LENGGURU 2017 EXPEDITION

Biodiversity assessment in reef twilight zone and cloud forests

(1st October 2017 – 30th November 2017)

R/V AIRAHA 2

MISSION REPORT

Régis Hocdé, Indra Bayu Vimono, Amir M. Suruwaki, Yosephine Tuti, Rizkie Satriya Utama, Abrar Mohammad, Paulus Boli, Hidayat Ashari, Hadi Wikanta, Jean-Baptiste Juhel, Christophe Cochet, Christophe Thébaud, Borja Milá, Gofir Abdul, Julien Leblond, Eric Bahuet, Gilles Diraimondo, Bruno Fromento, Jean Chevallard, Sumanta, the crew team, Bernard Pouyaud, Kadarusman, Laurent Pouyaud

October – November 2017, Kaimana Regency, West Papua, INDONESIA

LIPI

Institut de Recherche pour le Développement FRANCE

POLITEKNIK KELAUTAN DAN PERIKANAN SORONG

Mission report: LENGGURU 2017 Expedition 'Biodiversity assessment in reef twilight zone and cloud forests', R/V AIRAHA 2, 1st October 2017 – 30th November 2017, Kaimana Regency, West Papua, Indonesia.

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Summary :

The scientific Lengguru 2017 Expedition aimed at assessing the functional, genetic and morphological diversity of several marine biotas (reef fishes, echinoderms, hard corals, and gorgonians). Several methods were implemented: observations, sampling with DNA barcoding inventory and morphological description, baited remote underwater video systems (BRUVS) and environmental DNA. Environmental measurements and opportunistic observations (marine mammals...) were also performed. Lengguru 2017 focused also on the mountain avifauna prevailing in Kaimana Regency (Lengguru and Kumawa). Exploration and sampling effort were concentrated for the marine part on several reef slopes located in front of Kumawa and Lengguru ranges, in and off shore of Triton Bay (from -100 m to the surface). The expedition occurred between 1st October 2017 and 30th November 2017. The fieldwork in Kaimana Regency was done between 17th October and 20th November 2017 with the vessel 'Airaha 2'. Lengguru 2017 was a joint expedition of France and Indonesia Research Institutions.

Keywords:

birds, BRUV, capacity building, DNA barcoding, echinoderms, environmental DNA, gorgonians, hard corals, marine biodiversity, marine invertebrates, oceanographic cruise, reef fishes, scientific expedition

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I BACKGROUND AND AIMS

I-1 Background

Indonesia is the world's largest archipelago, lying between the Indian and Pacific Oceans and encompassing the heart of the Coral Triangle (CT) (Veron J. E. N. *et al.*, 2009). Indonesia is home to the richest marine biodiversity on Earth, with nearly 20% of the world's coral reefs, 10% for seagrass and 15% for mangroves ecosystems. The Bird's Head Isthmus, also called the Bird's Neck, connecting the Bird's Head Peninsula (BHP) with the rest of New Guinea, is one of the last pristine areas remaining in Southeast Asia. The Lengguru limestone karsts have evolved through complex tectonic uplift movements. For the last 10 million years, they have formed "islands within the island" which is today a major biodiversity reservoir with high levels of endemism.

In many areas of Southeast Asia, karst systems have formed "islands within islands" (Clements R. *et al.*, 2006). The high species diversity and endemism generally observed in karst landscapes is explained by a large array of ecosystems, complex and fragmented terrains, variable local climatic conditions, tectonic and eustatic histories, variable degrees of isolation, and incidence of random events. Karsts cover large sections of New Guinea but their exploration is the least advanced of any ecosystems in the Australasian region. In a review, Clements et al., (2006) stated that karsts contribute just 1% of the global and regional biodiversity research output from terrestrial and freshwater ecosystems conducted over a 20-year period (1985-2004). Given that karsts cover around 10% of the land area in Southeast Asia (Day M. J. & Urich P. B., 2000) and given that they encompass significant proportions of the surrounding region's biodiversity and endemism (Yong H. S. *et al.*, 2004), more studies need to be devoted to these ecosystems.

The Lengguru karsts are biogeographically located at the heart of the Coral Triangle (CT) (Veron J. (Charlie) E. N. *et al.*, 2011). Distributed on six Southeast Asian countries (Indonesia, Malaysia, Philippines, Papua-New-Guinea, Solomon, Timor-Leste), the CT is the marine mega diversity centre of the planet with more than 76% of world's coral reef species and more than 52% of Indo-pacific reef fish diversity. The richest diversities for soft corals, molluscs, crustaceans and many other biotas are also observed in the CT. The CT biodiversity epicentre is located in West Papua, an area still unexplored.

The Coral Triangle significantly sustains the world's fisheries, tuna industry and tourism sectors and direct activities for more than 200 million peoples. Nevertheless, intensification of environmental pressures coupled with impacts of global warming have already degraded around 40% of global reefs and mangroves during the last 40 years.

The largest archipelago in the world, Indonesia extends across more than 5000 km from west to east and encompasses more than half of the CT. Aware of the environmental and societal challenges faced by people and economic development, the Indonesian President Bapak Joko Widodo gave the sustainable management of marine resources one its major priority for the country.

Increasing the characterization of marine genetic resources by training and providing schorlarships to young researchers is a prerequisite for meeting this crucial and interesting challenge.

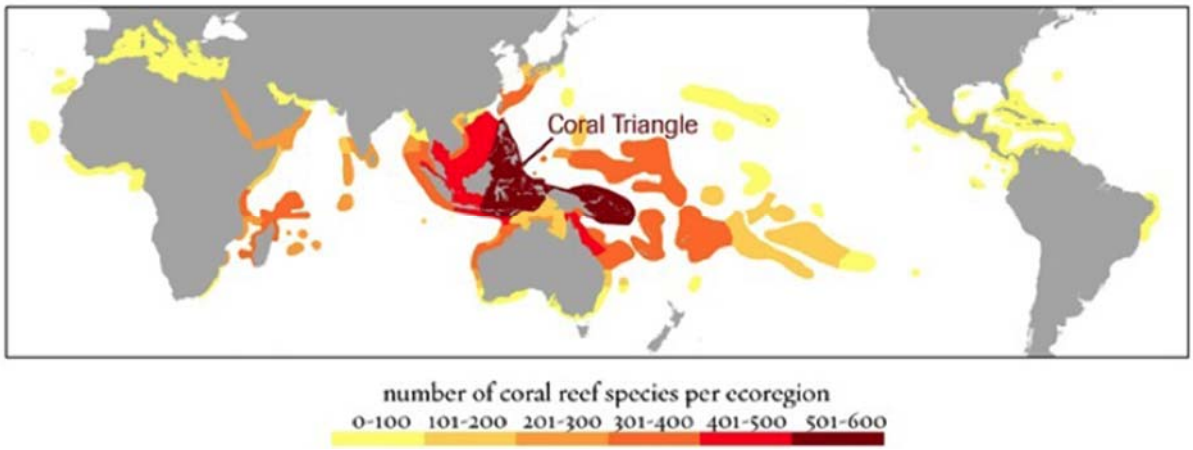


Figure 1. Global map with the reef fish species distribution. Location of the coral triangle (Veron et al. 2007)

I-2 A pluriannual research project

The “Lengguru 2017” scientific expedition is part of the multiyear program “Karst & Biodiversity in Western Papua / Biodiversity assessment in reef twilight zone” and is headed by IRD and Indonesian partners from LIPI-P2O and Politeknik KP Sorong. It contributes to a science-based assessment of functional, genetic and morphological diversity for several marine biotas (vertebrates, invertebrates, seagrass…) in an area with prime importance for biodiversity conservation. Several scientific disciplines are involved: taxonomy, evolutionary genetics, ecology and marine biology. Our joint research program fulfils the requirements of the 2010 Nagoya Protocol on “access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity”.

The general methodology is based on field surveys conducted in a large array of marine and mountain ecosystems. Specific ecosystems were selected according to the preliminary data obtained during the Franco-Indonesian expedition Lengguru 2014. Besides conducting an inventory of animal communities based on DNA barcoding and traditional taxonomy, biologists will also infer the phylogenetic relationships of the taxa collected in Lengguru with those originating from the peripheral regions.

The confrontation between the chronologies of geomorphologic processes with molecular clocks will enable researchers to understand their diversification processes and will test the karst region’s capacity as a reservoir of old lineages, speciation hotspots or arks of biodiversity.

This project also will provide an opportunity to increase significantly the barcoding inventory of marine resources in the Coral Triangle.

1-3 Objectives

The “Lengguru 2017” scientific expedition aims to assess the functional, genetic and morphological diversity of several marine biotas (echinoderms, hard corals, gorgonians and reef fishes). Exploration and sampling effort were concentrated for the marine part on several reef slopes located in front of the Kumawa and Lengguru ranges, in and off shore of Triton Bay (from -100 m to the surface). Species collection and sampling were performed by teams of divers in open circuit and closed circuit rebreather (CCR). Nets were also used. Barcoding of sampled species was systematically performed. Environmental DNA and baited cameras were used to investigate the marine biodiversity and physico-chemical variables (CTD, other variables) were

measured to characterize the abiotic environment. The project Lengguru 2017 Expedition also aims to inventory the morphological and genetic diversity of mountain avifauna.

The study area mainly focused on the '540 – SW coast of Papua' ecoregion of the Coral Triangle defined by Veron et al. (2011).

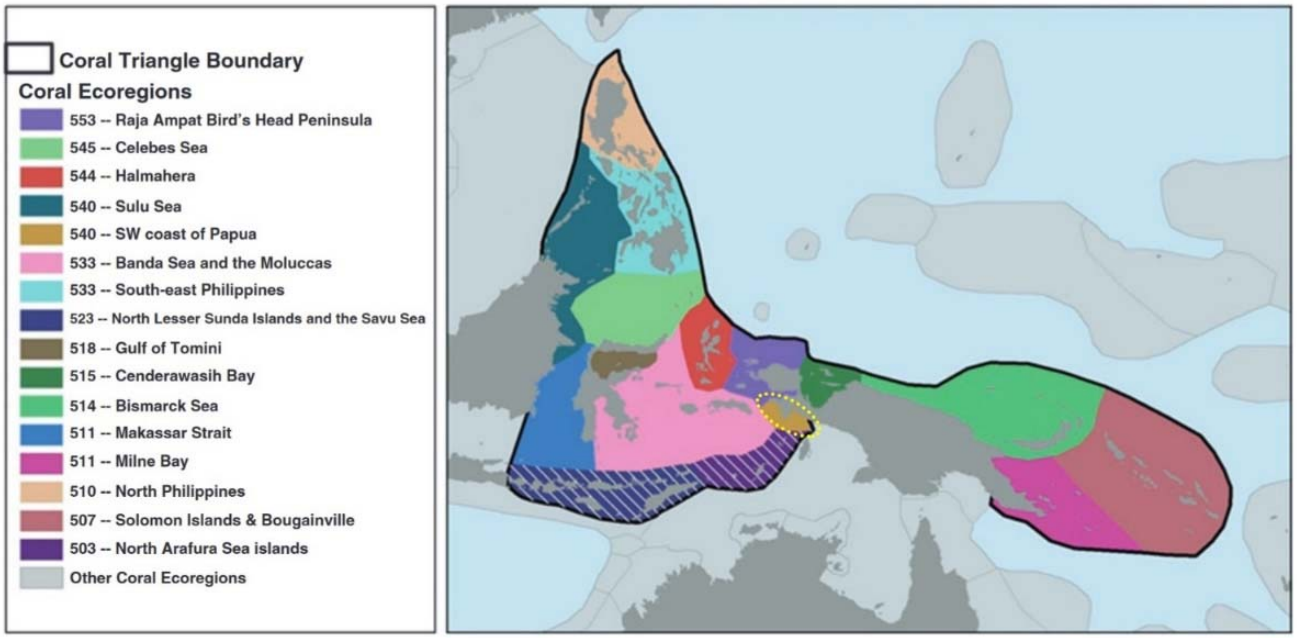


Figure 2. The 'Lengguru 2017' study area (yellow) among the 16 ecoregions of the Coral Triangle (Veron et al. 2011)

Figure 3. Pulau Sabuda, West Papua, Indonesia (© G. Diraimondo – Lengguru 2017)

II GENERAL INFORMATION ON THE MISSION

II-1 Project Term

1st October 2017 – 30th November 2017

II-2 Organizing Institutions

Institut de Recherche pour le Développement (IRD), France

Pusat Penelitian Oseanografi, Lembaga Ilmu Pengetahuan Indonesia (LIPI-P2O)

Politeknik Kelautan Dan Perikanan Sorong (Politeknik-KP-Sorong), Papua Barat, Indonesia

II-3 Principal investigators of the research project and the scientific expedition & contacts

Four Co-Principal Investigators (Co-PI) led the 'Lengguru 2017' scientific expedition. They obtained a research permit from the Indonesian Ministry of Research and Higher Education (3179/FRP/E5/Dit.KI/IX/2017). (See. § *IV-4 Research ethics and field studies*).

Dr. Laurent Pouyaud	IRD-ISEM Project Leader (PI): international scientific coordination, scientific leader of the expedition, France. laurent.pouyaud@ird.fr
Indra B. Vimono	LIPI-P2O, National scientific coordination (Co-PI), Indonesia. vimono@gmail.com
Dr. Kadarusman	Jakarta Fisheries University & Politeknik-KP-Sorong, Local scientific coordination (Co-PI), Indonesia. kadarusman@kkp.go.id)
Ir. Régis Hocdé	IRD-MARBEC (Co-PI), Head of the oceanographic cruise (R/V Airaha2), head of the underwater expedition, general coordination (technical, financial, administrative), diving team leader, scientific data-manager, France. regis.hocde@ird.fr

Figure 4. Airaha2 R/V (© G. Diraimondo – Lengguru 2017)

II-4 Marine operations management

Head of the oceanographic cruise, R/V Airaha2 :	Régis Hocdé, IRD-MARBEC
Captain of the Airaha2 research vessel :	Anjas A.S. Komboe, Politeknik-KP-Sorong
Head of hyperbaric operations:	Régis Hocdé, IRD-MARBEC
Diving operations safety officer:	Eric Bahuet, IRD

II-5 Collaborative Institutions / Research Units at IRD

Institutions

- Pusat Penelitian Biologi, Lembaga Ilmu Pengetahuan Indonesia (LIPI-RCB)
- Jakarta Fisheries University
- Dinas Perikanan dan Kelautan, Kabupaten Kaimana, Papua Barat, Indonesia
- Universitas Negeri Papua (UNIPA, Manokwari), Papua Barat, Indonesia
- Aix-Marseille University (AMU), France
- Museo Nacional de Ciencias Naturales (MNCN CSIC), Spain
- Paul Sabatier University (UPS – Toulouse), France

Research Units at IRD

- Institut des Sciences de l'Evolution de Montpellier (ISEM Montpellier), France
- MARine Biodiversity, Exploitation and Conservation (MARBEC Montpellier) France
- Institut Méditerranéen Biodiversité et Ecologie marine et continentale (IMBE-Marseille), France

II-6 Institutional support and corporate sponsorship

All costs were supported by public and private partners:

- Total foundation
- TIPKO
- BOLLORE (ex-SDV)
- Monaco Explorations (sequencing post expedition)
- IRD (ISEM, MARBEC, support services)
- LIPI RCO and RCB
- IFI, Jakarta French embassy
- UM MARBEC
- Politeknik Kelautan dan Perikanan Sorong
- CNES
- Diving equipment manufacturers: APDiving, BAUER compressors, La Palanquée, MARES, Seacam, InnOdive
- Caving equipment manufacturer: PETZL Foundation, EXPE

and by the European staff (personal equipments and devices).

II-7 List of participants: scientific staff, crew, logistics

The project comprises 19 Indonesians and 13 foreigners distributed in 2 research teams (ornithology and marine biology), 1 security and health team and 1 crew team (Airaha2 vessel).

Table 1 – List of foreign participants – Lengguru 2017
Nb: IRD** non official staff invited and under the responsibility of IRD

	Foreigner name/surnam	**Nationality**	**Institution**	**Activities**	**Period in Indonesi**
1	POUYAUD Laurent	French	IRD (ISEM)	Reef Fish Genetics Taxonomy	01/10 to 29/11
2	HOCDE Régis	French	IRD (MARBEC)	CCR Diver Logistics Marine Biodiversity	01/10 to 29/11
3	LEBLOND Julien	French	IRD**	CCR Diver Sampling	01/10 to 27/11
4	BAHUET Eric	French	IRD**	CCR Diver Head security, photograph	08/10 to 04/11
5	DIRAIMONDO Gilles	French	IRD**	CCR Diver, video & photograph	01/10 to 27/11
6	JUHEL Jean-Baptiste	French	IRD (MARBEC)	Diver, Reef Fish sampling	01/10 to 27/11
7	FROMENTO Bruno	French	IRD**	Basecamp logistic ornithology	01/10 to 27/11
8	AURELLE Didier	French	AMU (IMBE)	Gorgonian & Coral Genetics	08/10 to 21/11
9	MILA Borja	Spain	MNCN CSIC	Avian Genetics & Taxonomy	01/10 to 16/11
10	THEBAUD Christophe	French	UPS Toulouse	Avian Genetics & Taxonomy	01/10 to 27/11
11	COCHET Christophe	French	IRD (ISEM)	Fish sampling & Taxonomy	01/10 to 27/11
12	POUYAUD Bernard	French	IRD**	Logistics	01/10 to 27/11
13	CHEVALLARD Jean	French	IRD**	Doctor	01/10 to 27/11

Table 2 – List of indonesian participants – Lengguru 2017

	Indonesian counterpart name/surname	**Institution**	**Activities**	**Period on Field**
1	Hidayat Ashari	RCB-LIPI	Ornithology Genetics Taxonomy	07/10 to 26/11
2	Hadi Wikanta	RCB-LIPI	Ornithology Sampling	07/10 to 26/11
3	Indra Bayu Vimono	RCO-LIPI	Diver, Echinoderm Genetics Taxonomy	28/10 to 20/11
4	Yosephine Tuti	RCO-LIPI	Diver, Gorgonians Taxonomy	15/10 to 20/11
5	Mohammad Abrar	RCO-LIPI	Diver, Hard corals Genetics Taxonomy	07/10 to 20/11
6	Rizkie Satriya Utama	RCO-LIPI	Gorgonians Genetics Taxonomy	07/10 to 20/11
7	Sumanta	IRD (local staff)	Cooking and logistic	07/10 to 26/11
8	Paulus Boli	UNIPA Manokwari	Marine biology	15/10 to 03/11
9	Napoleon Lemauk	DISKAN Kaimana	Guide and logistic	17/10 to 19/11
10	Petrus Ruwe	DISKAN Kaimana	Guide and logistic	17/10 to 19/11

11	Kadarusman	Politeknik-KP-Sorong	Reef Fish Genetics Taxonomy	15/10 to 26/11
12	Amir M. Suruwaky	Politeknik-KP-Sorong	Diver Marine biology Sampling	12/10 to 23/11
13	Abdul Gofir	Politeknik-KP-Sorong	Diver Marine biology Sampling	12/10 to 23/11
14	Anjas A.S. Komboe	Politeknik-KP-Sorong	Airaha2 Captain	12/10 to 23/11
15	Dewa Muditha	Politeknik-KP-Sorong	Airaha2 Crew	12/10 to 23/11
16	Nataniel Kalagison	Politeknik-KP-Sorong	Airaha2 Crew	12/10 to 23/11
17	Khairil Umasugi	Politeknik-KP-Sorong	Airaha2 Crew	12/10 to 23/11
18	Anton A. Orisu	Politeknik-KP-Sorong	Airaha2 Crew	12/10 to 23/11
19	Amos Ajambua	DISKAN Manokwari	Marine sampling	07/10 to 26/11

Figure 5. Lengguru 2017 team front Airaha2 vessel (© G. Diraimondo – Lengguru 2017)

II-8 Network of experts

Many associated scientists have been involved in data treatment and valorization but did not participate to in the field work. They form the experts network of the Lengguru project. They are involved in training in French laboratories and in joined international scientific publications.

III OPERATIONS TIMETABLE & LIST OF STATIONS

III-1 Metadata of the oceanographic cruise

DOI of the oceanographic cruise : https://doi.org/10.17600/18001718

III-2 Planning of Marine Biology and Ornithology teams

Table 3 –Lengguru 2017 provisional timetable

	Date	Location - ornithology team	Location - marine biology team
Sa	30/09/2017	Trip Europe - Indonesia	
Su	01/10/2017	Arrival of European team in Jakarta	
	02-06/10/2017	Administrative formalities (immigration and RISTEK research visas)	
Sa-Su	07-08/10/2017	Trip Jakarta - Sorong	
	09-11/10/2017	Administrative formalities, logistics	
	12-14/10/2017	Trip Sorong - Kaimana	
Su	15/10/2017	Logistics Kaimana	
Mo	16/10/2017	Logistics Kaimana and meeting with Kaimana's Bupati	
Tu	17/10/2017	Transit Kaimana – Nusa Ulan (basecamp installation)	
	18/10/2017 To 18/11/2017	Dinas base camp east of Nusa Ulan / Pegunungan Kumawa mountains	Diving work in Pulau Nusa Ulan / Pulau Venu / Pulau Buasai (North and West) / Pulau Lauzara
Su	19/11/2017	Trip Nusa Ulan – Kaimana	
Mo	20/11/2017	BUPATI restitution meeting, conditioning of the samples	
	21-23/11/2017	Trip Kaimana – Sorong	
Fr	24/11/2017	Packing of equipment in Sorong	
Sa	25/11/2017	Restitution meeting Politeknik-KP-Sorong – Loading container	
Su	26/11/2017	Trip Sorong - Jakarta	
Mo	27/11/2017	Trip Jakarta – Europe (European participants)	

Tu	28/11/2017	Press conference in LIPI Central, preliminary report for Menristek
We	29/11/2017	Organization team: come back to France
Th	30/11/2017	Organization team: Arrival in Montpellier (France)

III-3 General description of research areas and visited locations, Cruise tracks

Lengguru's limestone karsts extend in the Seram Sea until lowest levels known of Quaternary marine regressions (-120m). Submerged anticlines form complex islands networks, rias and shallow rocky banks. For example, in Triton Bay, faults and rock collapses are numerous and represent original submarine landscape similar to natural labyrinths with high potentialities for exploring various assemblages of organisms. On the contrary, the southwest extremity of Kumawa is exposed to the strong Torres' east-west surface current, and consists of a sharp slope plunging to the abyssal pit of the Seram Sea and facing a permanent upwelling.

Our preliminary explorations on the Lengguru coastline show the following:

- Presence of a large sedimentary cone (terrigenous inputs from continental erosion) in the Arguni Bay and extending until the south cape of Pulau Adi; accumulation of deep and unstable submarine dunes alternating with numerous scattered coral reefs,
- A mesotidal regime characterized by asymmetric tides (2,6 m maximal range), tidal propagation extending far upstream (up to 100 km) in Arguni Bay (Sewiki Lake) and sometime forming tidal bore (observed on Lengguru River in October 2014),
- An important hydrodynamic regime with a westward-flowing current particularly strong on exposed capes (south extremity of Nusa Ulan Cape) with the presence of submarine hydraulic sand dunes with depths ranging between -20 and -50 m,
- A rugged and tormented geomorphology at south extremity of Nusa Ulan Cape with absence of fouling and presence of scarce benthic fauna on substrate exposed to current until 90-100 m depths,
- A disjoint abundance for many organisms compared to other areas in Indonesia with generally abundant species becoming rare in Lengguru and conversely rare species elsewhere becoming more abundant in the area,
- An important species diversity within each studied group but characterized by low intraspecific abundance at a given locality,
- A spectacular species diversity of soft corals and associated organisms in Triton Bay,
- A stratification of species assemblages according to depth with some species characterized by an unusually shallow occurrence (20-40 m) that are generally confined to depths below about 50-100m at most locations in the Indo-Pacific; an ascent of deep species probably explained by the permanent turbidity of the surface section of the water-column.

Exploration of outer reef slopes were made at six locations (Figure 20): (1) inner part of Triton Bay; (2) eastern part of Pulau Buasai; (3) outer part of Triton Bay; (4) Bitsyari Bay; (5) Pulau Venue; (6) southern part of Nusa Ulan.

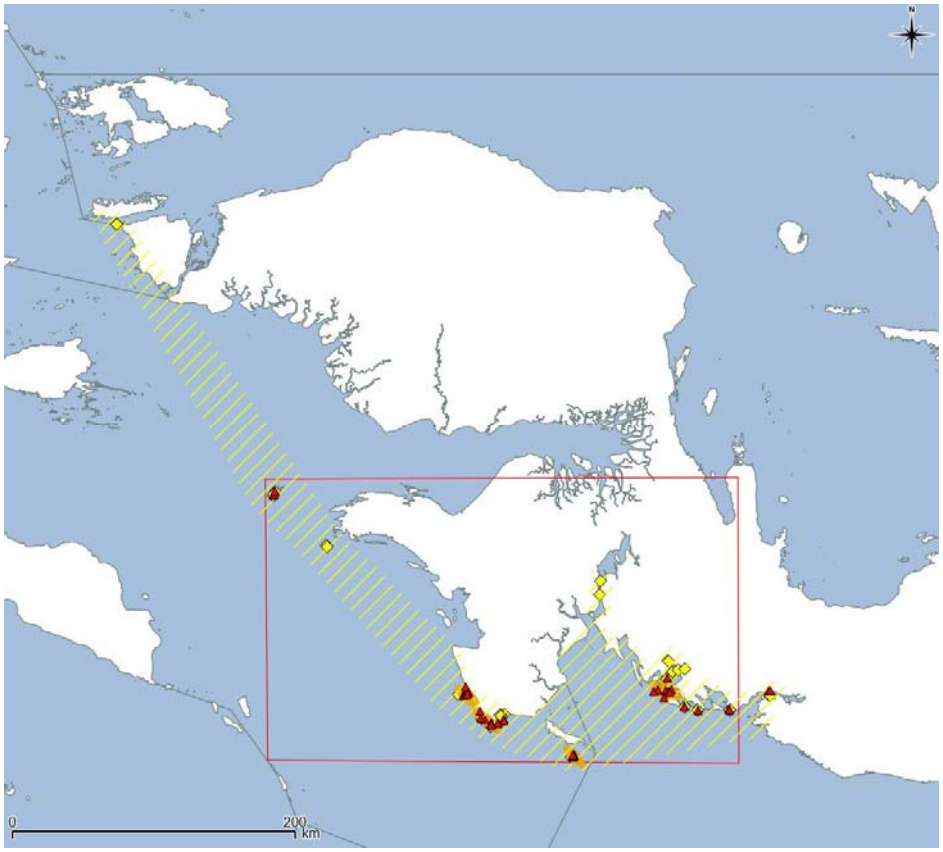


Figure 6: Research area (yellow lines) with localities explored
by diving teams (red triangles), eDNA locations (yellow lozenges) and BRUVs locations (orange circles)

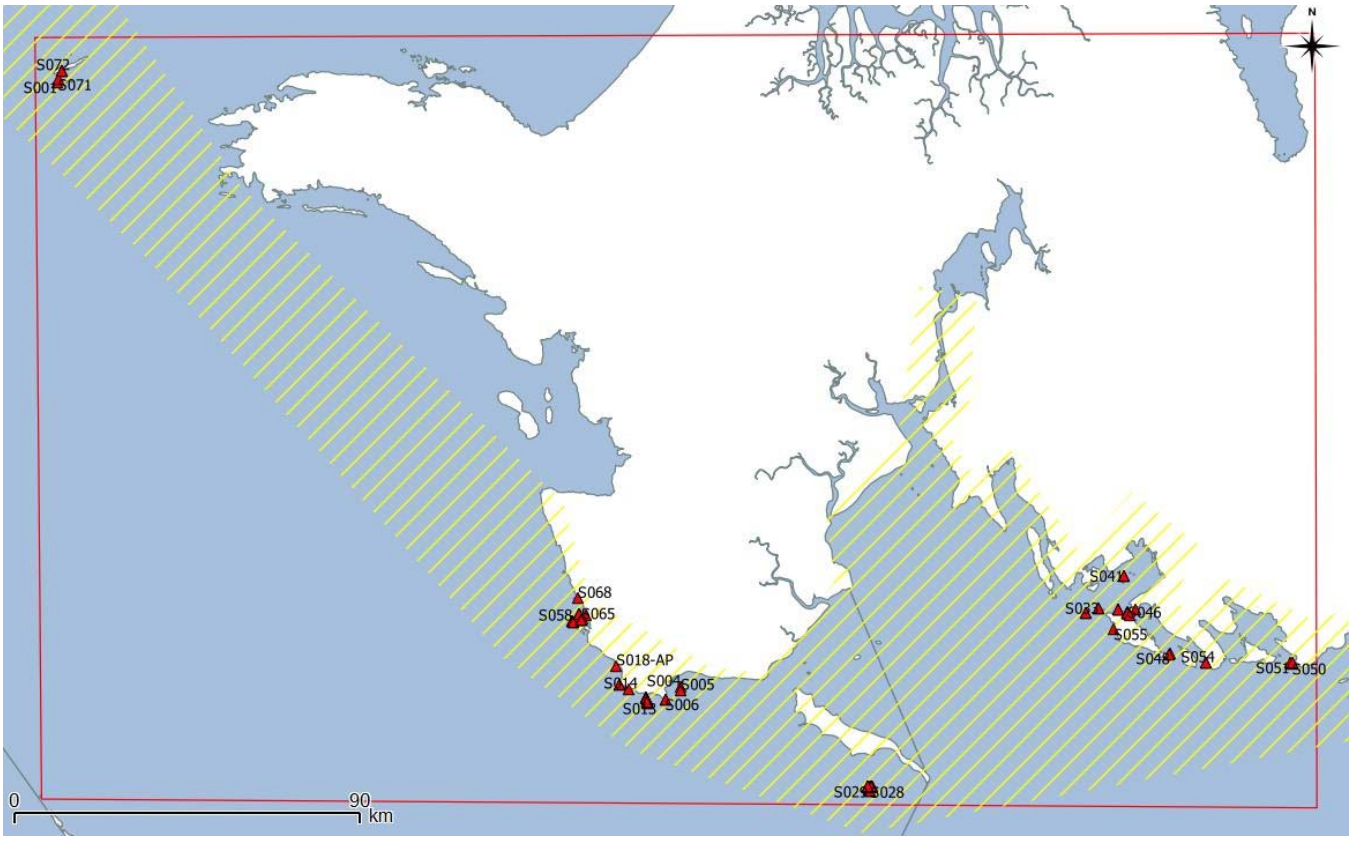


Figure 7: Map of the localities explored by diving teams (red triangles)

III-4 Statistics of scientific dives

Table 4: Statistics of scientific dives, by range of depths and by method

	Total	CCR	OC
Total number of scientific dives	376	148	228
Total number of training, discovery dives	33	13	20
Total number of dives	409	161	248

	Total	CCR	OC
Total time of scientific dives	683 hours	336 hours	347 hours

Areas and depths of intervention were organized according to capacity and level of experience of each diver. Deep dives (up to -100m) were investigated by 5 divers (R. Hocdé, J. Leblond, E. Bahuet, G. Di Raimondo) with electronical- closed circuit rebreathers (e-CCR), while conventional dives (up to 40m) were organized by other members (Y. Tuti, M. Abrar, I.B. Vimono, A. Suruwaki, Gofir, P. Boli, R. Satriva Utama, C. Cochet).

III-5 List of stations

Table 5: List of scientific diving stations (red triangles)

Diving stations	Longitude (East)	Latitude (North)	Localities
S001	131,59549	-2,6779	Pulau Sabuda (Banana Island) - South West tanjung of the South island
S002	132,97464	-4,11585	North (NE) wall of Pulau Nusaulang (big island front of Nusa Ulan)
S003	133,02015	-4,11885	Papisol cap
S004	133,05577	-4,08942	North face of the reef flat, before Pulau Derbi (Korowai ?)
S005	133,05658	-4,09782	Pulau Derbi
S006	133,02015	-4,11885	East face of Tanjung Papisol (Papisol Cap)
S007	132,97754	-4,12528	Nusa Ulan Island - South East Tanjung (SE Cap)
S008	132,97753	-4,12577	Nusa Ulan Island - South East Tanjung (SE Cap)
S009	132,97753	-4,12577	Nusa Ulan Island - South East Tanjung (SE Cap)
S010	132,97464	-4,11585	North wall of Pulau Nusaulang (big island front of Nusa Ula)
S011	132,9751	-4,11723	Nusa Ulan Island - North East
S012	132,97688	-4,12818	Nusa Ulan Island - South East
S013	132,97925	-4,12829	Nusa Ulan Island - South East
S014	132,93521	-4,09478	Nusa Ulan Island - West coast
S015	132,97829	-4,12148	Nusa Ulan Island - East face
S016	132,97829	-4,12148	Nusa Ulan Island - East face
S017	132,9769	-4,12602	Nusa Ulan Island - East face
S018	132,91273	-4,08471	Tanjung Suar (West cap of Nusa Ulan village)
S019	132,91273	-4,08471	Tanjung Suar (West cap of Nusa Ulan village)

S018-AP	132,90549	-4,04074	Tanjung Suar - North bay
S020	133,49632	-4,33012	Pulau Venu West
S021	133,49826	-4,32135	Pulau Venu North West
S022	133,49637	-4,32889	Pulau Venu West 2
S023	133,50023	-4,33406	Pulau Venu South
S024	133,50575	-4,32168	Pulau Venu South
S025	133,50023	-4,33406	Pulau Venu South
S026	133,50081	-4,32323	Pulau Venu North 2
S027	133,49508	-4,32617	Pulau Venu North 2
S028	133,50081	-4,32323	Pulau Venu North 2
S029	133,49341	-4,32241	Pulau Venu West 3
S030	133,49367	-4,32157	Pulau Venu West 3 bis
S031	133,49367	-4,32157	Pulau Venu West 3 bis
S032	134,03511	-3,90675	Pulau Sokkos North, NW face
S033	134,03511	-3,90675	Pulau Sokkos North, NW face
S034	134,07967	-3,90956	The 3 rocks, North of Pulau Aiduma
S035	134,07967	-3,90956	The 3 rocks, North of Pulau Aiduma (South face, between the 2 and 3 island East)
S036	134,07967	-3,90956	The 3 rocks, North of Pulau Aiduma (South face, between the 2 and 3 island East)
S037	134,738	-3,90965556	The 3 rocks, North of Pulau Aiduma (West Cap)
S038	134,00441	-3,91886	Pulau Lauzaro - NE Cap
S039	134,00441	-3,91886	Pulau Lauzaro - NE Cap
S040	134,745417	-3,90964722	The 3 rocks, North of Pulau Aiduma (between 1st and 2nd rocs from West)
S041	134,09264	-3,8319	Pulau Wia, North West rock of Pulau Nusurumi
S042	134,09264	-3,8319	Pulau Wia, North West rock of Pulau Nusurumi
S043	134,10236	-3,9148	Pulau Serawainus - Face NE
S044	0	0	Pulau Serawainus - Face SW
S045	134,1031	-3,91643	Pulau Serawainus - Crique SE et face NE
S045	134,1031	-3,91643	Pulau Serawainus - Crique SE et face NE
S045	134,1031	-3,91643	Pulau Serawainus - Crique SE et face NE
S045	134,1031	-3,91643	Pulau Serawainus - Crique SE et face NE
S046	134,1031	-3,91643	Pulau Serawainus - Face NE
S047	134,12082	-3,90906	Macro Rocks
S048	134,20125	-4,01155	SE Pulau Aiduma - Wall 100m
S049	134,19962	-4,01495	SE Pulau Aiduma - Goby Gully TB9
S050	134,48901	-4,03573	Island (NW of Tanjung Awura) - Tanjung South-East
S051	134,48189	-4,033	Island (NW of Tanjung Awura) - Tanjung South
S052	134,48788	-4,03287	Island (NW of Tanjung Awura) - Tanjung East
S053	134,28566	-4,0339	West Cap of Tanjung Nambina
S054	134,28703	-4,03357	West Cap of Tanjung Nambina
S055	134,070417	-3,95493333	North of P. Aiduma
S056	134,1031	-3,91643	Pulau Serawainus, NE face, "Little Komodo"
S057	134,10777	-3,92392	North-West of P. Aiduma
S058	132,80188	-3,93613	NW of Tanjung Pulau Mommon (North tanjung, East side)

S059	132,80188	-3,93613	NW of Tanjung Pulau Mommon (North tanjung, East side)
S060	132,83315	-3,92291	Tanjung Pulau Mommon, North small island, East side
S061	132,80287	-3,94034	Tanjung Pulau Mommon, Small islands on East side (Start: first South island / End: third North island)
S062	132,80287	-3,94034	Tanjung Pulau Mommon, Small islands on East side (Start: first South island / End: third North island) (or "Tiki-tiki")
S063	132,81792	-3,92135	North of Tanjung Pulau Mommon, Between North small islands, East side
S063	132,81792	-3,92135	North of Tanjung Pulau Mommon, Between North small islands, East side
S063	132,81792	-3,92135	North of Tanjung Pulau Mommon, Between North small islands, East side
S063	132,81792	-3,92135	North of Tanjung Pulau Mommon, Between North small islands, East side
S064	132,82387	-3,93388	North of Tanjung Pulau Mommon, Between North small islands, East side
S065	132,82346	-3,93279	Prospect of the enter / Big cave
S065	132,82346	-3,93279	Big cave
S066	132,82669	-3,93207	East of Tanjung Pulau Mommor
S067	132,82346	-3,93279	Big cave
S068	132,81551	-3,88301	North of the Tikitiki waterfall
S069	131,60571	-2,65057	Bay South-East - Pulau Sabuda
S070	131,60571	-2,65057	Bay South-East - Pulau Sabuda
S071	131,59814	-2,67144	SW Pulau Pisang - North wall
S072	131,60571	-2,65057	Bay South-East - Pulau Sabuda

IV METHODOLOGY, FIELD STUDIES AND DATA MANAGEMENT

IV-1 Sampling methodology and data acquisition

The sampling methodology for the marine biotas consisted of the manual collection of hard invertebrates (hard corals, gorgonians, echinoderms) and reef fishes along a vertical transect from -100m to the surface, and to determine their distribution according to depth. Each collected sample was photographed and labeled with a detailed description of its habitat (GPS coordinates, depth, salinity, etc.). The samples consisted of vouchers (Museum collections) and tissues for subsequent DNA barcoding analysis.

The specimens of reef fishes were mainly collected by hand or with 4 to 8 m long bottom gillnets deployed by open-circuit and closed-circuit divers in the 0-100 m depth range (Hocdé R. *et al.*, 2017). Eugenol or spearguns have been used sometimes. Some brackish and estuarine fishes were also collected with 10 m beach purse seines, and pelagic fish with line fishing and spearfishing.

The inventory of reef fishes was also performed with environmental DNA (eDNA) in order to detect hidden diversity. This consisted of the filtration of 2L of sea water (with 1 replicate) at different depths for each sampling station.

Besides the implementation of DNA barcoding and eDNA for the evaluation of reef fish diversity, a complementary approach was performed with the use of Stereo Baited Remote Underwater Video Systems (stereo-BRUVS). This observation tool allows to monitor reef communities, detect elusive species and investigate their behavior.

IV-2 Collection of biological samples

The marine samples were preserved in 70% ethanol, with fragments in 95% absolute ethanol, and stored at -20°C for genetic analysis.

Hard corals skeletons were air dried and stored at ambient temperature.

Blood and tissue samples from bird species were stored in pure ethanol for genetic analysis. Some specimens were collected and prepared as study skins, and are deposited at the Museum Zoologicum Bogoriense (Cibinong, Indonesia), and others were released after measurements and analysis.

IV-3 Oceanographic observations

Physico-chemical variables (CTD, other variables) were measured with both surface and autonomous underwater sensors (vertical profiles, eDNA sampling, diving profiles).

Measurements were performed in different habitats: offshore, coastal zones, estuaries, lagoons, upper lakes.

IV-4 Sample management, data accessibility and data citation

All samples are managed by Indonesian institutions. All data will be shared through international databases (NCBI, BOLD, GBIF…).

IV-5 Research ethics and field studies

The Lengguru 2017 Expedition is based on a joint collaboration between Indonesian and European scientists and is covered by a MOU signed between LIPI and IRD on 5th April 2017. The project is co-organized by IRD (French Institution), LIPI-P2O (National counterpart) and Politeknik-KP-Sorong (Local counterpart). RISTEK Authorization: 3179/FRP/E5/Dit.KI/IX/2017.

V PRELIMINARY RESULTS AND FURTHER CONSIDERATION – MARINE TEAM

V-1 Brief description of the main habitats

Research sites

The Lengguru Range is located in the Kaimana Regency (West Papua, Indonesia). It is characterized by a series of parallel and oblique folds, with altitude ranging from 600 to 1500 m. These carbonate anticlines are separated by deep valleys sometimes closed and rifted with no outflow of collected water (i.e. endorheic). Lengguru's topography consists of karst limestone shaped by uplift or subsidence geologic events and under the dissolving action of water on carbonate bedrocks since a dozen million years ago (cc. 10-12 Myr.). This rough and fragmented landscape displays unusual surface and marine subsurface features including sinkholes, vertical shafts, and multiple reef slopes.

These sedimentary outcrops are therefore characterized by a large array of ecological niches afforded by complex terrains, and promoting unexpected levels of biodiversity.

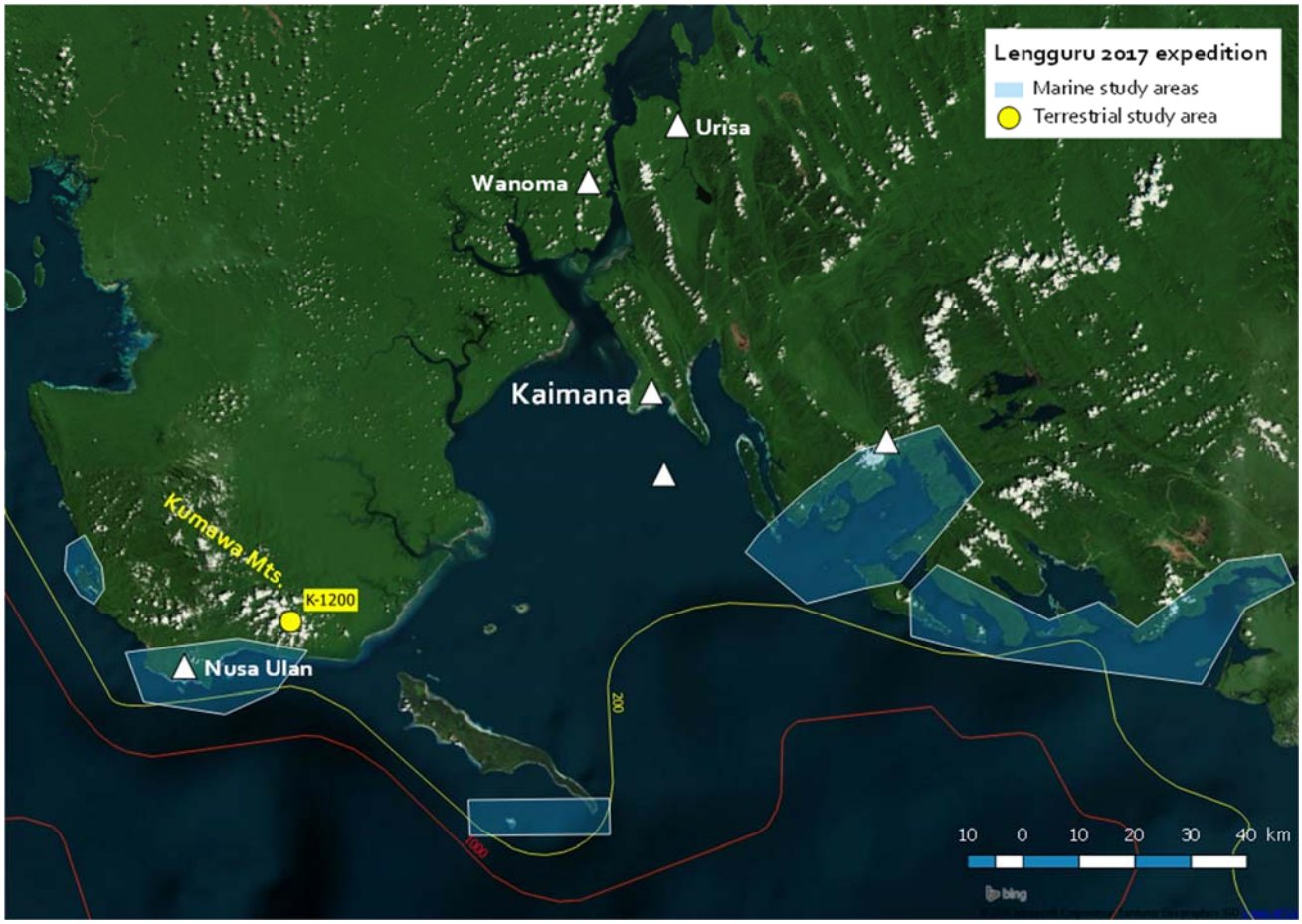


Figure 8: Geographic location of study sites

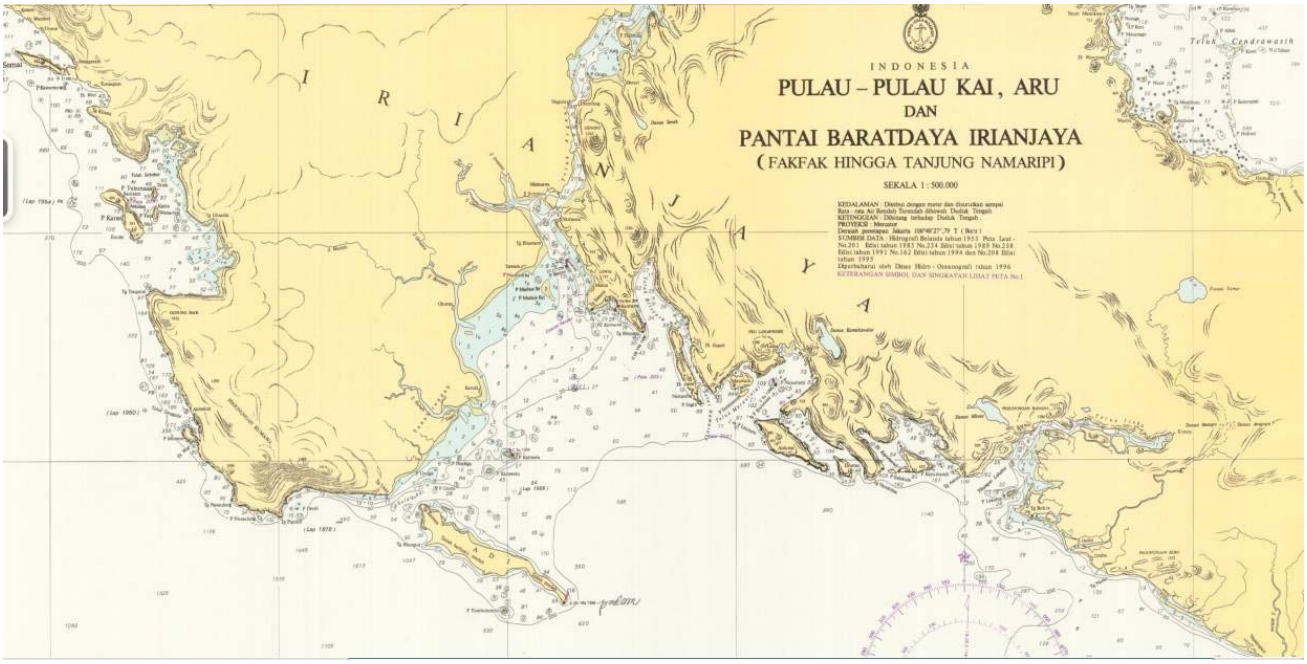


Figure 9: Bathymetric chart of the study area (Source: hydrographic service of Indonesia)

Figure 10. Topographic map of southwest Kaimana Regency (source: National Disaster Management Agency BNPB)

Preliminary results obtained during Lengguru 2010 lead us to consider two kinds of ecosystems with high scientific interests:

Submerged karsts and outer reef slopes:
Lengguru seafront at Triton Bay, Kumawa seafront at Nusa Ulan and Pulau Venu

Lengguru seafront consists of drowned karsts geologically built during successive marine regressions since the end of the Miocene. Preliminary investigations performed in 2014, revealed an important richness of ecosystems, such as submerged freshwater springs (Vruljas), flooded river canyons, stratified estuaries, coastal marine lakes, and reef slopes. We plan to explore these areas of interest with the help of a diving team equipped with conventional scuba systems (using Open Circuit with tanks and regulators) or with recycled-air scuba system (using some Closed Circuit Rebreathers – eCCR). Areas of investigation will be made at Nusa Ulan (Kumawa-Buruway), Pulau Venu (Arguni Bay), around Pulau Buasai, in & off shore of Triton Bay.

Montane cloud forests : Tops of Gunung Kumawa

Papuan biodiversity is known to increase with altitude. In Lengguru, the tops of anticlines are generally characterized by Lapies formations. Lapies are fissured limestone plateaus consisting of natural labyrinths and forming patchworks of habitats and forest types according to altitude, geological substrate, exposure to trade winds, rainfall and remoteness from seashore. These extreme ecosystems, never studied nor visited, were explored for the first time in 2014. We discovered that these original habitats host a number of differentiated avian taxa, with several potential new subspecies and species of birds.

V-2 Echinoderms

Echinoderms	collected specimens: - 17 sea stars - 7 sea cucumbers - 7 sea urchins	DNA samples : (identical)

Results to date > The principal investigator for Echinoderms, I. B. Vimono (RCO-LIPI) has obtained a 3-year PhD scholarship (2019 - 2022) from the French Foreign Office. The PhD will be registered at Montpellier University (France) under the supervision of L. Pouyaud (IRD) and P. Borsa (IRD). By the way, all material collected during 2014 and 2017 expeditions and additional material from other locations in Indonesia will be analyzed between the end of 2019 and the beginning of 2020 by I. B. Vimono.

V-3 Gorgonians

Gorgonians	800 collected specimens	800 DNA samples

Results to date > The principal investigator for Gorgonians, R. Satriya Utama (RCO-LIPI) was invited by the Lengguru program for a 4-week visit at MIO Laboratory (Marseille, France) in May-June 2018. In collaboration with D. Aurelle, he performed DNA extraction, PCR and sequencing of all material collected during Lengguru 2017.

Data treatment and scientific valorization are presently under process.

V-4 Hard Corals

Hard corals	> 500 collected specimens	603 DNA samples

Results to date > The principal investigator for Hard Corals, M. Abrar (RCO-LIPI) was invited by the Lengguru program for a 4-week visit at MIO Laboratory (Marseille, France) in May-June 2018. In collaboration with D. Aurelle, he performed DNA extraction, PCR and sequencing of all material collected during Lengguru 2017.

Data treatment and scientific valorization are presently under process.

V-5 Reef fishes

Reef fishes	2250 collected specimens	2250 DNA samples

Results to date > All collected specimens were preliminary identified on a morphologically basis by C. Cochet and L. Pouyaud between January and February 2018.

DNA was extracted from 1500 specimens in April 2018 in the RCO-LIPI genetic laboratory in Ancol. This operation was made on a large-scale extraction unit supported by the Lengguru program and involving specific material (INCU-Mixer MP4, Nucleovac 96 Vacuum Manifold, Vacuum Pump Chemker, microplate 96 centrifuge, and consumables). DNA extractions were performed in a collaborative work including H. Y. Sugeha, Kadarusman, and L. Pouyaud.

DNA was amplified at two mitochondrial loci (12S and COI) for all 1500 extracted specimens between July and August 2018. The work was done by H. Y. Sugeha and Kadarusman during their visit in France in July 2018 and in collaboration with L. Pouyaud.

All material was sequenced in France between the end of 2018 and the beginning of 2019.

At the present time, the molecular database of 1500 reef fishes has been achieved. Morphological and sequences data reveal the existence of around 450 species. This represents near half of expected species in the area following Allen G. R. & Erdmann M. V. (2012). To our knowledge, this is the largest reef fish molecular barcoding database available in the Coral Triangle. This database will be used as reference database for assignment of sequence data obtained from the eDNA operation.

COI DNA barcode revealed the presence of several new species which will be described soon from voucher specimens stored at RCO-LIPI.

Several collaborations were initiated to valorize these data and currently several papers are being prepared.

V-6 Stereo Baited Remote Underwater Video Systems (stereo-BRUVS)

Underwater video devices consisted of two Gopro© Hero 5 camcorders oriented horizontally toward a bait with an inward convergent angle of 8°. The bait was a mix of dried sardine powder, flour and sardine oil placed in a PVC canister suspended approximatively 1.4m in front of the cameras. The stereo-BRUVS were deployed from the boat at 6-20m deep (mean ± SD: 12.8 ± 3.8m) for one-hour recording. For each site, the stereo-BRUVS were set at least 400m apart. A total of 53 stereo-BRUVS were deployed.

Stereo-BRUVs	53 records	image analysis in progress

Video analyses > The footage will be hosted on an interactive platform named Webfish currently under development at the university of Montpellier. This open access platform will be connected to internet and will allow all Lengguru collaborators to process the footage. This platform will allow to measure species richness and abundance of marine organisms. It will also store thumbnails of each species to provide an image database for the development of automated species identification.

Ultimately, the ichthyological assemblages obtained using Stereo-BRUVS will be compared to the environmental DNA sequences to confirm identifications and evaluate the performance of both methods.

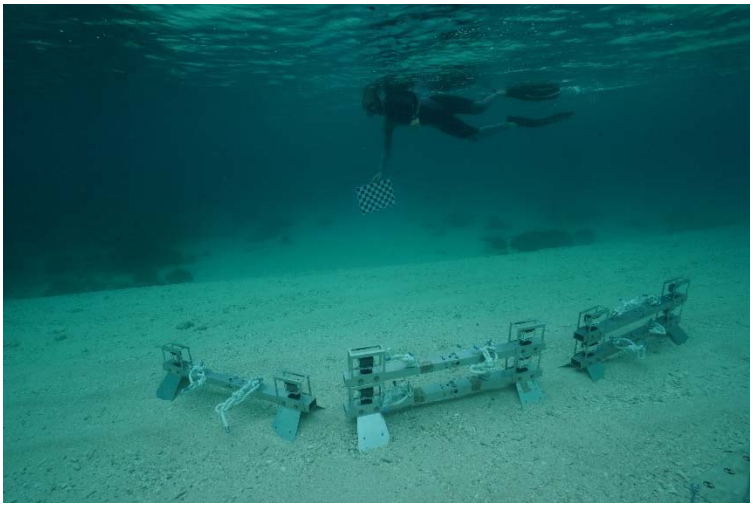


Figure 11. Calibration of Stereo BRUVS for 3D measurements

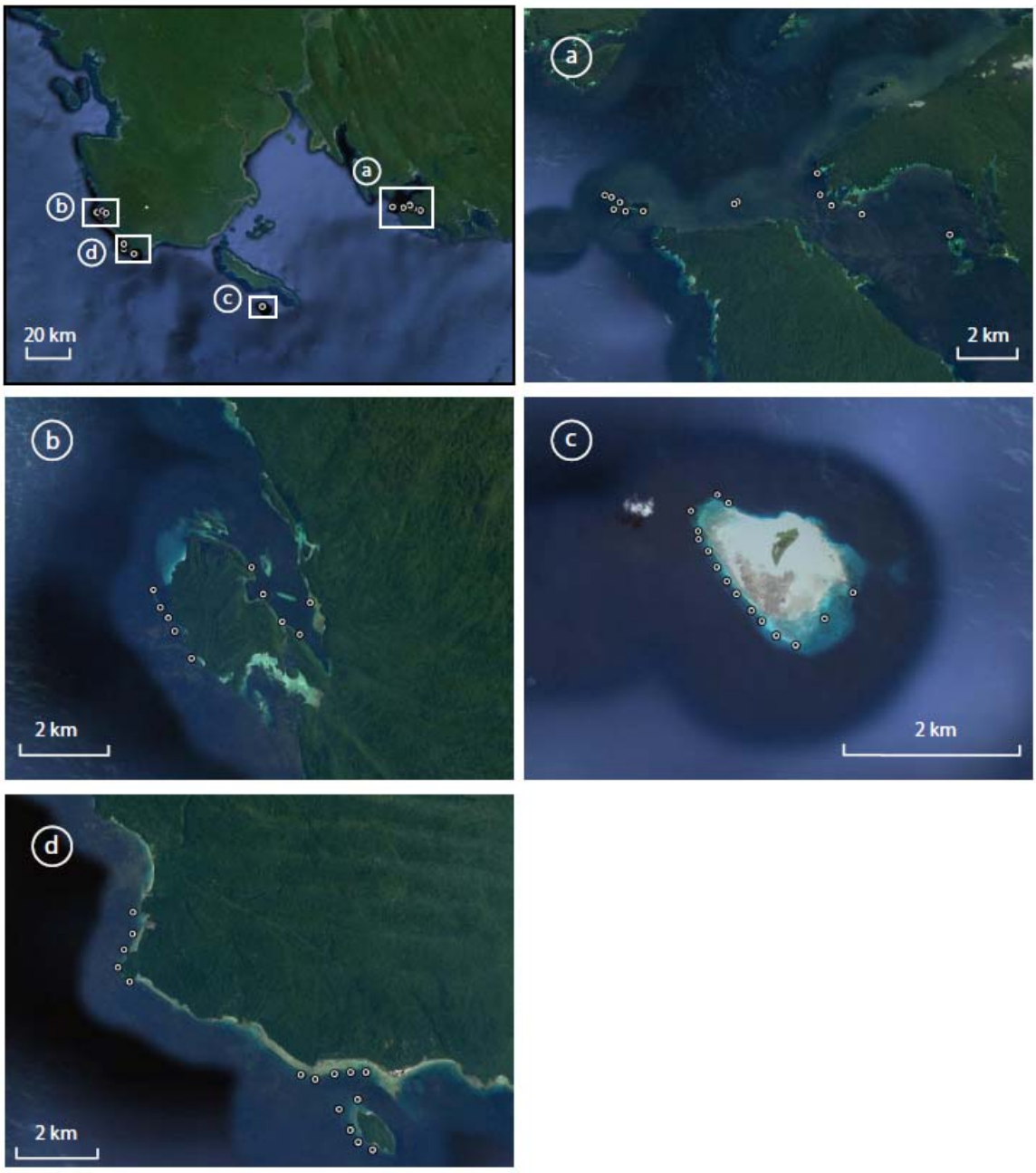


Figure 12. Map of Stereo BRUVS deployments in the Kaimana region and (a) triton bay zone, (b) Kitikiti zone, (c) Pulau Venu (Tumbu Tumbu) island and (d) Nusa Ulan zone.

Table 6 – List of stereo BRUVs stations

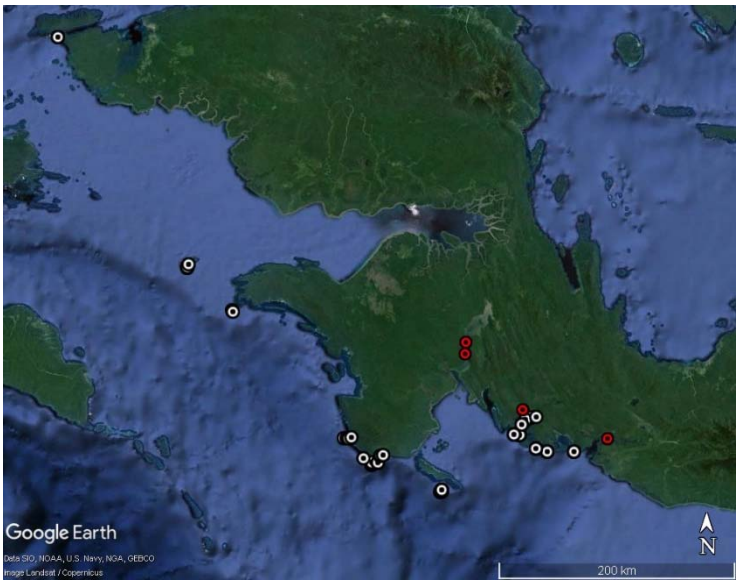
station	latitude	longitude	site	date	time	depth	rig	cam_left	cam_right	comments	hard_drive
nusa_ulan001	-04.10699	132.97247	nusa_ulan	22/10/2017	10:12	12	1	1	2	sandy substra	01-févr
nusa_ulan002	-04.10702	132.96887	nusa_ulan	22/10/2017	10:28	17	2	3	4	sandy substra	01-févr
nusa_ulan003	-04.10743	132.96507	nusa_ulan	22/10/2017	10:50	20	5	9	10	sandy substra	01-févr
nusa_ulan004	-04.10869	132.96053	nusa_ulan	22/10/2017	10:56	15	3	5	6	sandy substra	01-févr
nusa_ulan005	-04.10768	132.95721	nusa_ulan	22/10/2017	11:07	10	4	7	8	sandy substra	01-févr
nusa_ulan006	-04.12415	132.97322	nusa_ulan	23/10/2017	09:20	15	2	3	4		01-févr
nusa_ulan007	-04.12249	132.97002	nusa_ulan	23/10/2017	09:35	20	1	1	2		01-févr
nusa_ulan008	-04.11986	132.96834	nusa_ulan	23/10/2017	09:42	17	3	5	6		01-févr
nusa_ulan009	-04.11554	132.96593	nusa_ulan	23/10/2017	09:52	8	5	9	10		01-févr
nusa_ulan010	-04.11330	132.97028	nusa_ulan	23/10/2017	10:00	15	4	7	8		01-févr
nusa_ulan011	-04.08527	132.91551	nusa_ulan	25/10/2017	09:10	10	4	7	8		01-févr
nusa_ulan012	-04.08154	132.91228	nusa_ulan	25/10/2017	09:20	8	3	5	6		01-févr
nusa_ulan013	-04.07690	132.91350	nusa_ulan	25/10/2017	09:30	12	5	9	10		01-févr
nusa_ulan014	-04.07271	132.91530	nusa_ulan	25/10/2017	09:40	18	1	1	2		01-févr
nusa_ulan015	-04.06686	132.91505	nusa_ulan	25/10/2017	09:55	12	2	3	4		01-févr
pulau_venu01	-04.32162	133.49811	pulau_venu	28/10/2017	08:25	7	2	3	4		01-févr
pulau_venu02	-04.32045	133.49670	pulau_venu	28/10/2017	08:35	10	5	9	10		01-févr
pulau_venu03	-04.32272	133.49355	pulau_venu	28/10/2017	08:45	15	3	5	6		01-févr
pulau_venu04	-04.32656	133.49469	pulau_venu	28/10/2017	08:55	15	1	1	2		01-févr
pulau_venu05	-04.33015	133.49702	pulau_venu	28/10/2017	09:05	20	4	7	8		01-févr
pulau_venu06	-04.33350	133.49947	pulau_venu	28/10/2017	15:25	12	4	7	8		01-févr
pulau_venu07	-04.33677	133.50246	pulau_venu	28/10/2017	15:35	8	2	3	4		01-févr
pulau_venu08	-04.33957	133.50630	pulau_venu	28/10/2017	15:45	15	3	5	6		01-févr
pulau_venu09	-04.33644	133.50964	pulau_venu	28/10/2017	15:55	15	1	1	2		01-févr
pulau_venu10	-04.33327	133.51300	pulau_venu	28/10/2017	16:00	15	5	9	10		01-févr
pulau_venu11	-04.32546	133.49454	pulau_venu	29/10/2017	09:25	8	2	3	4		01-févr
pulau_venu12	-04.32811	133.49591	pulau_venu	29/10/2017	09:35	15	3	5	6		01-févr
pulau_venu13	-04.33194	133.49828	pulau_venu	29/10/2017	09:45	15	1	1	2		01-févr
pulau_venu14	-04.33551	133.50125	pulau_venu	29/10/2017	09:55	12	4	7	8		01-févr
pulau_venu15	-04.33846	133.50410	pulau_venu	29/10/2017	10:05	6	5	9	10		01-févr
triton_bay01	-03.90978	134.07840	triton_bay	02/11/2017	08:00	8	1	1	2		01-févr
triton_bay02	-03.90900	134.07951	triton_bay	02/11/2017	08:10	8	3	5	6		01-févr
triton_bay03	-03.91250	134.04749	triton_bay	02/11/2017	08:30	10	2	3	4		01-févr
triton_bay04	-03.91261	134.04140	triton_bay	02/11/2017	08:50	10	5	9	10		01-févr
triton_bay05	-03.91194	134.03731	triton_bay	02/11/2017	09:00	15	4	7	8		01-févr
triton_bay06	-03.90767	134.03619	triton_bay	02/11/2017	16:46	8	3	5	6		01-févr
triton_bay07	-03.90939	134.03923	triton_bay	02/11/2017	17:00	8	5	9	10		01-févr
triton_bay08	-03.90688	134.03381	triton_bay	02/11/2017	17:15	8	2	3	4		01-févr
pulau_aiduma01	-03.91322	134.12190	pulau_aiduma	05/11/2017	09:35	8	4	7	8		01-févr
pulau_aiduma02	-03.91017	134.11165	pulau_aiduma	05/11/2017	09:45	10	3	5	6		01-févr
pulau_aiduma03	-03.90635	134.10788	pulau_aiduma	05/11/2017	10:05	15	1	1	2		01-févr
pulau_aiduma04	-03.89861	134.10699	pulau_aiduma	05/11/2017	10:15	12	2	3	4		01-févr
pulau_aiduma05	-03.92014	134.15126	pulau_aiduma	05/11/2017	11:00	12	5	9	10		01-févr
kitikiti01	-03.93949	132.84041	kitikiti	16/11/2017	15:10	15	2	3	4		01-févr
kitikiti02	-03.94732	132.83783	kitikiti	16/11/2017	15:20	15	4	7	8		01-févr
kitikiti03	-03.94425	132.83363	kitikiti	16/11/2017	15:35	15	3	5	6		01-févr
kitikiti04	-03.93735	132.82903	kitikiti	16/11/2017	15:45	15	1	1	2		01-févr
kitikiti05	-03.93047	132.82614	kitikiti	16/11/2017	16:00	20	5	9	10		01-févr
kitikiti06	-03.93632	132.80209	kitikiti	17/11/2017	07:50	10	2	3	4		03-avr
kitikiti07	-03.94079	132.80408	kitikiti	17/11/2017	08:00	15	4	7	8		03-avr
kitikiti08	-03.94334	132.80609	kitikiti	17/11/2017	08:10	15	1	1	2		03-avr
kitikiti09	-03.94660	132.80783	kitikiti	17/11/2017	08:19	15	5	9	10		03-avr
kitikiti10	-03.95314	132.81210	kitikiti	17/11/2017	08:30	15	3	5	6		03-avr

V-7 Environmental DNA (eDNA)

The marine component of the Lengguru expedition aimed to investigate marine biodiversity in the Bird's Head region of West Papua. This objective was built around three axes: 1) Create a genetic reference database of sampled marine organisms, 2) Retrieve environmental DNA from water to implement a metabarcoding biodiversity assessment, and 3) Deploy baited underwater camera to record marine biodiversity on video.

Figure 13. CCR diver collecting water for eDNA.

Environmental DNA > The environmental DNA (eDNA) is an innovative tool allowing to detect the presence of organisms without directly seeing them. This method is based on the principle that organisms leave genetic traces in their surroundings through organic material including feces, mucus, gametes, shed skin or carcasses. The retrieved eDNA is then amplified, sequenced and compared (sequence assignment) to the genetic sequence databases (Lengguru reference database, GenBank).



Sampling > In the Lengguru expedition, eDNA was collected from water using different methods according to the sampled depth. For surface samples, the water was collected in DNA-free plastic bags from a dinghy or during snorkeling facing the current. For mid-water samples (10 – 100 m deep), the water was sampled in DNA-free plastic bags during close circuit rebreather (CCR) diving. For deep-water samples (100 – 300m deep), the water was sampled using Niskin bottles.

Figure 14. Map of the Bird's Head of Papua showing the location of eDNA samples using 0.22µm (white) and 0.45µm filters (red).

eDNA	106 0.22µm filters	10 0.45µm filters

Filtration > Two types of filter were used according to the water turbidity to avoid clogging. Marine and clear river/lakes samples were filtered using 0.22µm Sterivex filter units. A volume of 2L was filtered for each point with a duplicate (2L x 2 filters) at different depth (from surface to 270m). A total of 106 0.22µm filters were used.

Estuaries, bays and rivers samples were filtered using 0.45µm Sterivex filter units. A volume of 5L was filtered for each point with a duplicate (5L x 2 filters). A total of 10 0.45µm filters were used for surface sampling only.

Table 7. Summary of environmental DNA sampling

Type of filter	Number of filters	Depth
0.45	10	Surface
0.22	49	Surface
	28	3 - <40m
	19	40 - <100m
	10	>= 100m

Extraction, amplification & sequencing > The extraction, amplification and sequencing were performed in a collaborating laboratory, Spygen (http://www.spygen.com/fr/). This laboratory is specialized in environmental DNA treatment and equipped with cleanrooms to avoid contamination.

The DNA sequences obtained with the 0.45µm filters and 10 of the 0.22µm filters were amplified with the vertebrate 12S primer V05 to evaluate the diversity of vertebrate and optimize the laboratory analyses protocol.

The DNA sequences from all the filters were amplified with a teleost specific primer Teleo2 to evaluate the diversity of fishes. This approach is more precise and allows to get a clearer picture of the ichthyological assemblages.

Results to date > A big corpus of DNA sequences was obtained. Species assignment to online reference databases and custom database from species barcoding indicates the occurrence of around 393 marine fish species. Both 12S online reference databases and custom database cover 40% of the checklist of coastal fish (1,610 species). Thus, a large fraction of fish species is not sequenced underestimating the diversity found in our samples.

Two scientific articles have now been submitted. The first article reveals the incompleteness of online reference databases and put forwards new approached to overcome it. The second paper uses eDNA to estimate the hidden diversity left undetected by both traditional census methods and checklists.

Table 8 – List of eDNA stations

station	replicate_nur	lat	long	site	country	date	time	depth	depth_substr	temp	volume	filter	categories	sampling	Comment
LENG001	1	-02.67790	131.59549	pulau_pisang	west_papua	14/10/2017	13:30	0	10	29.1	2	0.22	surface	snorkeling	Vial identified S001
LENG001	2	-02.67790	131.59549	pulau_pisang	west_papua	14/10/2017	13:30	0	10	29.1	2	0.22	surface	snorkeling	Vial identified S001
LENG001	3	-02.67790	131.59549	pulau_pisang	west_papua	14/10/2017	13:30	0	10	29.1	1.6	0.22	surface	snorkeling	Vial identified S001
LENG002	1	-04.11588	132.97463	nusa_ulan_ea	west_papua	17/10/2017	15:30	0	12	29.5	2	0.22	surface	snorkeling	
LENG002	2	-04.11588	132.97463	nusa_ulan_ea	west_papua	17/10/2017	15:30	0	12	29.5	2	0.22	surface	snorkeling	
LENG003	1	-04.11785	133.01915	nusa_ulan_ea	west_papua	18/10/2017	12:00	39	40	29.5	2	0.22	mid	CCR_dive	
LENG003	2	-04.11785	133.01915	nusa_ulan_ea	west_papua	18/10/2017	12:00	39	40	29.5	1.7	0.22	mid	CCR_dive	Buffer does not cover all the filter
LENG004	1	-04.11746	133.02032	nusa_ulan_ea	west_papua	18/10/2017	12:15	0	10	30	2	0.22	surface	snorkeling	
LENG004	2	-04.11746	133.02032	nusa_ulan_ea	west_papua	18/10/2017	12:15	0	10	30	2	0.22	surface	snorkeling	
LENG005	1	-04.06037	133.05912	nusa_ulan_ea	west_papua	18/10/2017	17:00	0	3	30	2	0.22	surface	snorkeling	River estuary (saltwater)
LENG005	2	-04.06037	133.05912	nusa_ulan_ea	west_papua	18/10/2017	17:00	0	3	30	2	0.22	surface	snorkeling	River estuary (saltwater)
LENG006	1	-04.11746	133.02032	nusa_ulan_ea	west_papua	19/10/2017	07:00	0	10	30	2	0.22	surface	snorkeling	Replicate LENG004 - 2h before filtration
LENG006	2	-04.11746	133.02032	nusa_ulan_ea	west_papua	19/10/2017	07:00	0	10	30	2	0.22	surface	snorkeling	Replicate LENG004 - 2h before filtration
LENG007	1	-04.12453	132.97571	nusa_ulan	west_papua	20/10/2017	10:15	0	15	30.8	2	0.22	surface	snorkeling	
LENG007	2	-04.12453	132.97571	nusa_ulan	west_papua	20/10/2017	10:15	0	15	30.8	2	0.22	surface	snorkeling	
LENG008	1	-04.13307	132.97514	nusa_ulan	west_papua	21/10/2017	09:10	100	103	26.5	2	0.22	deep	CCR_dive	
LENG008	2	-04.13307	132.97514	nusa_ulan	west_papua	21/10/2017	09:10	100	103	26.5	2	0.22	deep	CCR_dive	
LENG009	1	-04.13307	132.97514	nusa_ulan	west_papua	21/10/2017	15:00	30	30	29.2	2	0.22	mid	CCR_dive	LENG007-8-9-10 same point, different depth
LENG009	2	-04.13307	132.97514	nusa_ulan	west_papua	21/10/2017	15:00	30	30	29.2	2	0.22	mid	CCR_dive	
LENG010	1	-04.13565	132.97421	nusa_ulan	west_papua	24/10/2017	10:30	193	210	16.1	2	0.22	deep	niskin_bottle	sampling with niskin bottle
LENG010	2	-04.13565	132.97421	nusa_ulan	west_papua	24/10/2017	10:30	200	220	15.2	1.3	0.22	deep	niskin_bottle	LENG10 under thermocline
LENG011	1	-04.12602	132.97690	nusa_ulan	west_papua	24/10/2017	16:00	31	33		2	0.22	mid	CCR_dive	
LENG011	2	-04.12602	132.97690	nusa_ulan	west_papua	24/10/2017	16:00	31	33		2	0.22	mid	CCR_dive	
LENG012	1	-04.08471	132.91273	nusa_ulan	west_papua	25/10/2017	10:00	35	37		2	0.22	mid	CCR_dive	
LENG012	2	-04.08471	132.91273	nusa_ulan	west_papua	25/10/2017	10:00	35	37		1.9	0.22	mid	CCR_dive	
LENG013	1	-04.32327	133.50134	pulau_venu	west_papua	26/10/2017	10:00	0	10		2	0.22	surface	snorkeling	
LENG013	2	-04.32327	133.50134	pulau_venu	west_papua	26/10/2017	10:00	0	10		2	0.22	surface	snorkeling	
LENG014	1	-04.32135	133.49826	pulau_venu	west_papua	26/10/2017	15:00	27	30		2	0.22	mid	CCR_dive	
LENG014	2	-04.32135	133.49826	pulau_venu	west_papua	26/10/2017	15:00	27	30		2	0.22	mid	CCR_dive	
LENG015	1	-04.32225	133.49443	pulau_venu	west_papua	27/10/2017	09:15	0	8	29.3	2	0.22	surface	snorkeling	
LENG015	2	-04.32225	133.49443	pulau_venu	west_papua	27/10/2017	09:15	0	8	29.3	2	0.22	surface	snorkeling	
LENG016	1	-04.33406	133.50023	pulau_venu	west_papua	27/10/2017	09:30	30	30		2	0.22	mid	CCR_dive	
LENG016	2	-04.33406	133.50023	pulau_venu	west_papua	27/10/2017	09:30	30	30		1.6	0.22	mid	CCR_dive	
LENG017	1	-04.33682	133.48660	pulau_venu	west_papua	27/10/2017	17:00	140	170		2	0.22	deep	niskin_bottle	
LENG017	2	-04.33682	133.48660	pulau_venu	west_papua	27/10/2017	17:00	150	170		2	0.22	deep	niskin_bottle	
LENG018	1	-03.90609	134.03523	triton_bay	west_papua	31/10/2017	16:30	80	86		2	0.22	deep	niskin_bottle	
LENG018	2	-03.90609	134.03523	triton_bay	west_papua	31/10/2017	16:30	80	86		2	0.22	deep	niskin_bottle	
LENG019	1	-03.90622	134.03543	triton_bay	west_papua	31/10/2017	17:00	0	8		2	0.22	surface	snorkeling	
LENG019	2	-03.90622	134.03543	triton_bay	west_papua	31/10/2017	17:00	0	8		2	0.22	surface	snorkeling	
LENG020	1	-03.90981	134.07770	triton_bay	west_papua	01/11/2017	09:50	0	80		2	0.22	surface	snorkeling	
LENG020	2	-03.90981	134.07770	triton_bay	west_papua	01/11/2017	09:50	0	80		1.9	0.22	surface	snorkeling	
LENG021	1	-03.90956	134.07967	triton_bay	west_papua	01/11/2017	10:30	80	80		2	0.22	deep	CCR_dive	
LENG021	2	-03.90956	134.07967	triton_bay	west_papua	01/11/2017	10:30	80	80		2	0.22	deep	CCR_dive	
LENG022	1	-03.90956	134.07967	triton_bay	west_papua	01/11/2017	10:30	25	25		2	0.22	mid	CCR_dive	
LENG022	2	-03.90956	134.07967	triton_bay	west_papua	01/11/2017	10:30	25	25		2	0.22	mid	CCR_dive	
LENG023	1	-03.72099	134.09822	lengguru_rive	west_papua	03/11/2017	13:25	0	surface		5	0.45	river	boat	
LENG023	2	-03.72398	134.10167	lengguru_rive	west_papua	03/11/2017	13:40	0	surface		5	0.45	river	boat	
LENG024	1	-03.79458	134.12033	triton_bay	west_papua	03/11/2017	17:30	70	77		2	0.22	deep	niskin_bottle	
LENG024	2	-03.79458	134.12033	triton_bay	west_papua	03/11/2017	17:30	70	77		2	0.22	deep	niskin_bottle	
LENG025	1	-03.79458	134.12033	triton_bay	west_papua	03/11/2017	18:00	0	77		2	0.22	surface	snorkeling	
LENG025	2	-03.79458	134.12033	triton_bay	west_papua	03/11/2017	18:00	0	77		2	0.22	surface	snorkeling	
LENG026	1	-03.77847	134.16130	lobo	west_papua	04/11/2017	08:14	3	3		2	0.22	resurgence	snorkeling	
LENG026	2	-03.77847	134.16130	lobo	west_papua	04/11/2017	08:14	3	3		2	0.22	resurgence	snorkeling	
LENG027	1	-03.77903	134.16254	lobo	west_papua	04/11/2017	09:00	0	3		2	0.22	surface	snorkeling	
LENG027	2	-03.77903	134.16254	lobo	west_papua	04/11/2017	09:00	0	3		2	0.22	surface	snorkeling	
LENG028	1	-03.83190	134.09264	lobo	west_papua	04/11/2017	09:00	50			2	0.22	mid	CCR_dive	
LENG028	2	-03.83190	134.09264	lobo	west_papua	04/11/2017	09:00	50			2	0.22	mid	CCR_dive	
LENG029	1	-03.83190	134.09264	lobo	west_papua	04/11/2017	12:00	0			2	0.22	surface	snorkeling	
LENG029	2	-03.83190	134.09264	lobo	west_papua	04/11/2017	12:00	0			2	0.22	surface	snorkeling	

LENG030	1	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	09:45	0	95			2	0.22	surface	snorkeling	
LENG030	2	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	09:45	0	95			2	0.22	surface	snorkeling	
LENG031	1	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	11:00	93	95			2	0.22	deep	CCR_dive	
LENG031	2	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	11:00	93	95			2	0.22	deep	CCR_dive	
LENG032	1	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	11:00	25	95			2	0.22	mid	CCR_dive	
LENG032	2	-04.01173	134.20171	pulau_aiduma	west_papua	07/11/2017	11:00	25	95			2	0.22	mid	CCR_dive	
LENG033	1	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	10:45	0	95			2	0.22	surface	snorkeling	
LENG033	2	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	10:45	0	95			2	0.22	surface	snorkeling	
LENG034	1	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	12:30	80	95			2	0.22	deep	CCR_dive	
LENG034	2	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	12:30	80	95			2	0.22	deep	CCR_dive	
LENG035	1	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	12:30	33	95			2	0.22	mid	CCR_dive	
LENG035	2	-04.03573	134.48901	tanjung_boi	west_papua	08/11/2017	12:30	33	95			2	0.22	mid	CCR_dive	
LENG036	1	-03.93996	134.74069	etna_bay	west_papua	09/11/2017	08:20	0	37			5	0.45	surface	snorkeling	
LENG036	2	-03.94102	134.74156	etna_bay	west_papua	09/11/2017	08:58	0	37			5	0.45	surface	snorkeling	
LENG037	1	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	14:50	0	90			2	0.22	surface	snorkeling	
LENG037	2	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	14:50	0	90			2	0.22	surface	snorkeling	
LENG038	1	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	15:30	70	90			2	0.22	deep	CCR_dive	
LENG038	2	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	15:30	70	90			2	0.22	deep	CCR_dive	
LENG039	1	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	15:30	31	90			2	0.22	mid	CCR_dive	
LENG039	2	-04.03521	134.28719	pulau_aiduma	west_papua	09/11/2017	15:30	31	90			2	0.22	mid	CCR_dive	
LENG040	1	-03.77537	134.20151	kamaka_lake	west_papua	11/11/2017	08:53	0	30			2	0.22	surface	boat	
LENG040	2	-03.77537	134.20151	kamaka_lake	west_papua	11/11/2017	08:53	0	30			2	0.22	surface	boat	
LENG041	1	-04.06772	133.03728	nusa_ulan_riv	west_papua	13/11/2017	10:37	0			0.8		0.22	surface	boat	River estuary (freshwater - to concentrate to filtrate 2L)
LENG041	2	-04.06772	133.03728	nusa_ulan_riv	west_papua	13/11/2017	10:37	0			0.8		0.22	surface	boat	
LENG042	1	-04.06683	133.03258	nusa_ulan_riv	west_papua	13/11/2017	10:55	0			0.8		0.22	surface	swimming	River cascade (freshwater - to concentrate to filtrate 2L)
LENG042	2	-04.06683	133.03258	nusa_ulan_riv	west_papua	13/11/2017	10:55	0			0.8		0.22	surface	swimming	
LENG043	1	-04.06683	133.03258	nusa_ulan_riv	west_papua	13/11/2017	10:37	0				5	0.45	surface	swimming	replicate LENG042
LENG044	1	-04.06837	133.03748	nusa_ulan_riv	west_papua	13/11/2017	15:24	0				5	0.45	surface	swimming	replicate LENG041
LENG045	1	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	11:50	0				2	0.22	surface	boat	
LENG045	2	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	11:50	0				2	0.22	surface	boat	
LENG046	1	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	12:30	70	70			2	0.22	deep	CCR_dive	
LENG046	2	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	12:30	70	70		1.1		0.22	deep	CCR_dive	
LENG046	3	-03.93609	132.80188	kitikiti	west_papua	15/11/2017	11:20	70	70			2	0.22	deep	niskin_bottle	replicate LENG046 done the day after to complete the missing volume
LENG047	1	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	13:00	30	70			2	0.22	mid	CCR_dive	
LENG047	2	-03.93609	132.80188	kitikiti	west_papua	14/11/2017	13:00	30	70			2	0.22	mid	CCR_dive	
LENG048	1	-03.93424	132.78685	kitikiti	west_papua	15/11/2017	11:40	120	135			2	0.22	deep	niskin_bottle	
LENG048	2	-03.93424	132.78685	kitikiti	west_papua	15/11/2017	11:40	120	135			2	0.22	deep	niskin_bottle	
LENG049	1	-03.93543	132.76505	kitikiti	west_papua	16/11/2017	08:49	270	300			2	0.22	deep	niskin_bottle	
LENG049	2	-03.93543	132.76505	kitikiti	west_papua	16/11/2017	08:49	270	300			2	0.22	deep	niskin_bottle	
LENG050	1	-03.92841	132.82257	kitikiti_lake	west_papua	16/11/2017	15:46	0				2	0.22	surface	swimming	
LENG050	2	-03.92841	132.82257	kitikiti_lake	west_papua	16/11/2017	15:46	0				2	0.22	surface	swimming	
LENG051	1	-03.22096	133.67038	arguni_bay	west_papua	18/11/2017	10:15	0	35.6	31.3		5	0.45	surface	boat	3h before conservation buffer
LENG051	2	-03.22096	133.67038	arguni_bay	west_papua	18/11/2017	10:15	0	35.6	31.3		5	0.45	surface	boat	3h before conservation buffer
LENG052	1	-03.30699	133.66507	arguni_bay	west_papua	18/11/2017	11:56	0	70	31.7		5	0.45	surface	boat	3h before conservation buffer
LENG052	2	-03.30699	133.66507	arguni_bay	west_papua	18/11/2017	11:56	0	70	31.7		5	0.45	surface	boat	3h before conservation buffer
LENG053	1	-02.99063	131.93184	cap_west	west_papua	21/11/2017	13:55	85	90			2	0.22	deep	niskin_bottle	sampling from the Airaha
LENG053	2	-02.99063	131.93184	cap_west	west_papua	21/11/2017	13:55	85	90			2	0.22	deep	niskin_bottle	sampling from the Airaha
LENG054	1	-03.00112	131.93817	cap_west	west_papua	21/11/2017	14:30	0	90			2	0.22	surface	boat	
LENG054	2	-03.00112	131.93817	cap_west	west_papua	21/11/2017	14:30	0	90			2	0.22	surface	boat	
LENG055	1	-02.65144	131.60634	pulau_pisang	west_papua	22/11/2017	11:14	0	5			2	0.22	surface	snorkeling	divers in the area of sampling
LENG055	2	-02.65144	131.60634	pulau_pisang	west_papua	22/11/2017	11:14	0	5			2	0.22	surface	snorkeling	divers in the area of sampling
LENG056	1	-02.67144	131.59814	pulau_pisang	west_papua	22/11/2017	11:30	30	55			2	0.22	mid	CCR_dive	
LENG056	2	-02.67144	131.59814	pulau_pisang	west_papua	22/11/2017	11:30	30	55			2	0.22	mid	CCR_dive	
LENG057	1	-00.95288	130.60258	channel_soro	west_papua	23/11/2017	10:45	30	300			2	0.22	mid	niskin_bottle	sampling from the Airaha
LENG057	2	-00.95288	130.60258	channel_soro	west_papua	23/11/2017	10:45	30	300			2	0.22	mid	niskin_bottle	sampling from the Airaha
LENG058	1	-00.95288	130.60258	channel_soro	west_papua	23/11/2017	11:00	0	300			2	0.22	surface	snorkeling	sampling from the Airaha
LENG058	2	-00.95288	130.60258	channel_soro	west_papua	23/11/2017	11:00	0	300			2	0.22	surface	snorkeling	sampling from the Airaha

V-8 Opportunistic observations (elasmobranchs, marine mammals, reptiles...)

Many opportunistic observations have been performed for different vertebrate groups: elasmobranchs (rays and sharks), marine mammals, reptiles (estuarine and sea turtles, sea snakes)... Occurrence data were provided.

V-9 Images database: photos & videos

Both underwater and terrestrial *in situ* images were produced for scientific or communication purposes: pictures of specimens, stereo cameras footages (BRUVS), aerial images by drone, images of surroundings.

All images are of high quality. Tens of thousands images and hours of video are currently stored.

Figure 15. Lengguru 2017 images database

VI PRELIMINARY RESULTS AND FURTHER CONSIDERATION – TERRESTRIAL TEAM

VI-1 Ornithology

Scientific priorities > During the Lengguru 2014 expedition, the ornithological team captured at 1200m elevation in the Kumawa Mountains a male bird that belongs to the berrypecker genus *Melanocharis* but appears to be an undescribed taxon.

The examination of the bird in the field quickly revealed that it shared similarities with *M. longicauda*. However, it became also quite clear that this bird belongs to a population that may represent a distinct taxon, be it a different subspecies of *longicauda* or even a different species of *Melanocharis* : while tail pattern and upperparts were like nominate *longicauda*, its underparts were shiny white with a lemon wash on throat, breast, and flanks. A specimen was collected by LIPI personnel and deposited at the MZB. Comparisons between this specimen and other *Melanocharis* specimens revealed further differences, the most obvious being a difference in body size, the Kumawa individual being larger than any other *Melanocharis* in the collection.

Altogether, the substantial differences between the Kumawa berrypecker and other berrypeckers were pointing towards a putatively undescribed species.

We proposed, as a first priority for the Lengguru Expedition 2017, to increase sampling effort in the Kumawa mountains to provide a robust scheme into which to determine whether the undescribed Kumawa *Melanocharis* population represents a new species or a subspecies of *Melanocharis longicauda*.

The mountains of New Guinea consist of the Central Range plus a number of smaller outlying ranges. Seven of these outlying ranges have been recognized in western Papua (Papua Barat), including the Kumawa Mts. A number of montane bird species or superspecies are distributed across these mountain ranges and available data suggest that population differentiation has occurred between populations inhabiting the different ranges (Diamond J. M., 1985; Beehler B. M. & Pratt T. K., 2016). Therefore, we proposed as a second priority to identify the relationship between the Kumawa Mts populations and populations from other mountain ranges, since there is some indication in the taxonomic literature that in some species these populations may be more closely related to populations from the Wandammen, van Rees, and Foja than to populations from the Arfak/Tamrau system. During the Lengguru Expedition 2017 we then sought to obtain samples, amenable to population genetic analyses, from a number of species with challenging taxonomy and distribution: *Heteromyias albispecularis*, *Tregellasia leucops*, *Phylloscopus poliocephalus*, *Peneothello bimaculata*, *Crateroscelis murina*, *Sericornis beccari/nouhusy*?, *Sericornis spilodera*, and *Meliphaga orientalis*.

Sampling > Our sampling strategy consisted in capturing birds in several localities between 1100 and 1200m elevation on the southern slopes of Kumawa Mts., in a habitat that can be described as cloud forest. Birds were captured using standard mist nets, targeting primarily understory birds. Individuals were aged using plumage characteristics, and the degree of skull ossification. They were weighed and marked permanently with numbered metal rings to avoid resampling the same individuals. Wing rulers and dial calipers were used to acquire on each individual a set of standard morphometric measurements. Approximately 10 microliters of blood were collected by venipuncture from each bird and immediately conserved in 100% ethanol for further genetic analyses. Every captured bird has been photographed from various angles according to a standard procedure. Species were identified

by eye in the field based on the team's expertise, the new field guide "Birds of New Guinea" (Pratt T. K. & Beehler B. M., 2015), and unpublished documents kindly provided by Dr. Beehler.

Results > We did 15 days of netting at 1200 m and 4 at 1100 m, with an average of 14 nets (12 meters each) and 6 hours of operation per day for a total of about 1400 net hours, between October 22 and November 9, 2017.

A total of 215 birds were captured, belonging to 26 species (Table 9).

We were successful at capturing three additional individuals of the undescribed *Melanocharis* as well as individuals of all other target species with the exception of *Peneothello bimaculata*.

Table 9 – Species and number of individuals captured

Birds	215 captured specimens	215 DNA samples

Species	**English name**	**Captures**
Aerodramus nuditarsus (?)	Bare-legged swiftlet (?)	2
Ailuroedus melanotis	Black-eared catbird	2
Cacomantis castaneiventris	Chestnut-breasted cuckoo	2
Chaetorhynchus papuensis	Drongo fantail	7
Cicinnurus magnificus	Magnificent bird of paradise	2
Colluricincla megarhynchus	Little shrike-thrush	27
Craterocelis murina	Rusty mouse-warbler	16
Drepanornis albertisi	Black-billed sicklebill	1
Heteromyias albispecularis	Ashy robin	21
Melanocharis sp. nov.	Undescribed berrypecker	3
Melilestes megarhynchus	Long-billed honeyeater	6
Meliphaga orientalis	Mountain meliphaga	8
Myzomela cruentata	Red myzomela	6
Myzomela rosenberghi	Red-collared myzomela	3
Oedistoma iliolophus	Spectacled longbill	17
Ornorectes cristatus	Piping bellbird	1
Philemon buceroides	Helmeted friarbird	1
Phylloscopus poliocephalus	Island leaf-warbler	6
Pitohui dichrous	Hooded pithoui	2
Sericornis nouhuysi (?)	Large scrubwren (?)	28
*Sericornis spilo*dera	Pale-billed scrubwren	8
Symposiachrus axillaris	Fantailed monarch	10
Toxorhamphus novaguinaea	Yellow-bellied longbill	13
Tregellasia leucops	White-faced robin	20
Zosterops novaeguineae	New Guinea white-eye	2
Erythrura trichroa	Blue-faced parrotfinch	1

All blood samples were taken by Borja Milá and have been deposited at the Museum Zoologicum Bogoriense (MZB)'s ornithological collection in Cibinong, West Java, Indonesia.

Some specimens were collected and prepared as museum skins in the field by LIPI personnel and have been deposited at MZB.

All fieldwork was conducted according to relevant guidelines by the government of the Republic of Indonesia and under research permits issued by RISTEK (Indonesia) (for 2014, 304/SIP/FRP/SM/X/2014; for 2017, 3179/FRP/E5/Dit.KI/IX/2017) and relevant Indonesian government collecting permits.

VII POST-EXPEDITION VALORIZATION

VII-1 Capacity building, research fellowships

More than ten different events were organized in Indonesia and in France during the post-Lengguru Expedition for promoting research acquisition and valorization and for strengthening research capacities.

VII-2 Ongoing publications

The work in progress concerns all groups. Several publications are expected from this year 2020: on eDNA, on the genetic sequence database of reef fish, on gorgonian and hard coral taxonomy...

These Lengguru 2017 results will also allow the production of other publications in ecology or in the context of larger-scale inter-site comparisons in the future.

VII-3 Medias, communications, scientific dissemination

Since the end of the expedition, several actions were made including :

- TV documentaries broadcasted on ARTE, Ushuaia TV, TV5 Monde channels
- Press, medias
- Productions dedicated to young people (seminars in school, articles to young public)
- Scientific dissemination (seminars in several festivals)

VIII CONCLUSIONS AND PERSPECTIVES

The main objective of the Lengguru 2017 Expedition was to start and impulse an interdisciplinary international scientific cooperation on terrestrial and marine biodiversity domains at the heart of the Coral Triangle in West Papua (Indonesia). The Indonesian Institute of Sciences (LIPI) with the Research Centre for Oceanology (RCO) for marine biodiversity heads this program together with the Sorong Polytechnic School (Politeknik-KP-Sorong) and the French Research Institute for Development (IRD).

All the field objectives were fulfilled in terms of visited ecosystems panel, material collected, and international cooperation.

Preliminary results obtained from morphological observation and DNA barcoding are nearly achieved for all taxa enabling the valorization in international and Indonesian scientific journals.

The Lengguru team will continue in the coming months to acquire and to valorize jointly the results. In that frame, it is expected to pursue the organization and support of research fellowships for Indonesian counterparts. This includes international midterm visits but also PhD degrees, which must be increased.

In term of capacity building we expect to continue to upgrade molecular capacities at RCO-LIPI especially for large-scale PCR amplification on 96 plates. We also plan to pursue training session in Indonesia and collaboration activities such as organization of new field trips and joint research network on marine biodiversity.

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APPENDIX

A-1 Co-authored scientific publications and reports in the framework of the LENGGURU program since 2010

2010

Kadarusman, Sudarto, E. Paradis & L. Pouyaud. 2010. Description of *Melanotaenia fasinensis*, a new species of rainbowfish (Melanotaeniidae) from West Papua, Indonesia with comments on the rediscovery of M. ajamaruensis and the endangered status of *M. parva*. Cybium, 34(2): 207-215.

2011

Allen G.R. & R.K. Hadiaty. 2011. A new species of Rainbowfish (Melanotaeniidae) from Western New Guinea (West Papua Province, Indonesia). Fishes of Sahul, 25(1): 602-607.

Kadarusman, Sudarto, J. Slembrouck & L. Pouyaud. 2011. Description of Melanotaenia salawati, a new species of rainbowfish (Melanotaeniidae) from Salawati Island, West Papua, Indonesia. Cybium, 35(3): 223-230.

Kadarusman. 2012. Rainbowfishes from West Papua (Melanotaeniidae): Evolution and Systematics. PhD, ED SEVAB, University Paul Sabatier, Toulouse 3, June 2012, 161 pp.

Kadarusman, R.K. Hadiaty, Sudarto & L. Pouyaud. 2012. Expedition Lengguru-Kaimana 2010. Preliminary Assessment of Karst Biodiversity. Final Report, 146 pp.

Keith P., Allen G.R., Lord C. & R.K. Hadiaty. 2011. Five new species of *Sicyopterus* (Teleostei: Gobioidei: Sicydiinae) from Papua New Guinea and Papua. Cybium, 3 (4): 2 -318.

2012

Kadarusman, N. Hubert, R.K. Hadiaty, Sudarto, E. Paradis & L. Pouyaud. 2012. Cryptic diversity in Indo-Australian rainbowfishes revealed by DNA Barcoding: implications for conservation in a biodiversity hotspot candidate. PLoSONE 7(7): e40627.

Kadarusman, R.K. Hadiaty, G. Segura, G. Setiawibawa, D. Caruso & L. Pouyaud. 2012. Four new species of Rainbowfishes (Melanotaeniidae) from Arguni Bay, West Papua, Indonesia. Cybium 36(2): 369-382.

Keith P., R.K. Hadiaty & C. Lord. 2012. A new species of Belobranchus (Teleostei: Gobioidei: Eleotridae) from West Pacific Islands. Cybium, 36(3): 479-484.

Pouyaud L., Kadarusman, R.K. Hadiaty, J. Slembrouck, N. Lemauk, R.V. Kusumah & P. Keith. 2012. Oxyeleotris colasi (Teleostei: Eleotridae), a new blind cavefish from Lengguru in West Papua, Indonesia. Cybium, 36(4): 521-529.

Suroto H. 2012. Hunian Prasejarah Gua Karas Kaimana. In Papua TH. IV, No. 2/ November 2012, Arkenas Jurnal.

2013

Fahmi, M. R., Solihin, D. D., Soewardi, K., Pouyaud, L., Shao, Z., & Berrebi, P. 2013. A novel semi-multiplex PCR assay for identification of tropical eels of genus Anguilla in Indonesian waters. *Fisheries science*, *79*(2), 185-191.

2014

Nugraha, M. F. I., Pouyaud, L., Carman, O., Kadarusman, Widyastuti, U. & Avarre, J. C. 2014. Development of twelve novel polymorphic microsatellite DNA markers for the Boeseman's rainbowfish (*Melanotaenia boesemani*) and tests for their cross-utility in 21 rainbowfish species from West Papua (Indonesia). *European Journal of Wildlife Research*, 60(6): 941-946.

2015

Fahmi, Melta Rini; Solihin, Dedy Duryadi; Soewardi, K.; Pouyaud, Laurent; Berrebi, Patrick. Molecular Phylogeny and Genetic Diversity of Freshwater Anguilla Eels in Indonesian Waters Based on Mitochondrial Sequences. *Vie et Milieu - Life and Environment* **2015**, *63* (3), 139–150. https://pdfs.semanticscholar.org/6182/a885bcb2cbae2fede2be6d62c21c2ae39973.pdf.

Fahmi, M. R.; Solihin, D. D.; Shao, Z.; Pouyaud, L.; Berrebi, P. Population Genetic Structure of the Tropical Eel *Anguilla Bicolor* in Indonesian Waters Based on Microsatellite Markers. *Folia Zoologica* **2015**, *64* (2), 87–96. https://doi.org/10.25225/fozo.v64.i2.a1.2015.

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2016

Juswara, L.; Schuiteman, A.; Droissart, V. Four New Orchid Species from the Lengguru Fold Belt, West Papua, Indonesia. *PK* **2016**, *61*, 47–59. https://doi.org/10.3897/phytokeys.61.7590.

2017

Hocdé R, Menou J-L, Pouyaud L, Surukawy AM, Vimono IB. At the heart of the coral triangle in West Papua: an indonesian-french scientific exploration of a white area with closed-circuit rebreathers (eCCR). [Poster]. Poster presented at the: IIIrd European Conference on Scientific Diving (ECSD); March 22, 2017; Funchal, Madeira, Portugal. http://www.documentation.ird.fr/hor/fdi:010069727.

Hocdé R. (**2017**) LENGGURU 2017 cruise, RV Airaha2, https://doi.org/10.17600/18001718

2018

Dong, J.; Kergoat, G. J.; Vicente, N.; Rahmadi, C.; Xu, S.; Robillard, T. Biogeographic Patterns and Diversification Dynamics of the Genus Cardiodactylus Saussure (Orthoptera, Grylloidea, Eneopterinae) in Southeast Asia. *Molecular Phylogenetics and Evolution* **2018**, *129*, 1–14. https://doi.org/10.1016/j.ympev.2018.06.001.

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