback mother calf pairs have been observed as early as 23 of February (in Baia de Mordeira, Sal in 1995 and in the Bay of Sal Rei, Boavista in 2002), and as late as June 5 (at Punta Preta, Sal, Robert Mannink personal communication). A calf is defined as; < 5 meters in total length; often of gray body coloration; remaining most of the time a position within one body length of the female (see Clapham et al. 1999; Clapham and Mead 2001). Most observed calves had folded dorsal fins, fetal folds and some calves had wrinkles similar to a "pickle". Nearly all encounters with mother-calf pairs were in waters <15 meters deep (see Smultea 1994).

Presence of singers

Humpback whale songs have been described in great detail by many authors (see Payne and Guinee 1983; Payne and McVay 1971, Winn et al. 1975; 1981; Winn and Winn, 1978; Noad et al. 2000).

Comparisons of humpback whale songs showed that within the North Atlantic Ocean basin this population could share similar songs, while the differences to songs from other basins (North Pacific) were significant (Winn *et al.* 1981). Recent studies (Reiner *et al.* 1996; Carrillo *et al.* 1999; Hazevoet and Wenzel, 2000; Jann and Wenzel 2001) confirmed this continued presence of singing male humpbacks, especially around the islands of Sal and Boavista between February and May.

Humpback whale songs have been recorded during every field season. The first song of the year was recorded as early as 17 February (1990) (Reiner et al. 1996) and as late into the season as 12 May (1996) (Hazevoet & Wenzel 2000). Planned further analyses will assess inter-annual variation in CVI songs and compare songs between the eastern and western North Atlantic. We assume that by mid-May most humpbacks have started their migration northward to the feeding grounds.

Discussion

Over the years several authors have suggested the existence of two breeding stocks of North Atlantic humpback whales, one along the western and another along the eastern margin of the North Atlantic Ocean basin, separated at Cape Farewell, Greenland. However, the degree of separation, overlap and limits of the two proposed stocks have often been questioned (Mitchell and Reeves 1983; Larsen et al. 1996; Palsboll et al. 1995; 1997; Smith et al. 1999; Stevick et al. 1999a).

The number of humpback whales identified during this project (n=42), the sightings of mothers with young calves, recorded humpback songs, and surface-active groups provide further evidence that the Cape Verde Islands are currently used as breeding and calving habitat by humpbacks during the winter and spring.

The re-sighting to Iceland is the first evidence for a feeding ground destination for humpback whales from the Cape Verde Islands. As animals identified in the Denmark Strait have also been identified in the West Indies (Martin et al. 1984), this re-sighting is consistent with overlap on the feeding grounds between animals from the West Indies and Cape Verde populations rather than distinct feeding ground destinations for individuals from the two breeding areas.

This re-sighting to an eastern feeding area, coupled with no re-sightings to western feeding areas and/or the West Indies is consistent with the theory that humpbacks from the Cape Verde Islands represent a breeding group distinct from that found in the West Indies. It is also consistent with this group feeding preferentially or exclusively in eastern feeding grounds. This model is further supported by nuclear genetic differences between eastern and western feeding areas (Larsen et al. 1996; Palsboll et al. 1995; 1997).

Understanding the stock origin of the whales wintering in the CVI is important to the management of humpback whales in the North Atlantic. Winn et al. (1981) discussion of shared song type by North Atlantic humpbacks between the Cape Verde Islands and West Indies (n=1) provides another means of comparing these two groups. A larger sample size of songs will be required annually and inter-annually to compare songs (vocal dialects) to discriminate between stocks.

This photographic match to Iceland indicates that at least some humpbacks from Cape Verde waters go to the known North Atlantic eastern feeding grounds. It is difficult to interpret effort for the NAHWC by region and years. The NAHWC humpback fluke catalogue has grown considerably over the last 50 years, and YoNAH was a limited two year study (1992 and 1993). However, the low match rate (n=1) strongly suggests that most of the humpbacks in the CVI are utilizing some other (eastern North Atlantic) feeding area in which there is current little or no sampling effort. This one match, to the smallest collection in the eastern feeding grounds (Table 1), and an eighteen year lapse between sightings for this individual is not surprising, when you consider the limited sighting and photo-identification effort in these waters over the last 20 years.

Were the West Indies and the Cape Verde Islands to represent habitats used by a single interbreeding stock, utilizing the western and eastern feeding grounds equally, a high level of movement between these areas would be anticipated, while none was observed. Additionally, this single-stock model leaves unresolved the source of the east-west genetic variation observed by Larsen et al. 1996; Palboll et al. 1995; 1997.

Larsen et al. (1996) analysis of biopsy samples from the central and north eastern North Atlantic detected no significant deviations from proportions, nor any differences in genotype frequencies between localities at the nuclear loci. However, the mitochondrial analyses revealed two distinct matrilineal aggregations: the central and north eastern North Atlantic. Larsen's findings were not compatible with the idea of a separate eastern north Atlantic breeding ground unless one has been established recently. However, the proposed alternative hypothesis of a common North Atlantic panmictic population (wintering primarily in the West Indies) in which individual whales display maternally directed site fidelity to specific feeding grounds.

CONCLUSIONS

Recent intensive studies of the North Atlantic humpback whale population have raised questions about the possibility of two distinct stocks of humpbacks in the North Atlantic (Larsen et al. 1996; Palboll et al. 1995; 1997; Smith et al. 1999). As shown in Palsboll *et al.* (1995; 1997), genetic tagging can be used to identify single individuals allowing not only to estimate abundance through mark-recapture techniques, but also to determine the sex of the animal, making it also possible to distinguish abundance

estimates and behaviour of males and females. Further more, genetic studies of North Atlantic feeding aggregations (Palsboll *et al.*, 1995; 1997) have shown that there are two distinct genetic populations: this heterogeneity is due to maternally site directed fidelity, a behaviour also documented for humpbacks in the Gulf of Maine (Weinrich 1998). It is not known if the humpbacks of the Cape Verde Islands follow this behaviour pattern and how they may contribute to this heterogeneity. It is therefore of great importance to apply this genetic tagging technique in the Cape Verde Islands.

In general, the photo identification has to be intensified to possibly answer questions of population movements on local and ocean wide basis. Genetic samples need to be gathered and compared to those obtained during the YoNAH collection.

Research efforts in the Cape Verde Islands have usually been limited over the years, with unfortunately little concrete results to ascertain the stability, habitat use, migratory patterns of those humpbacks which visit these waters (Winn et al. 1991; Reiner et al. 1996; Carrillo *et al*. 1999; Hazevoet and Wenzel, 2000; Jann and Wenzel 2001). It is still not known if the population in the archipelago is stable, declining or increasing, the later being potentially the case in the rest of the North Atlantic (Smith *et al.* 1999). Research efforts will need to expand include more photo identification, biopsy program and song analysis throughout the Eastern North Atlantic Ocean basin.

ACKNOWLEDGEMENTS

We wish to acknowledge the Captains and crews of the ships Holland, Corvette and Sodade, the volunteers who made this research possible through their very often enthusiastic participation. A number of friends and reviewers greatly assisted us with earlier drafts of this manuscript. A special thanks to Tim Smith, Phil Clapham, Kees Hazevoet, Melissa Alexander, Whale Dolphin Conservation Society, Cetacean Society International, and Durant Hembree for their years of encouragement regarding humpback whale research in the eastern North Atlantic, especially Cape Verde Islands and Iceland.

REFERENCES

Clapham, P.J., S. E. Wetmore, S.E., T.D. Smith, and Mead, J. G. 1999. Length at birth and at independence in humpback whales. Journal of Cetacean Research and Management 1:141-146.

Clapham, P. J. and J. G. Mead 1999. Megaptera novaeangliae. Mammalian Species No. 604. pp. 1-9, 3 figs. Published by the American Society of Mammalogists.

Carrillo, M., Jann, B., Seton and R., Wenzel, F. 1999. Present status of humpback whales in the Cape Verde islands. Poster presented at the 13th Biennial Conference on the Biology of Marine Mammals, Maui, Hawaii, December 1999

Hazevoet C.J. 1995. *The birds of the Cape Verde Islands*. B.O.U. Check-list No.13 British Ornithologists' Union, Tring, Herts, UK 192 pp.

Hazevoet, C.J. and Wenzel, F.W. 2000. Whales and dolphins (Mammalia, Cetacea) of the Cape Verde Islands, with special reference to the humpback whale *Megaptera novaeangliae* (Borowski, 1781). *Contr. to Zool.* 68(3): 197-211.

Jann, B. and Wenzel, F.W. 2001. Humpback whales in the Cape Verde Islands. Paper SC/53/NAH19 presented to the IWC Scientific Committee, July 2001, London. UK.

Jann, B., F.W. Wenzel, and Reeves R.R. 2002. Humpback whales (*Megaptera novaeangliae*, Borowski 1781 Cetacea, Mysticeti) of the Cape Verde Islands: Past and Present. Proceedings of the Flora and Fauna Conference of the Atlantic Islands, Praia, Cape Verde Islands, Sept. 2002.

Katona, S.K. and Whitehead H. 1981. Identifying humpback whales using their natural markings. *Polar Record* 20:439-444.

Katona, S.K. and Beard, J.A. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. *Rep. int. Whal. Commn* (special issue) 12:295-305.

Larsen A.H., J., Sigurjonsson, N. Øien, G. Vikingsson, and Palsboll, P. J. 1996. Population genetic analysis of mitochondrial and nuclear genetic loci in skin biopsies collected from central and northeastern North Atlantic humpback whales (*Megaptera novaeangliae*): population identity and migratory destinations. Proc. R. Soc. Lond. Ser. B. 263:1611-18.

Martin, A.R., Katona, S.K., Mattila, D., Hembree, D. and Waters T.D. 1984. Migration of humpback whales between the Caribbean and Iceland. Journal of Mammalogy 65, 330-333.

Mitchell, E. and Reeves R.R. 1983. Catch history, abundance and present status of Northwest Atlantic humpback whales. *Rep. int. Whal. Commn* (special issue) 5:153-212

Noad, M.J., Cato, D.H., Bryden, M.M., Jennert, M.-N. and Curt, K., Jennert, S. 2000. Cultural revolution in whale songs. *Nature* 408:537

Palsboll, P.J., Allen, J., Berube, M., Clapham, J., Feddersen, T.P., Hammond, P.S., Hudson, R.R., Jorgensen, H., Katona, S., Larsen, A.H., Larsen, F., Lien, J., Mattila, D.R., Sigurjonsson, Sears, R., Smith, T., Sponer, R., Stevick, P. and Lien, N. 1997. Genetic tagging of humpback whales. *Nature* 388:767-769.

Palsboll, P.J., Clapham, P.J., Mattila, D.K., Larsen, F., Sears, R., Siegismund, H.R., Sigurjonsson, J., Vasquez, O. and Arctander, P. 1995. Distribution of mtDNA haplotypes in North Atlantic humpback whales: the influence of behaviour on population structure. *Mar. Ecol. Prog. Ser.*116: 1-10.

Payne, R. and Guinee, L.N. 1983. Humpback whale (*Megaptera novaeangliae*) songs as an indicator of "stocks." pp. 333-358 in R. Payne (ed.), Communication and Behavior of Whales. AAAS Selected Symposium 76, Westview Press, Boulder, Colorado.

Payne R.S., and McVay, S. 1971. Songs of humpback whales. Science 173:585-597

Reeves, R.R., S.L. Swartz, S.E. Wetmore and P.C. Clapham. 2001. Historical occurrence and distribution of humpback whales in the eastern and southern Caribbean Sea, based on data from American whaling logbooks. J. Cetacean Res. Management 3(2):117-129.

Reeves, R.R., Clapham, P.C. and Wetmore, S.E. 2002. Humpback whale (*Megaptera noavaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. J. Cetacean Res. Management 4(3) IN PRESS

Reeves, R.R. and T.D. Smith. 2002. Historical catches of humpback whales in the North Atlantic Ocean: an overview of sources. Journal of Cetacean Research and Management 4(3). IN PRESS.

Reiner, F., Dos Santos, M.E. and Wenzel, F.W. 1996. Cetaceans of the Cape Verde Archipelago. Mar. Mammal Sci. 12(3):434-443.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsball, P.J., Sigurjonsson, J., Stevick, P.T. and Oien, N. 1999. An ocean basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Mar. Mammal Sci. 15(1):1-32.

Smultea, M.A., 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with calf in coastal habitat near the island of Hawaii. Can. J. Zool. 72: 805-811.

Stevick, P.T., Oien, N. and Mattila, D.K. 1998. Migration of a humpback whale between Norway and the West Indies. Mar. Mammal Sci. 14(1):162-166

Stevick, P.T., Oien, N. and Mattila, D.K. 1999a. Migratory destinations for humpback whales from Norwegian and adjacent waters: evidence for stock identity. J. Cetacean Res. Manage. 1(2):147-152.

Stevick, P.T., Carlson, C.A. and K.C. Balcomb 1999b. A note on migratory destinations of humpback whales from the eastern Caribbean. J. Cetacean Res. Manage. 1(2):251-254.

Weinrich, M. 1998. Early experience in habitat choice by humpback whales (*Megaptera novaeangliae*). J. of Mammalogy 79(1):163-170.

Winn, H.E., Edel, R.K. and Taruski, A.G. 1975. Population estimate of the humpback whale (*Megaptera novaeangliae*) in the West Indies by visual and acoustic techniques. J. Fish. Res. Bd. Canada 32(4):499-506.

Winn, H.E., Thompson, T.J., Cummings, W.C., Hain, J., Hudnall, J., Hays, H. and Steiner W.W. 1981. Song of the humpback whales - population comparisons. Behav. Ecol. Sociobiol. 8:41-46.

Winn, H.E. and Winn, L.K. 1978. The song of the humpback whale, *Megaptera novaeangliae* in the West Indies. Marine Biol. 47:97-114.

Figure 1. Maps of the Cape Verde Islands, with 100m contours, as in Hazevoet (1995), with permission of the author

Figure 2 and 3. Fluke photographs of NAHWC#4504, from the Denmark Strait west of Iceland at 65° 66'N, 27° 30'W in July of 1982 and again photographed on March 10, 1999 in the Bay of Sal Rei, Boavista, Cape Verde Islands at 16° 02'N, 23° 02'W.