Applied Ocean Research 67 (2017) 109–124

Contents lists available at ScienceDirect

Applied Ocean Research

journal homepage: www.elsevier.com/locate/apor

Application of leeway drift data to predict the drift of panga skiffs: Case study of maritime search and rescue in the tropical pacific

Ben A. Brushett[a,b,*], Arthur A. Allen[c], Brian A. King[b], Charles J. Lemckert[a,d]

[a] Griffith School of Engineering, Griffith University, Gold Coast, 4222, Australia
[b] RPS, PO Box 1679 Surfers Paradise, 4217, Australia
[c] U.S. Coast Guard, Office of Search and Rescue (CG-SAR-1),U.S. Coast Guard International Ice Patrol 1 Chelsea Street, New London, CT 06320, United States
[d] University of Canberra, Built Environment and Design, Faculty of Arts and Design, Bruce, ACT, 2617, Australia

ARTICLE INFO

Article history:
Received 13 February 2017
Received in revised form 12 June 2017
Accepted 8 July 2017

Keywords:
Ocean modelling
Search and rescue
Leeway
Consensus
Forecasting

ABSTRACT

The use of Search and Rescue (SAR) drift forecasting in an operational capacity is demonstrated through two SAR case studies, each predicting the drift of a panga skiff for 120 h (Case 1) and 72 h (Case 2). The leeway characteristics of panga skiffs were previously unknown, until a leeway field study was undertaken in mid-2012 to empirically determine the influence of wind and waves on their drift. As part of the two case studies described herein, four ocean models were used as environmental forcing for a stochastic particle trajectory model, to forecast the drift and resulting search areas for the panga skiffs. Each of the four ocean models were tested individually, and then combined into a consensus forecast to ascertain which ocean model was the most accurate in terms of distance error of modelled positions compared to actual panga skiff locations. Additionally, a hit analysis was undertaken to determine whether the panga skiff was located within the forecast search areas for each ocean model, and for consensus search areas. Finally, an assessment of the search area sizes was carried out to assess the single ocean model forecast search area sizes, and how they compared with the consensus search area size. In both of the case studies, all four ocean model forecast search areas contained the panga skiff at the time intervals tested, indicating a 100% hit rate and general consensus between the ocean models. The consensus search area, where all four ocean models overlapped, was approximately one third the size of the average single model search area. This demonstrates that the consensus search areas provide a more efficient search area compared to individual ocean model search area forecasts.

1. Introduction

Timely response to maritime search and rescue (SAR) cases is vital to the successful location of missing persons, craft or objects (hereafter referred to collectively as search objects). In maritime SAR cases the position of a missing search object is not fixed, as it may be with many land based/terrestrial SAR cases, rather search objects within the maritime environment drift as the result of a combination of the prevailing ocean currents, winds and waves. The drift of the search object causes the search datum to change with time, hence complicating the search efforts further. This added complexity of a moving search datum decreases the chances of locating the search object as time progresses, in part due to the many accumulating uncertainties that are traditionally associated with forecasting the drift of objects at sea over time.

For these reasons, SAR drift forecast models are routinely used by many SAR agencies to predict the drift of search objects. Hence SAR drift models must account for the drift of a search object, in addition to accounting for the numerous uncertainties and possible errors that surround SAR cases in general. In addition to the details specific to an incident, such as last known position, time and the type of search object, three key elements are required to ensure the drift of a search object is accurately represented in SAR drift models. These elements are; 1) the leeway characteristics for the search object being modelled; 2) hindcast/nowcast/forecast environmental data (winds and ocean currents); and 3) an estimate of the horizontal dispersion required to account for the smaller sub grid scale turbulence and transport mechanisms that the larger scale ocean models and wind models are not able to reproduce.

There are several different ocean models available for the same geographic locations, and it is known that they often produce

* Corresponding author at: RPS, PO Box 1679 Surfers Paradise, 4217, Australia.
E-mail addresses: bbrushett@apasa.com.au (B.A. Brushett), Arthur.A.Allen@uscg.mil (A.A. Allen), bking@apasa.com.au (B.A. King), charles.lemckert@canberra.edu.au (C.J. Lemckert).

http://dx.doi.org/10.1016/j.apor.2017.07.004
0141-1187/

different estimates of the surface currents [1–4]. This permits the SAR operator to replicate the same scenario forecast with different ocean currents as different model inputs, and compare the results. When more than one model forecast coincides or overlaps, there is a degree of consensus between those model forecasts. The greater number of ocean models providing coinciding forecasts may provide the SAR operator with greater confidence in the forecast outcome, and the areas where the model forecasts coincide may potentially be given higher priority for asset allocation over other areas where consensus was not evident. The consensus forecasting approach for predicting the drift of floating objects has been investigated previously which investigated forecasting the trajectories of multiple ocean drifter buoys in the Timor Sea [2] and the Indian Ocean [1]. It was found that a decrease in hit rate (the probability that the search object will be located within a forecast search area) was evident with the 3+ and 4 model consensus forecast areas, however, the greater reduction in associated search area size indicated that the consensus areas provided a more efficient search area (i.e. higher hit rate per unit of search area). Hence, it was proposed that it may be beneficial to focus search efforts on the consensus overlap areas, especially in situations where there may not be adequate search assets available to successfully cover any single search area forecast.

The present study describes two case studies where the Lagrangian particle model, SARMAP [5] was used to forecast the drift and determine consequent search areas for flat bottomed panga skiffs, off the Federated States of Micronesia (FSM) in the Pacific Ocean (Fig. 1). Panga skiffs (19 and 23 foot) are one of the most common craft in the tropical Pacific Islands due to their low construction costs, durability, and seaworthiness. Fig. 2 shows a photo of a 5.8 m (19-foot) panga skiff deployed during the search

Fig. 2. Photo of a 5.8 m (19-foot) panga skiff loaded with current meter, wind station, GPS iridium beacons, flasher unit, and sandbags to replicate 2 POB loading, as tested during the Leeway field test.

and rescue exercise (SAREX). The first case study involved forecasting the 120 h (5-day) drift of the 19-foot panga skiff, deployed during a United States Coast Guard (USCG) leeway field test and SAREX in May-June 2012. The panga skiff had been instrumented to collect environmental (winds and currents) and positional data that was then used to calculate the vessel's leeway characteristics (the effect of wind and waves on the drift of the panga skiff, relative to the ocean currents). The instrumentation attached to the panga skiff is visible in Fig. 2. The second case study involved an actual SAR incident, which occurred during the leeway field test, and involved forecasting the 72 h (3-day) drift of a missing 23-foot panga skiff with 2 persons on board (POB). As no leeway data was previously available for panga skiffs (prior to the leeway field test) to enable an accurate forecast of their drift, it was timely and fortunate that the leeway coefficients were able to be determined from

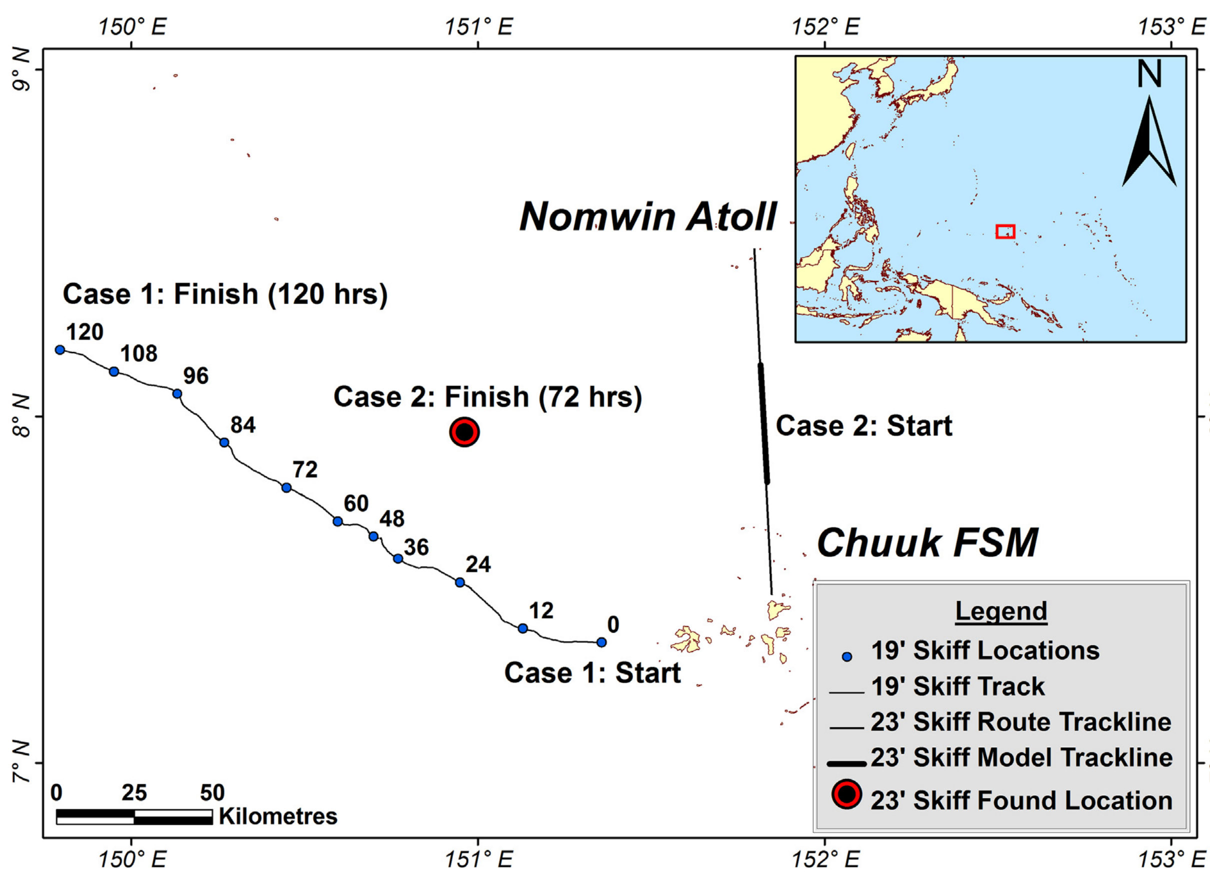

Fig. 1. Location map showing: Case 1–19-foot Panga skiff deployed during the SAREX, drift over 120 h; and Case 2–23 foot Panga skiff during the SAR incident, drift over 72 h.