Marine Policy 136 (2022) 104921

Contents lists available at ScienceDirect

Marine Policy

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

Short communication

First evidence of migration across the South Pacific in endangered Amsterdam albatross and conservation implications

Karine Delord [a,*], Timothée Poupart [a], Nicolas Gasco [b], Henri Weimerskirch [a], Christophe Barbraud [a]

[a] Centre d'Etudes Biologiques de Chizé UMR 7372, CNRS, F-79360 Villiers en Bois, France
[b] Laboratoire de Biologie des Organismes et Ecosystèmes Aquatiques (BOREA), MNHN, CNRS, UCN, IRD, SU, UA, Paris, France

ARTICLE INFO

Keywords:
Diomedea amsterdamensis
National Plan of Actions
Juvenile dispersal
Immature at sea distribution
International conservation responsibility

ABSTRACT

Albatrosses are amongst the most globally-threatened species and fisheries bycatch is one of the major conservation issues worldwide. Among the albatrosses the Amsterdam albatross is listed as one of the most endangered species. Within the current National Plan of Actions framework, the present study outlines the first results of a multi-year survey evaluating juvenile dispersal and immature at sea distribution using geolocation and conservation implications. Here we report the first evidence of an Amsterdam albatross wandering for extensive periods outside the Indian Ocean, in the Pacific Ocean. This unprecedented and novel finding is discussed in terms of overlaps with fisheries and conservations issues. This study brings new insights on movements of vagrant stages of an endangered species, paving the way for refined assessments updates of species vulnerability to ongoing anthropogenic threats while providing basic conservation guidance. This makes it possible to point out the responsibility of the various management bodies both for the high seas regional fisheries management organisations and for exclusive economic zones.

1. Introduction

Many seabirds undergo long-distance migrations between their breeding and wintering areas. This is particularly the case to reach upwelling systems: across North Pacific [1,2], across South Pacific from Australia to the Humboldt Current region [3] or across South Atlantic to the Benguela/Agulhas Current region [4]. As oceanic migrants albatrosses are amongst the most globally-threatened species and have direct interaction with fishing vessels, fisheries bycatch is one of the major conservation issue worldwide [5–7].

Albatrosses are long-lived species (i.e. high adult survival rates, delayed sexual maturity and low fecundity) and large-sized species (i.e. *Diomedea* spp.) breed biennially if successful in fledging a chick [8]. Given these extreme life-history traits, population trajectories are highly sensitive to changes in adult mortality. Albatrosses have a wide at sea distribution and are therefore potentially threatened by a multitude of fisheries in national and international waters [4,9–12]. Naïve juvenile albatrosses disperse widely and may have distinct routes and use different areas compared to adults [13–15].

Among the albatrosses the Amsterdam albatross (*Diomedea amsterdamensis*) is listed among the most endangered species due to a very small population (~ 300–350 individuals; Barbraud et al. unpublished data) and being endemic to a single isolated island in the southern Indian Ocean, Amsterdam Island. It is one of the world's rarest birds. Very sensitive to additional mortality [16,17], the Amsterdam albatross is identified as a priority species to protect, especially at risk due to bycatch [18], and has benefited from two successive National Plans of Actions since 2011 (NPOA 1st: 2011–2015, 2nd: 2018–2027). The Amsterdam albatross is a dispersive migrant known to undertake long-distance movements from eastern to western South Indian Ocean, occasionally reaching South Atlantic and therefore, crossing many fishing areas [14,19]. To our knowledge no observation of incidental catch has been reported for this species. Yet this does not imply that it is not happening especially i) in fisheries without onboard observers dedicated to bycatch or not required to report bycatch or ring recoveries, or in Illegal, Unreported and Unregulated (IUU) fisheries, ii) when low percentage of hauled hooks (<5%) are being surveyed by bycatch-dedicated observers onboard vessels [20], and iii) due to identification issues. During last decades, bycatch estimates of hundreds of albatrosses were reported in the South Indian Ocean [21] and

* Correspondence to: CEBC-CNRS, 79360 Villiers-en-Bois, France.
E-mail address: karine.delord@cebc.cnrs.fr (K. Delord).

https://doi.org/10.1016/j.marpol.2021.104921
Received 28 July 2021; Received in revised form 17 November 2021; Accepted 14 December 2021
Available online 24 December 2021

included several species at risk across the Southern Hemisphere [18].

As part of a multi-year survey evaluating juvenile dispersal and immature at-sea distribution linked to the current NPOA framework for the Amsterdam albatross, the present study reports the first evidence from a single individual that Amsterdam albatross can wander for extensive periods outside the Indian Ocean, in the Pacific Ocean. This unprecedented, unexpected and novel finding is discussed in terms of overlap risk with fisheries and conservation issues.

2. Materials and methods

2.1. Study species and data loggers

Amsterdam Island (37° 50′ S; 77° 33′ E) is located in the subtropical part of the southern Indian Ocean.

In this oceanic area, the southern subtropical front (SSTF) delimits the warmer subtropical from the colder sub-Antarctic waters [22]. The Amsterdam albatross, like other great albatrosses, is a biennial breeder [23,24], with high survival during juvenile, immature and adult phase [17]. Juvenile birds fledge and migrate independently from the adults in January. Immature birds may visit the colony when they are 4 − 7 yrs old, but generally only start breeding at 9 yrs old [16].

Previous study during the first months at sea of juveniles Amsterdam albatross showed an initial rapid movement taking all individuals away from the vicinity of their native colony. Then, they dispersed at large-scale in the entire southern Indian Ocean (15–135° E, ~ 4 500 km from the colony), through a large range of latitudinal gradient (27–47° S) similarly to the adults during their sabbatical period [14,19].

The main objective of the ongoing NPOA is to improve the conservation status of the species by removing or reducing the threats on breeding success and survival rates for the species. Planned actions concern specific objectives regarding threats on land (i.e. pathogen contamination, limitation or eradication of introduced invasive species) and at sea (i.e. at-sea distribution of different stages, habitat modelling and projection, overlap risk assessment with fisheries, implementation of the most efficient bycatch mitigation measures). Under this NPOA framework, a study was launched to gain additional knowledge on the at-sea distribution of the immature stage (between fledging and the first return on land), a period for which only very limited data exist [14,19]. Hence, the study of juvenile birds at-sea movements was completed using Global Location Sensing (GLS; Mk15-British Antarctic Survey). GLSs record the ambient light level every 10 min, from which local sunrise and sunset hours can be inferred allowing estimating location every 12 h [25]. Locations based on light-based archival tags are associated with spatial error estimates (~200 km; [26]). Beside the accuracy of those loggers, broad-scale movements can be confidently identified and allowed us to track the birds for prolonged periods with a minimal disturbance [13]. The birds were tagged as chick (n = 21) in 2011 before leaving the colony for the first time. To date, at year t + 9, we have retrieved 12 of the 21 GLS loggers deployed (recovery rate ~57%) from which 10 individual tracks were estimated (2 loggers failed to record data), thereby allowing to extend the study of juvenile and immature stages over a period up to ~ 3.1 yrs after fledging. The present study focuses on one individual which travelled outside the Indian Ocean, revealing a new migratory pathway and bringing additional information about fisheries overlap.

3. Data and processing

3.1. Fishing data

To describe the overlap between the distributions of the tracked bird and fishing effort (i.e. longline and trawl), we collated the data available from the relevant regional fisheries management organisations (RFMOs; Table 1, Fig. 1, Appendix A) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Note that some RFMO fishing effort datasets are very incomplete (particularly in the Indian Ocean) and can thus result in biased estimates of overlap, particularly when comparing across different RFMOs [27]. To assess the association of albatrosses with fishing vessels [28] we used Global Fishing Watch (GFW) available datasets for assessing fisheries interactions by estimating daily overlap between fishing activity (presence and intensity) and bird distribution (twice daily locations), i.e. a proxy of being at risk to incidental bycatch (Appendix A).

3.2. Fishery observer data

The seabird observation data collected during fishing activities by the scientific onboard observers [29] were used to identify direct interactions through photo-identification of individuals ringed as part of an ongoing long-term monitoring capture-recapture study (CEBC dataset; see [17]). Observer data were collected under the French Southern Ocean Fishery Observer Program [30] and entered on board into an electronic logbook designed by the Muséum National d′Histoire Naturelle de Paris (MNHN) and then uploaded in an 11 G Oracle database named "PECHEKER" hosted and managed by MNHN [29].

3.3. Analysis of light data

We used the FLightR R package [31,32] to determine post-fledging migration movements and timing. FLightR uses the slope of the light curve around twilight to estimate locations. We defined twilights with

Table 1
Summary of regional fisheries management organisations characteristics competent in the high seas overlapping with an Amsterdam albatross tracked during its first 3 yrs at sea.

Ocean basin	Organisation	Targeted species	Gear type	Fishing effort data availability
Indian Ocean	Indian Ocean Tuna Commission (IOTC)	Tunas	Longline	https://www.iotc.org/data/datasets/latest/CELongline
Indian Ocean	Southern Indian Ocean Fisheries Agreement (SIOFA)	Non-tunas	Longline, trawl	Not considered (data not available)
Pacific Ocean	Western and Central Pacific Fisheries Commission (WCPFC)	Tunas	Longline	https://www.wcpfc.int/wcpfc-public-domain-aggregated-catcheffort-data-download-page
Pacific Ocean	InterAmerican Tropical Tuna Commission (IATTC)	Tunas	Longline	https://www.iattc.org/PublicDomainData/IATTC-Catch-by-species1.htmhttps://www.iattc.org/PublicDomainData/IATTC-Catch-by-species1.htm
Pacific Ocean	South Pacific Regional Management Organisation (SPRFMO)	Non-tunas	Longline, trawl	https://www.sprfmo.int/data/catch-information/
Atlantic Ocean	International Commission for the Conservation of Atlantic Tuna (ICCAT)	Tunas	Longline	Not considered (no overlap)
Atlantic Ocean	South East Atlantic Fisheries Organisation (SEAFO)	Non-tunas	Longline, trawl	Not considered (weak overlap)
Global – Southern Ocean	Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)	Non-tunas	Longline, trawl	https://www.ccamlr.org/en/data/access-and-use-ccamlr-data

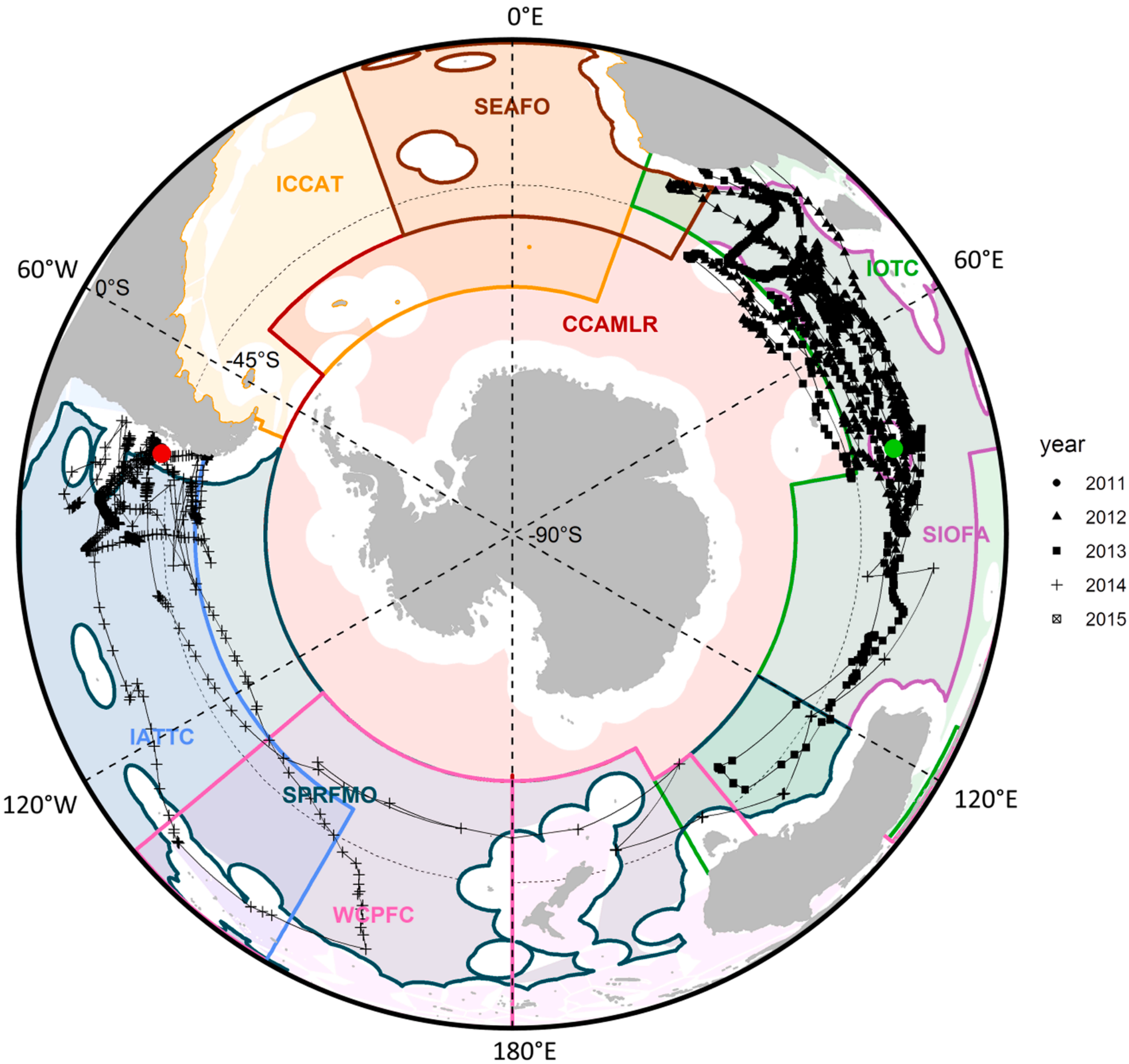

Fig. 1. At sea track of a transoceanic immatureAmsterdam albatross Diomedeaamsterdamensis after fledging from Amsterdam Island, southern Indian Ocean,tracked up to age ~3 yrs. Thefirst part of the journey was spent in the southern Indian Ocean (IO: 06/12/11- 06/02/14) and the final part in the southern Pacific Ocean (PO: 07/02/14 –24/02/15). The areas of competence of Regional FisheriesManagement Organizations (RFMOs) in the high seas are reported: Southern IndianOcean Fisheries Agreement (SIOFA), Indian Ocean Tuna Commission (IOTC), SouthPacific Regional Management Organisation (SPRFMO), West Central PacificFisheries Commission (WCPFC), Inter American Tropical Tuna Commission (IATTC),International Commission for the Conservation of Atlantic Tunas (ICCAT), SouthEast Atlantic Fisheries Organisation (SEAFO), Convention on the Conservation ofAntarctic Living Marine Resources (CCAMLR). The different Exclusive EconomicZones (EEZs) are also presented (white areas). The breeding colony on theAmsterdam Island is denoted by a green dot, the red dot indicated the lastavailable location.

the *preprocessLight* function followed by an additional automated screening using the *twilightEdit* function, in the TwGeos [33] R package (Appendix A).

3.4. Overlap with fisheries

The number of GLS locations situated in Highs Seas, RFMOs and Exclusives Economic Zones (EEZs) areas were counted using R software (version 4.0.4) in order to assess the percentage of the entire movement in each area. Then, the GLS locations of the albatross were aggregated in visited cells, according to the spatial accuracy of the fishing data. This spatial overlap based on the common centroids of the cells was completed by a temporal join to assess the concomitant use of the same cell by the bird and the fishing vessels (e.g. proxy of being at risk to incidental bycatch, see Appendix A).

4. Results

Out of the ten juvenile individuals with recorded tracks, nine distributed entirely in the southern Indian Ocean during their first years at sea (not illustrated, see [19]). However, surprisingly, one travelled outside the Indian Ocean, providing the first evidence that Amsterdam albatross can wander in the Pacific Ocean (Fig. 1). Before its GLS tag stopped (1176 days after leaving the colony), this individual travelled a total distance of ~185 800 km and went as far as 12,915 km away from its colony. During its first three years at sea, this individual crossed two Ocean basins: the Indian Ocean and the Pacific Ocean. It distributed mainly in the southern Indian Ocean (~66% of locations), but in a totally unexpected way it also spent a large part of its time in the southern Pacific Ocean (~34%), the rest being distributed among the global Southern Ocean (<~1%). The bird spent its first 793 days (06/12/2011–06/02/2014) in the Indian Ocean basin and the next 383 days in the Pacific Ocean basin (06/02/2014–24/02/2015). The latitudinal range expanded between −22.8°S to − 54.8°S. As the device stopped recording off the Chilean coast (10,696 km away from Amsterdam Island), the return journey to the colony was not completed (Fig. 1).

The bird distributed mainly in high seas (78% of the locations) and within 13 EEZs (22% of locations; Appendix Table S1 & S2). In high seas, its distribution overlapped with seven RFMOs (3 targeting tuna-like species and 3 targeting non-tuna-like species; Table 1, Appendix Table S3, Fig. 1 & 2). Overlaps occurred in the southern Indian Ocean within IOTC (~62%) and SIOFA (~48%) areas, and in Pacific Ocean RFMOs (SPRFMO: 24%, WCPFC: 2% and IATTC: 28%) areas.

The French EEZs was the most overlapping country with 5 EEZs representing up to 41% of the bird's distribution (Fig. A2), followed by Chile (2 EEZs, ~38%), South Africa (2 EEZs, ~15%), and New Zealand (~1.8%).

While SIOFA was created only recently (agreement signed in 2006) and entered into force in 2012 the overlap between fishing effort and bird location could not be estimated due to data inaccessibility.

4.1. Overlap with fishing effort

This Amsterdam albatross movement encompassed 143 cells on the RFMOs grid (3,340,661 km^2) and 451 cells on the GFW grid (1,383,682 km^2). These cells were spatially overlapping with fishery areas for 82% and 66% respectively.

The spatio-temporal overlap with the monthly RFMO fishing data showed no concomitant use of the same cell with trawling (data available only for SPRFMO and CCAMLR). However, it happened with longlining for 120 cells visits (36%, Fig. 3a). These potential interactions happened primarily in IOTC (95 cells visits, 79%) and to a lesser extent in IATTC (12 cells visits, 10%), CCAMLR (9 cells visits, 7.5%) and WCPFC (4 cells visits, 3.6%). In time, this overlap spanned almost all the trip duration, occurring on 27 months out of the 39 recorded. It also included all the months of the year. The corresponding fishing effort was 7,655,856,920,785, 2,068,290 and 7041 deployed hooks respectively in IOTC, IATTC, CCAMLR and WCPFC.

The spatio-temporal overlap with the daily GFW data showed concomitant use of the same cell with fishing vessels detected during the same day for 11 cells visits (0.7%, Fig. 3b) in 2012. These potential interactions happened primarily in IOTC / SIOFA (7 cells visits, 63.6%) in May, June, November and December with maximum fishing effort estimated at 24 h. CCAMLR was also concerned to a lesser extent with 4 cells visits (36.3%) in April, with maximum fishing effort estimated at 22 h.

4.2. Fishery observer data

Sixteen observations of Amsterdam albatrosses were reported for fifteen different individuals, during 2018–2021 (28 Feb - 6 Apr) and from the stern of a pot fishery vessel targeting the Saint Paul rock lobster (*Jasus paulensis*). All the observed individuals were immature birds (aged between 2 and 11 yrs) that never attempted to breed, except one breeding adult (aged 15 yrs). They were all observed within the Amsterdam and Saint Paul EEZ. Observations from on-board observers provide evidence of direct interactions with fishing vessels and instances of prey consumption (offals) related to fishing activity (Appendix Fig. A1).

5. Discussion

This is the first evidence that Amsterdam albatross wander for extended periods outside the Indian Ocean, in the Pacific Ocean (except short visits in the southeastern part of the Atlantic Ocean; [19]). This novel finding changes the scope of coverage (e.g. spatial and temporal extent) and conservation strategy for the species. Unexpectedly the South Pacific RFMOs were largely at risk of overlap. Multi-year tracking datasets of immature birds of this extremely rare species is an important input to fisheries management processes, highlighting new fisheries that were not considered to pose risk to this species until now. Furthermore, our results clearly evidenced for the first-time direct interactions with fishing vessels during the immature stage.

Even if the way back to Amsterdam Island was not recorded, it is likely that this bird went back to its birth colony following the prevailing winds of the Antarctic circumpolar current belt, as wandering albatrosses *D. exulans* from the South Indian do [13]. Therefore, we strongly suspect that Amsterdam albatrosses may also cross the South Atlantic to complete a circumpolar navigation, and potentially use all the RFMOs of the Southern Ocean (ICCAT, SEAFO or more of the CCCAMLR areas).

This unique migratory behaviour is unprecedented for the Amsterdam albatross either because it may be very rare, or alternatively, because only few juvenile individuals (n = 10) have been successfully tracked over several years. This raises the possibility of the existence of an unrevealed or novel migratory pathway unknown for this species. Although this finding concerns a single bird to date, it represents 10% of the individuals tracked so far.

As previously described for juveniles Amsterdam albatross in their first year, this bird distributed mainly within the South Indian during its first years at sea after fledging [19]. French, South African and Australian EEZs were previously identified as important foraging areas for this

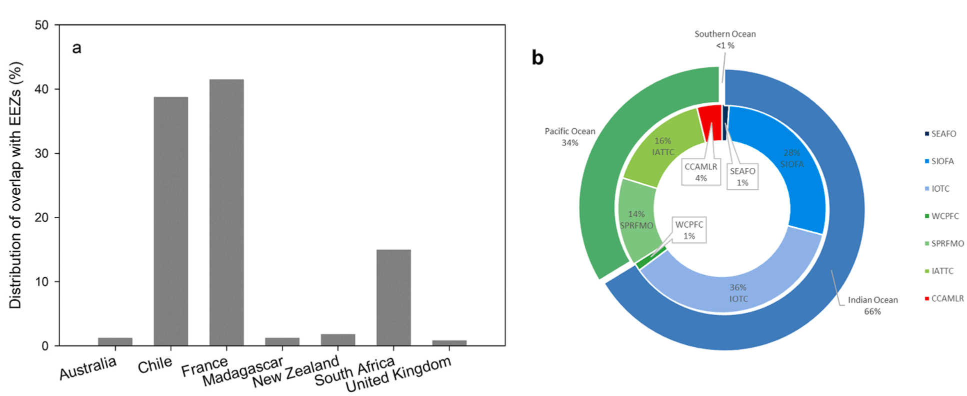

Fig. 2. Distribution of the different levels of overlapbetween at sea distribution of one Amsterdam albatross Diomedea amsterdamensis after fledging up to age ~3 yrs and marinewaters across Ocean basins. Percentages by a) the different Exclusive EconomicZones countries, and b) the different Regional Fisheries ManagementOrganizations (RFMOs) in the high seas (inner pie-chart: Southern Indian OceanFisheries Agreement (SIOFA), Indian Ocean Tuna Commission (IOTC), South PacificRegional Management Organisation (SPRFMO), West Central Pacific FisheriesCommission (WCPFC), Inter American Tropical Tuna Commission (IATTC),International Commission for the Conservation of Atlantic Tunas (ICCAT), SouthEast Atlantic Fisheries Organisation (SEAFO), Convention on the Conservation ofAntarctic Living Marine Resources (CCAMLR)), and Ocean Basins (outer pie-chart)are depicted.

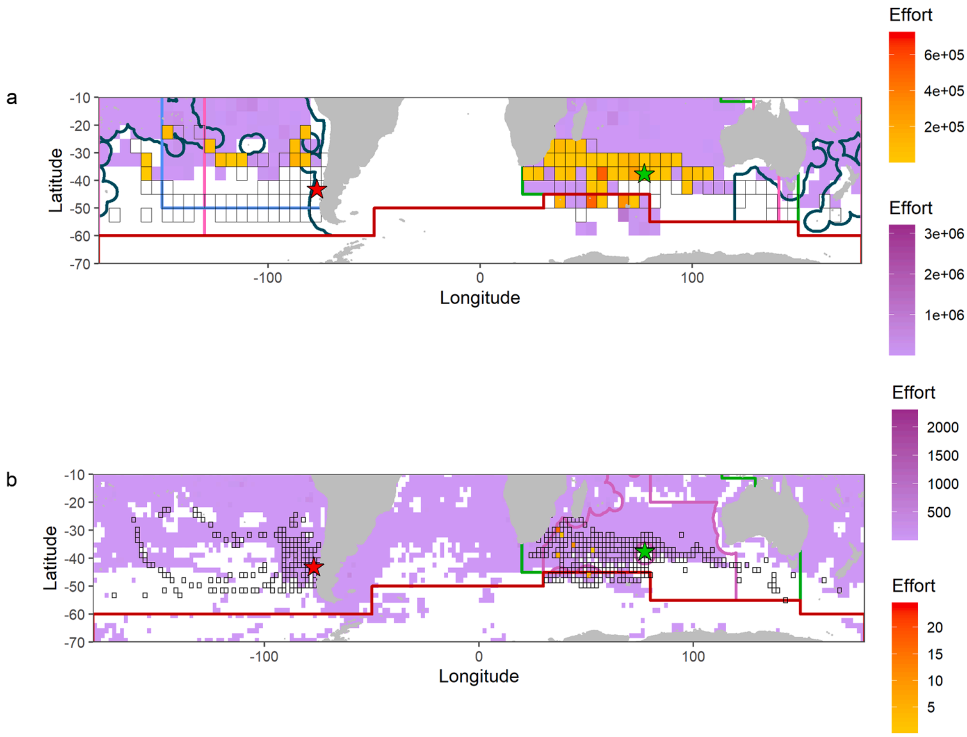

Fig. 3. Overlap between an immature of Amsterdam albatross *Diomedea amsterdamensis* tracked up to age ~3 yrs after fledging and fishing effort while this bird was at sea through different ocean basins visited using a) Regional Fisheries Management Organizations (RFMOs) dataset, with fishing effort expressed as the number of hooks set (longline fishing, aggregated monthly data, 5°x5° cell grid) and b) Global Fishing Watch dataset, with fishing effort expressed as hours (aggregated daily data, 200 ×200 km cell grid). The fishing effort is represented by the purple and the yellowish scales, corresponding respectively to the effort not matching and matching spatio-temporally the bird's movement. Fishing data were obtained from corresponding RFMOs in the high seas (see Materials and Methods Section). The areas of competence of RFMOs (coloured lines) and the different Exclusive Economic Zones (EEZs) are also presented (indigo blue areas). The 1st and last locations of the individual track are denoted (1st: green dot, last: red dot). (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

species [19], but new concerned EEZs have arisen from this study: Chilean and New Zealand EEZs. The finding of this unrevealed migratory pathway highlights that the conservation of this species goes far beyond France, which already provides a high level of protection within its EEZs particularly for the French Southern and Antarctic Lands [34], and the South Indian. This individual distributed largely over the high seas overlapping mainly with two RFMOs areas (i.e. IOTC and SIOFA, and overlaying marginally with the Indian part of the SEAFO). Nonetheless, in a completely unexpected way the South Pacific RFMOs were also largely overlaid (i.e. SPRFMO, IATTC and WCPFC). This reinforces the need for the application of best practices for bycatch mitigation measures and fisheries observer coverage to be mandated and enforced at a global scale to ensure no negative effects on this endangered population.

Despite the contrasted results of overlap analysis between RFMOs and GFW data, both approaches conducted on a partial migration of a single individual confirmed the potential for interactions with fisheries in different RFMOs. Nonetheless, some RFMO fishing effort datasets are known to be very incomplete (namely in the Indian Ocean) resulting in a biased estimate of overlap. The approach using GFW data should be important to consider in order to complement and refine the overlap estimations, especially concerning specific fisheries (i.e. South Pacific trawl activity occurs in EEZS while SPRFMO covers trawling data only in the high seas).

The Amsterdam albatross is identified as a priority species to protect, especially at risk due to bycatch [18] with breeding adults foraging in a dense boat seascape (i.e. including density of fishing vessels [35]). Even if fine scale analysis between breeding adults tracked with GPS and AIS data seemed to reveal low interactions with fishing vessels [35], and especially for juvenile Amsterdam albatrosses [36], our results show clear evidence of direct interactions with fishing vessels during the immature stage. This suggests that interactions are likely underestimated, given the opportunistic aspect of these data, the elusiveness of this species and its identification difficulty. Further study on the juveniles' dispersal at sea with GLS loggers are needed to improve the knowledge on their spatial distribution and exposition to fisheries interactions. Additional deployments are planned during the ongoing NPOA.

We reported the first evidence of an immature of the Amsterdam albatross crossing the Pacific Ocean and estimated the relative importance of national jurisdictions and high seas areas for this individual. This bird made extensive use of the high seas, reinforcing the stake each country has in the management of biodiversity in international waters. While in the high seas, this individual, in each ocean basin, spent the most time within the areas of competence of the five RFMOs targeting tuna and non-tuna species. By making explicit the relative responsibilities that each country and RFMO has for the management of shared biodiversity [37] and by providing new evidence for direct interactions with fishing vessels, this work provides novel and important information for the conservation and management of this endangered species at the appropriate scale in the marine realm.

CRediT authorship contribution statement

Karine Delord: Conceptualization, Data curation, Investigation, Methodology, Resources, Formal analysis, Software, Validation, Project administration, Writing – original draft. **Timothée Poupart**: Visualization, Investigation, Formal analysis, Software, Validation, Writing – original draft. **Nicolas Gasco**: Data curation, Supervision, Writing – review & editing. **Henri Weimerskirch**: Project administration, Writing – review & editing. **Christophe Barbraud:** Project administration, Funding acquisition, Writing – review & editing.

Acknowledgements

This study was made possible thanks to all the field workers involved in the monitoring program on Amsterdam albatross, namely Jean-Baptiste Thiebot, Jérémy Demay, Rémi Bigonneau, Romain Bazire, Hélène Le Berre, Marine Quintin, Marine Devaud, Chloé Tanton, Jérémy Dechartre and Anthony Le Nozahic. We are grateful to Richard Phillips, British Antarctic Survey, Cambridge for providing GLS loggers. This study is a contribution to the National Plan of Actions for Amsterdam albatross. This monitoring program was supported financially and logistically by the French Polar Institute IPEV (program 109, resp. Henri

Weimerskirch), the Zone Atelier Antarctique (CNRS-INEE), Terres Australes et Antarctiques Françaises. All work was carried out in accordance with the IPEV ethics committee. We acknowledge Dominique Joubert for the management of the demographic CEBC database. We would also like to thank Daphnis De Pooter at the CCAMLR Secretariat for assisting with the provision of the fishery data from Divisions 58.4.4a, 58.4.4b, 58.5.1, 58.5.2, 58.6, 58.7, 51 (CI and PEI), and all data owners for their permission for the use of the data, in accordance with the Rules for Access and Use CCAMLR Data. We thank the Museum National d'Histoire Naturelle (MNHN) de Paris (Charlotte Chazeau, Patrice Pruvost, Alexis Martin—PECHEKER database). The contribution of captains, crews and fishery observers (particularly Marion Kauffmann, Cyrielle Jac, Samuel Perroteau) who collected the data is gratefully acknowledged. We thank two anonymous reviewers for constructive comments on an earlier version of the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2021.104921.

References

[1] M. Frederiksen, B. Moe, F. Daunt, R.A. Phillips, R.T. Barrett, M.I. Bogdanova, T. Boulinier, J.W. Chardine, O. Chastel, L.S. Chivers, S. Christensen-Dalsgaard, C. Clement-Chastel, K. Colhoun, R. Freeman, A.J. Gaston, J. Gonzalez-Solis, A. Goutte, D. Grémillet, T. Guilford, G.H. Jensen, Y. Krasnov, S.H. Lorentsen, M. L. Mallory, M. Newell, B. Olsen, D. Shaw, H. Steen, H. Strom, G.H. Systad, T. L. Thorarinsson, T. Anker-Nilssen, Multicolony tracking reveals the winter distribution of a pelagic seabird on an ocean basin scale, Divers. Distrib. 18 (2012) 530–542.

[2] A.J. Gaston, Y. Hashimoto, L. Wilson, First evidence of east–west migration across the North Pacific in a marine bird, Ibis 157 (2015) 877–882.

[3] M. Brooke, Albatrosses and petrels across the world, Oxford (2004).

[4] R. Phillips, J.R.D. Silk, J.P. Croxall, V. Afanasyev, V.J. Bennett, Summer distribution and migration of nonbreeding albatrosses: individual consistencies and implications for conservation, Ecology 86 (2005) 2386–2396.

[5] J.P. Croxall, S.H.M. Butchart, B. Lascelles, A.J. Stattersfield, B. Sullivan, A. Symes, P. Taylor, Seabird conservation status, threats and priority actions: a global assessment, Bird. Conserv. Int. 22 (2012) 1–34, https://doi.org/10.1017/S0959270912000020.

[6] R.A. Phillips, R. Gales, G. Baker, M. Double, M. Favero, F. Quintana, M.L. Tasker, H. Weimerskirch, M. Uhart, A. Wolfaardt, The conservation status and priorities for albatrosses and large petrels, Biol. Conserv. 201 (2016) 169–183.

[7] S. Good, G. Baker, M. Gummery, S. Votier, R. Phillips, National Plans of Action (NPOAs) for reducing seabird bycatch: developing best practice for assessing and managing fisheries impacts, Biol. Conserv. 247 (2020), 108592.

[8] J. Warham, The Petrels: Their Ecology And Breeding Systems, Academic Press, London, 1990.

[9] B. Baker, M.C. Double, R. Gales, G.N. Tuck, C.L. Abbott, P.G. Ryan, S.L. Petersen, C. J.R. Robertson, R. Alderman, A global assessment of the impact of fisheries-related mortality on shy and white-capped albatrosses: conservation implications, Biol. Conserv. 137 (2007) 319–333.

[10] S.G. Zador, A.E. Punt, J.K. Parrish, Population impacts of endangered short-tailed albatross bycatch in the Alaskan trawl fishery, Biol. Conserv. 141 (2008) 872–882.

[11] K. Delord, C. Barbraud, C.A. Bost, B. Deceuninck, T. Lefebvre, R. Lutz, T. Micol, R. A. Phillips, P.N. Trathan, H. Weimerskirch, Areas of importance for seabirds tracked from French southern territories, and recommendations for conservation, Mar. Policy 48 (2014) 1–13.

[12] S. Jiménez, R.A. Phillips, A. Brazeiro, O. Defeo, A. Domingo, Bycatch of great albatrosses in pelagic longline fisheries in the southwest Atlantic: contributing factors and implications for management, Biol. Conserv. 171 (2014) 9–20.

[13] H. Weimerskirch, Y. Cherel, K. Delord, A. Jaeger, S.C. Patrick, L. Riotte-Lambert, Lifetime foraging patterns of the wandering albatross: life on the move!, J. Exp. Mar. Biol. Ecol. 450 (2014) 68–78.

[14] S. de Grissac, L. Börger, A. Guitteaud, H. Weimerskirch, Contrasting movement strategies among juvenile albatrosses and petrels, Sci. Rep. 6 (2016) 26103.

[15] R.A. Orben, A.J. Connor, R.M. Suryan, K. Ozaki, F. Sato, T. Deguchi, Ontogenetic changes in at-sea distributions of immature short-tailed albatrosses Phoebastria albatrus, Endanger. Species Res. 35 (2018) 23–37.

[16] H. Weimerskirch, N. Brothers, P. Jouventin, Population dynamics of Wandering Albatross *Diomedea exulans* and Amsterdam Albatross *D. amsterdamensis* in the Indian Ocean and their relationship with long-line fisheries: conservation implications, Biol. Conserv. 79 (1997) 257–270.

[17] P. Rivalan, C. Barbraud, P. Inchausti, H. Weimerskirch, Combined impact of longline fisheries and climate on the persistence of the Amsterdam albatross, Ibis 152 (2010) 6–18.

[18] E. Abraham, Y. Richard, N. Walker, W. Gibson, D. Ochi, S. Tsuji, S. Kerwath, H. Winker, M. Parsa, C. Small, Assessment of the risk of surface longline fisheries in the Southern Hemisphere to albatrosses and petrels, for 2016, in: 2019.

[19] J.-B. Thiebot, K. Delord, C. Marteau, H. Weimerskirch, Stage-dependent distribution of the critically endangered Amsterdam albatross in relation to Economic Exclusive Zones, Endanger. Species Res. 23 (2014) 263–276.

[20] H.-W. Huang, Bycatch of high sea longline fisheries and measures taken by Taiwan: actions and challenges, Mar. Policy 35 (2011) 712–720.

[21] H.W. Huang, K.M. Liu, Bycatch and discards by Taiwanese large-scale tuna longline fleets in the Indian Ocean, Fish Res. 106 (2010) 261–270.

[22] I.M. Belkin, A.L. Gordon, Southern Ocean fronts from the Greenwich meridian, J. Geophys. Res. 101 (1996) 3675–3696.

[23] J.P. Roux, P. Jouventin, J.L. Mougin, J.C. Stahl, H. Weimerskirch, Un nouvel albatros Diomedea amsterdamensis n. sp. découvert sur l'île Amsterdam (37°50′S, 77°35′E)., Oiseau R F O. 53, 1983. 1–11.

[24] P. Jouventin, J. Martinez, J.-P. Roux, Breeding biology and current status of the Amsterdam Island Albatross *Diomedea amsterdamensis*, Ibis 131 (1989) 182.

[25] R.P. Wilson, J.J. Ducamp, G. Rees, B.M. Culik, K. Niekamp, Estimation of location: global coverage using light intensity, in: I.M.S.S. Priede (Ed.), Ellis Horward, Chichester, 1992, pp. 131–134.

[26] R.A. Phillips, J.R.D. Silk, J.P. Croxall, V. Afanasyev, D.R. Briggs, Accuracy of geolocation estimates for flying seabirds, Mar. Ecol. Prog. Ser. 266 (2004) 265–272.

[27] M. Francis, S.D. Hoyle, Estimation of fishing effort in the Southern Hemisphere, Ministry for Primary Industries, Wellington, New Zealand, 2019.

[28] R.A. Orben, J. Adams, M. Hester, S.A. Shaffer, R.M. Suryan, T. Deguchi, K. Ozaki, F. Sato, L.C. Young, C. Clatterbuck, Across borders: external factors and prior behaviour influence North Pacific albatross associations with fishing vessels, J. Appl. Ecol. (2021).

[29] A. Martin, C. Chazeau, N. Gasco, G. Duhamel, P. Pruvost, Data curation, fisheries, and ecosystem-based management, Case Study Pech. Database (2021).

[30] N. Gasco, Contributions to marine science by fishery observers in the French EEZ of Kerguelen, in: 2011: pp. 93–98.

[31] E. Rakhimberdiev, A. Saveliev, T. Piersma, J. Karagicheva, FLightR: an R package for reconstructing animal paths from solar geolocation loggers, Methods Ecol. Evol. 8 (2017) 1482–1487.

[32] S. Lisovski, S. Bauer, M. Briedis, S.C. Davidson, K.L. Dhanjal-Adams, M. T. Hallworth, J. Karagicheva, C.M. Meier, B. Merkel, J. Ouwehand, Light-level geolocator analyses: a user's guide, J. Anim. Ecol. 89 (2020) 221–236.

[33] S. Wotherspoon, M.D. Sumner, S. Lisovski, TwGeos: basic data processing for light-level geolocation archival tags. R package., (2016).

[34] J. Claudet, C. Loiseau, A. Pebayle, Critical gaps in the protection of the second largest exclusive economic zone in the world, Mar. Policy 124 (2021), 104379, https://doi.org/10.1016/j.marpol.2020.104379.

[35] A. Corbeau, J. Collet, F. Orgeret, P. Pistorius, H. Weimerskirch, Fine-scale interactions between boats and large albatrosses indicate variable susceptibility to bycatch risk according to species and populations, Anim. Conserv. (2021).

[36] H. Weimerskirch, J. Collet, A. Corbeau, A. Pajot, F. Hoarau, C. Marteau, D. Filippi, S.C. Patrick, Ocean sentinel albatrosses locate illegal vessels and provide the first estimate of the extent of nondeclared fishing, Proc. Natl. Acad. Sci. 117 (2020) 3006–3014.

[37] M. Beal, M.P. Dias, R.A. Phillips, S. Oppel, C. Hazin, E.J. Pearmain, J. Adams, D. J. Anderson, M. Antolos, J.A. Arata, Global political responsibility for the conservation of albatrosses and large petrels, Sci. Adv. 7 (2021) eabd7225.