Average Velocities of some Ocean Currents as Deduced from the Recovery of Plastic Drift Cards[1]

G. H. Stander, L. V. Shannon, and J. A. Campbell

Division of Sea Fisheries
Department of Industries
Republic of South Africa

ABSTRACT

Twenty-four drift cards, released in 1964 through 1966 in the vicinity of Cape Town and at various locations in the Atlantic Ocean, have been recovered on the coasts of: North and South America, three islands in the South Atlantic, England, France, Nigeria, and Australia. The travel times indicated by 19 of these cards have been used to estimate the mean velocities of the presumed current systems involved. The rate of card recovery and the long distances traveled by the cards have proved conclusively that the solid polythene drift card is durable.

Introduction. During 1964 and 1965, approximately 4000 plastic drift cards (Duncan 1965) were released within a 300-km radius of Cape Town with a view to obtaining more information about the seasonal variations in the inshore circulation pattern. In addition, 1800 cards were released by vessels during voyages in the Atlantic Ocean: by R. S. AFRICANA II into the Cape Basin during 1965; by a commercial vessel between Cape Town and England in 1966; and by another commercial vessel between Cape Town and Brazil in 1966.

Approximately a year after the inception of our program in 1964, one of the drift cards released within 300 km of Cape Town was returned from Ilha da Trindade off Brazil. Subsequently, eight additional cards released within 300 km of Cape Town were returned from St. Helena and Australia. As of January 1968, 15 cards released by the vessels noted above had been recovered at coastal locations on the North and South Atlantic and in Australia. Table I gives the date and location of each release and recovery for 24 cards.

It is the purpose of this paper to discuss in detail the 19 drift cards that traveled long distances. Five cards released near the English Channel and

1. Accepted for publication and submitted to press 27 May 1969.

Table I. Data on drift-card releases and recoveries at distant localities.

Date and locality of release	Date and locality of recovery*	Est. transp. rate (cm/sec)	Currents involved
WITHIN 300 KM OF CAPE TOWN			
7/X/64 34°42′S, 17°00′E	10/XII/65 Ilha da Trindade	23	Benguela, South Equatorial (Atl.), Brazil.
22/VII/65 34°35′S, 14°42′E	7/II/66 St. Helena I.	17	Benguela, South Atlantic Drift
6/I/65 35°53′S, 21°22′E	2/I/67 Hopetoun, W. Australia	17	Return Agulhas, West Wind Drift
6/I/65 35°53′S, 21°22′E	12/XI/66 Albany, W. Australia	17	Return Agulhas, West Wind Drift
8/I/65 36°09′S, 20°15′E	30/VII/67 Hamelin Bay, W. Australia	12	Return Agulhas, West Wind Drift
3/IV/65 35°53′S, 21°22′E	20/VII/67 Mouth of Alexander R., W. Australia	14	Return Agulhas, West Wind Drift
4/VII/65 36°32′S, 21°37′E	16/VII/67 Bunbury, W. Australia	16	Return Agulhas, West Wind Drift
4/VII/65 36°32′S, 21°37′E	20/VIII/67 Port Fairy, Victoria, Australia	18	Return Agulhas, West Wind Drift
3/VII/65 34°33′S, 21°05′E	16/VII/67 Safety Bay, near Freemantle, W. Australia	16	Return Agulhas, West Wind Drift
CAPE BASIN OF SOUTH ATLANTIC			
11/XI/64 31°51′S, 12°24′E	11/V/67 Tristan da Cunha	16	South Atlantic Drift, South Equatorial (Atl.), Brazil, West Wind Drift
17/XI/64 32°29′S, 12°06′E	4/X/65 Ilha da Trindade	29	South Atlantic Drift, South Equatorial (Atl.)
16/IV/65 33°23′S, 09°31′E	–/IX/67 150 km N. of Vitória, E. Santos, Brazil	7	South Atlantic Drift, South Equatorial (Atl.), Brazil

En route, Cape Town to Southampton, England			
25/IV/66	22/VII/66	29	Guinea
04°17′N, 16°18′W	Iyagbe Beach, Nigeria		
27/IV/66	16/VII/67	13	Canaries, Atlantic N. Equatorial
18°32′N, 17°51′W	Anguilla, British West Indies		
27/IV/66	16/IX/67	15	Canaries, Atlantic N. Equatorial
18°32′N, 17°51′W	Cocoa Beach, Florida, U.S.A.		
28/IV/66	15/IX/67	16	Canaries, Atlantic N. Equatorial, Gulf Stream
25°21′N, 17°24′W	Avon, N. Carolina, U.S.A.		
2/V/66	29/V/66	9	—
48°52′N, 05°14′W†	Jersey Island		
2/V/66	30/V/66	9	—
48°52′N, 05°14′W†	Jersey Island		
2/V/66	22/VI/66	6	—
48°52′N, 05°14′W†	Carteret, Normandy, France		
2/V/66	7/V/67	2	—
48°52′N, 05°14′W†	Broomhill Sands, Sussex, England		
2/V/66	6/XI/66	1	—
48°26′N, 05°43′W†	Pleubian, Brittany, France		
En route, Cape Town to Brazil			
22/XII/66	22/II/67	21	Brazil
23°10′S, 43°35′W	Porto Alegre, southern Brazil		
24/XII/66	27/I/67	7	Brazil
33°34′S, 52°08′W†	Near Santa Vitória, Brazil		
24/XII/66	25/I/67	10	Brazil
33°34′S, 52°08′W†	Between Cabo Polonio and Punta Loberos, Uruguay		

* The date of recovery indicates when the card was found, not when it actually reached the point of recovery.
† Not shown in Fig. 1, as the distance traveled was too short.

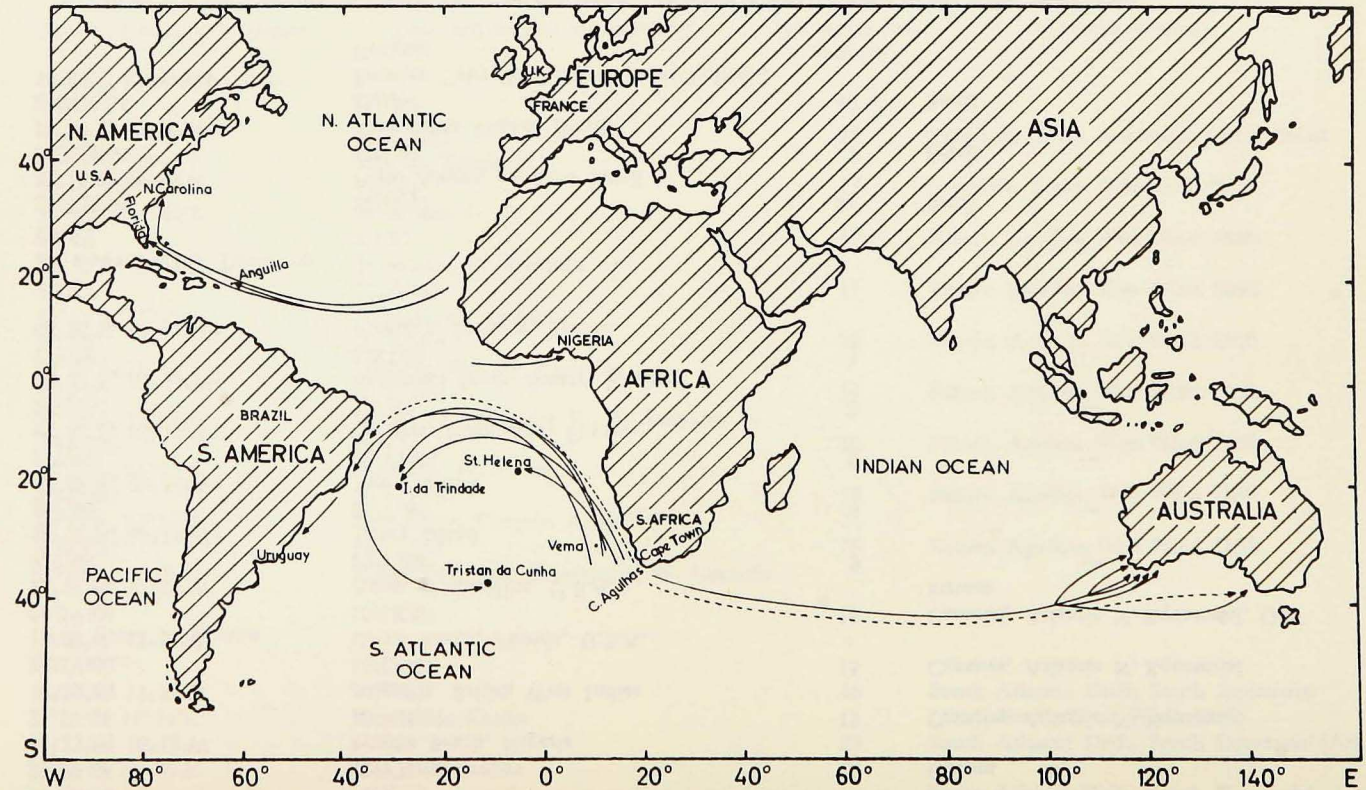

Figure 1. Probable trajectories of the plastic drift cards discussed. See Table I for details.

recovered on Jersey Island, France, and England, though included in Table I, are not discussed because the distances traveled were short and the area involved is subject to the influence of strong tidal currents. Details of the survey relative to the inshore circulation off Cape Town have been discussed elsewhere; of the releases at stations within 80 km of Cape Town, the recovery of cards was 14% (Duncan and Nell, in press).

The travel times indicated by the recoveries listed in Table I have been used to deduce approximate mean velocities for several pertinent current systems. Fig. 1 indicates the routes that we believe the cards followed between release and recovery. Obviously, the velocity estimates are very sensitive to the inferred trajectories, but, with our knowledge of the areas concerned, we believe that at least the order of values obtained is dependable.

Australian Recoveries. As of January 1968, seven cards had been recovered in Australia: six on the southern and western coasts of Western Australia, and one near Port Fairy in Victoria. All of these cards were released immediately east of Cape Agulhas, between 20°E and 22°E: one card was released 8 km from the coast and six at stations located 130 to 200 km from the coast. Undoubtedly these cards were carried southward by the Agulhas Current and the Return Agulhas Current to the latitude of the West Wind Drift, which carried them to Australia. The time interval between release and recovery, 23 to 31 months, suggests that the mean velocity of the West Wind Drift in the Indian Ocean is not less than 16 cm/sec. This velocity is in reasonably good agreement with a velocity of 18 cm/sec obtained for a drift bottle that was also released in 1964 east of Cape Agulhas and recovered in Victoria (Fig. 1, dotted line).

South Atlantic Recoveries. Eight cards were recovered on either the mainland of South America or on islands of the South Atlantic (Table I; Fig. 1).

Two cards were recovered on Ilha da Trindade. One of these cards, released near Cape Town (34°42'S, 17°00'E), was presumably swept northward by the Benguela Current (which merges with the South Atlantic Drift at its seaward boundary), thence westward by the South Equatorial (Atlantic) Current, and finally southward by the Brazil Current. The estimated transport rate is 23 cm/sec. The other card, released near the Vema Seamount (32°29'S, 12°06'E), was dropped beyond the edge of the Benguela Current and probably traveled a more direct route across the Atlantic. This may well account for its higher transport rate of 29 cm/sec. Thus the estimated transport rate for these two cards is in fair agreement.

One card, recovered on St. Helena Island, was dropped about 300 km west of Cape Town and presumably moved slowly in a northwesterly direction with the South Atlantic Drift. Relative to the two above-mentioned cards, the transport rate of this card was considerably slower: 17 cm/sec.

Of the four cards recovered on the South American mainland, only one was released near South Africa—in the Cape Basin. The travel rate estimated for this card is only 7.3 cm/sec. However, a drift bottle released in the same locality as the card (Fig. 1, broken line) and also washed up on the coast of Brazil gave a transport rate of 26 cm/sec. There is no reason to believe that the card and bottle followed widely divergent paths, and it is therefore presumed that there was a considerable time lag between the landing of the card and its subsequent recovery. In any event, the rate of 26 cm/sec for the bottle is in much better agreement with the rates noted above for other cards.

The other three cards recovered on the coast of Brazil were dropped fairly close to the coast and were recovered shortly after their release. The first of these cards, released at 23°10'S, 43°35'W, provides an estimated flow of 21 cm/sec for this section of the Brazil Current. The other two cards were dropped almost 1000 km further south (33°34'S, 52°08'W) and were recovered in Brazil and Uruguay. These two cards provide estimated rates of only 7 and 10 cm/sec, respectively. Possibly the northward flowing Falkland Current is already exerting its influence at this higher latitude, and this may be a factor in the lower transport rate. Also, the marked decrease in the population density southward from 23°S may be a factor in the low rates, since the chances of a drift card being observed are considerably reduced.

From a practical point of view, a card dropped east of the Vema Seamount (31°38'S, 8°20'E) and recovered on Tristan da Cunha 30 months later is of particular interest. This card could have reached this island only by following the South Atlantic gyre. If the path shown in Fig. 1 is assumed, then the average velocity throughout this almost complete circuit is 16 cm/sec. By extrapolation it has been found that the time for a complete circuit would be about three years.

In the Tristan da Cunha-Gough area, the rock lobster *Jasus tristani* is common, and its discovery on the isolated Vema Seamount (Simpson and Heydorn 1965) has given rise to considerable speculation regarding the mechanism by which this population is maintained. For obvious reasons, the possibility that adults migrate to Vema seems remote, but the migration of larvae to the Seamount seems to be a reasonable possibility. It is estimated that the larval life (phyllosoma stage) of *Jasus* species is about nine months (Lazarus 1967), and it is conceivable that the population on Vema is augmented by the transport of larvae that reach the Seamount as they are ready to assume a benthic form of existence. However, if a flow rate of 16 cm/sec in the South Atlantic gyre is assumed (see below), a voyage of nine months for the larvae from Tristan to Vema does seem rather long. But if the larvae travel eastward and traverse a corner of the turbulent mixing area southwest of Cape Town before being carried northward in the direction of Vema, then a time lapse of nine months becomes more realistic.

Finally, if we consider the eight estimated minimum current velocities

reported above for the South Atlantic gyre (7 to 29 cm/sec) and if we omit consideration of the three lowest values (7, 9, 10 cm/sec), we have five values ranging between 16 and 29 cm/sec and a mean value of 21 cm/sec.

North Atlantic Recoveries. Two cards have been recovered on the coast of the United States — one in Florida, the other in North Carolina. These cards were released in the Canaries Current 17 months prior to recovery. The flow rate of the Atlantic North Equatorial Current as determined from these cards is 15 and 16 cm/sec, respectively. It is assumed that the cards passed to the east and north of the West Indies, but they could very well have passed around the islands via the Antilles Current and then the Florida Current.

A third card, also released in the Canaries Current at the same time as the two cards noted above, was recovered on Anguilla. The estimated velocity of only 13 cm/sec is probably due to a long interval between the landing of the card and its recovery. This island is sparsely populated.

A single card recovered in Nigeria was released off the African Coast (4°17'N, 16°18'W). The velocity indicated for the Guinea Current is 29 cm/sec.

The Drift Cards. The durability of the plastic drift card has been proved beyond doubt. Cards picked up in Australia and Tristan da Cunha after being afloat for two to two-and-a-half years were, without exception, clearly legible. They did, however, show signs of sand and rock abrasion and displayed marks that suggested attacks by fish and sea birds, but they did not accumulate sessile marine forms. Woodhead seabed drifters used by this Division often tend to accumulate large numbers of barnacles (*Balanus* sp.). Although wind may exert some influence on the movement of the solid drift cards, this effect is considered to be small. Experiments to modify the balance of the cards and so further minimize the possibility of wind error are in progress.

Acknowledgment. The authors are indeed grateful to Yngve H. Olsen for his interest in the preparation of this paper and for the useful advice and constructive criticism he offered.

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