BRIN
BADAN RISET
DAN INOVASI NASIONAL

COREMAP-CTI

GUIDEBOOK

Scientific Diving of Marine Biology

and Underwater Occupational Safety Health

Rikoh Manogar Siringoringo,
Ni Wayan Purnama Sari, Giyanto, et al.

GUIDEBOOK

Scientific Diving of Marine Biology

and Underwater Occupational Safety Health

Buku ini tidak diperjualbelikan.

First published in 2023 by BRIN Publishing
Available to download free: penerbit.brin.go.id

GUIDEBOOK

Scientific Diving of Marine Biology

and Underwater Occupational Safety Health

Rikoh Manogar Siringoringo,
Ni Wayan Purnama Sari, Giyanto, et al.

BRIN Publishing

Catalogues in Publications

Guidebook Scientific Diving of Marine Biology and Underwater Occupational Safety Health/Rikoh Manogar Siringoringo, Ni Wayan Purnama Sari, Giyanto, Muhammad Abrar, Kunto Wibowo, Puji Rahmadi, Oksto Ridho Sianturi, Irfan Kampono, Munasik, Beginer Subhan, Muhammad Hafizt, & Raden Sutiadi–Jakarta: BRIN Publishing, 2022.

xiv hlm. + 86 hlm.; 14,8 x 21 cm

ISBN 978-623-8052-46-2 (e-book)

1. Diving 2. Underwater Operations
3. Scientific Diving

627.7

Editor : Bambang Trimansyah
Ni Wayan Purnama Sari
Puji Rahmadi
Rafli Syahrizal
Rikoh Manogar Siringoringo

Copyeditor : Ayu Tya Farany
Proofreader : Dhevi E.I.R. Mahelingga
Layouter : Den Binikna & Dhevi E.I.R. Mahelingga
Cover designer : Den Binikna & Dhevi E.I.R. Mahelingga
Cover photo source : Pia on Pexels
The design uses Inria Sans & Serif fonts.

First printing : January 2023

Published by:

BRIN Publishing, member of Ikapi
Directorate of Repositories, Multimedia, and Scientific Publishing
Gedung B.J. Habibie, Jln. M.H. Thamrin No. 8,
Kb. Sirih, Kec. Menteng, Kota Jakarta Pusat,
Daerah Khusus Ibukota Jakarta 10340
Whatsapp: 0811-8612-369
E-mail: penerbit@brin.go.id
Website: penerbit.brin.go.id

PenerbitBRIN
Penerbit_BRIN
penerbit_brin

In collaboration with:

COREMAP
Pasir Putih Raya Street Number 1, RT 08/RW 10,
East Pademangan, Pademangan District, North Jakarta City,
Special Capital Region of Jakarta 14430

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX

FOREWORD

Indonesia is the largest archipelagic country in the world, rich in biological resources. Sustainable utilization of resources requires integrated management. In carrying out this management and utilization, talented human resources are needed, one of which is competent in scientific diving. Scientific diving is a dive that is carried out for data collection in the framework of research interests.

Currently, human resources in the field of scientific diving are still limited. Meanwhile, the need to carry out research activities that require diving knowledge is constantly increasing. The vastness of Indonesian waters requires a lot of human resources. The synergy between stakeholders, such as universities, research institutions, non-governmental organizations, and practitioners interested in scientific diving, is essential. Therefore, a guidebook is needed that can be used as an essential reference in carrying out scientific diving activities.

This book conveyed various processes of scientific diving activities in marine biology. This diving activity has a very high potential risk. Therefore, in carrying out data collection, occupational health and safety aspects are the main ones. Efforts to avoid potential risks in implementing data collection activities or dive procedures are part of organizing scientific dives.

We hope this book can guide researchers, students, and practitioners interested in the field of scientific diving, especially in carrying out scientific activities in marine biology. Meanwhile, for teachers or lecturers, this book can be used as teaching material for marine biology and underwater occupational safety health scientific diving.

Jakarta, June 2022
Head of Research Center for Oceanography,
National Research and Innovation Agency (BRIN)

Dr. Udhi Eko Hernawan

PREFACE

Research on coral reefs and related ecosystems is one of the main tasks and functions of the Research Center for Oceanography-National Research and Innovation Agency. As stipulated in the Decree of the Head of the Geospatial Information Agency Number 54 of 2015, LIPI is the guardian of coral reef ecosystem data in Indonesia. Therefore, the program's implementation prioritizes the collected and reported data's safety, currentness, accuracy, and traceability. At the same time, the program's implementation must also comply with the provisions of the prevailing laws and regulations in Indonesia.

To meet the needs of talented human resources in scientific diving activities, especially in the field of marine biology, the Indonesian National Work Competency Standard (SKKNI) for Scientific Diving for Marine Biology was established through the Decree of the Minister of Manpower of the Republic of Indonesia Number 116 of 2019. The availability of SKKNI Scientific Diving in Marine Biology is expected to be a measure of competence that must be possessed by a scientific diver in the field of marine biology in Indonesia. This competence can be applied in assessing aquatic biological resources' potential and condition, damage due to oil spills, and ship grounding.

Concerning the above, it is necessary to compile a book that can be used as a guide in implementing safe and orderly scientific diving following scientific rules and applicable regulations. Therefore, the Research Center for Oceanography–National Research and Innovation Agency started coordinating scientific diving and underwater occupational safety experts to prepare this book. The writing team hopes this book can be helpful and guide in conducting marine biology research, especially in Indonesia.

Jakarta, June 2022

Writing team

CHAPTER I

INTRODUCTION

Scientific diving has been going on for decades in Indonesia. One of the scientific diving activities is monitoring coral reef ecosystems, better known as the coral reef condition assessment methodology. However, the vastness of Indonesia's waters is challenging to monitor coral reefs together. Therefore, one coral reef monitoring strategy is creating nodes or regional representation in various regions in Indonesia. Furthermore, strengthening the capacity of human resources through various basic training activities and advanced training. After obtaining a license, this training begins with diving training, followed by coral reef monitoring materials. The fields taught are coral reefs, coral fish, and another benthic biota.

This training activity involves various stakeholders, including universities, central government, local governments, non-governmental organizations, and other institutions interested in diving, as well as conducting assessments of coral reefs. Data retrieval diving activities are growing along with the time and development of diving technology. In addition to the equipment that has been improving, the opportunity to carry out diving activities is also getting higher. In the 1990s, diving equipment was still classified as luxury equipment, and there were still few people who had the opportunity to do diving. From 2000 to 2020, the equipment became easier to obtain, and the price was already more affordable. Therefore, the interest in diving is already very high. In addition to marine students, ordinary people have also carried out many diving activities for data collection, recreation, and sports.

Dives for this data collection on several references are divided into several dive groups: archaeological, oceanographic, geological, limnological, journalistic, and marine biology (DGUV R-112). Each of the fields is distinguished from its discipline. The purpose of such dives is also different. Diving activities related to scientific research are distinguished from diving activities only for sports and recreation or diving as a diving tour guide. In recreational diving activities, divers only want to enjoy the beauty of the underwater world, called *fundive*. Tour guide divers assist in bringing divers or guests to get exciting objects, as well as to carry out supervision to avoid dangerous things. Meanwhile, scientific divers conduct data retrieval for research purposes.

The scientific diving activities developed in Indonesia are limited to being carried out by each government agency, university, and non-governmental organization. In the national context, it can be said that the scientific diving of marine biology has not been standardized. This is due to the absence of regulations that regulate nationally and the limited human resources with adequate expertise. The retrieval of research materials from the bottom of the sea, most of them are carried out by foreign researchers or at least domestic researchers/domestic research institutes cooperate with foreign research institutions. This is inversely proportional to international regulations implementing MTA (material transfer agreements) since 2014.

After a reasonably long process, diving activities for data collection in marine biology have entered the standardization stage. In 2019, the Indonesian National Work Competency Standard (SKKNI) regulated scientific diving in marine biology for standardization. The establishment of standardization of diving activities has also begun to follow regulations from the Ministry of Manpower. Article 1 paragraph (2) of Law Number 13 of 2003 concerning Manpower states, "Labor is any person who can do work to produce goods and services both to meet their own needs and for the community." Furthermore, Article 1 paragraph (3) of Law Number 13 of 2003 states, "A worker/laborer is any person who works by receiving wages or other forms of remuneration." Through this definition, it can be concluded that a scientific diver of marine biological research belongs to the labor class, namely an occupational diver in the category of scientific divers. In addition, Law Number 13 of 2003 in Article 4 also emphasizes the importance of protection for workers. Therefore, diving workers are entitled to wages, training, equal treatment, and prevention and protection of workplace dangers.

This *Guidebook for Scientific Diving of Marine Biology and Underwater Occupational Safety Health* was prepared with the aim of becoming a reference for decision-makers, research divers, supporting workers, lecturers, and students of marine sciences, agencies or institutions, as well as parties working in underwater research activities in the field of marine biology in Indonesia. Through this guidebook, it is hoped that underwater research activities in marine biology can be carried out properly, safely, and at minimal risk of accidents for data-taking divers. Thus, the data produced can be accurate, traceable, and reported promptly and comply with the provisions of applicable laws and regulations in Indonesia.

CHAPTER II

GENERAL REQUIREMENTS

A. Required Documents

The document of scientific diving activities is the primary document that is directly related and is mandatory in scientific diving activities. The primary documents include an official assignment letter from the head of the institution to carry out diving research activities, diving certificates, dive logs, CPR and first aid certificates, certificates of health and eligibility for diving, certificates of guarantees of occupational safety and health, and other documents. All of these documents have a validity period, so it is necessary to ensure that all documents have not expired. In addition, these documents also need to be checked related to the fulfillment of contemporary elements or updates. If the documents relating to the diving activity are not met, then steps can be taken to review the implementation of the activity or suspended until the documents are fulfilled. The description of the mandatory documents in each research dive activity is as follows:

1. A warrant of official duty from the head of the authorized institution.
2. Known hazard identification, risk analysis, and risk control documents signed by all dive team members. The reference can be enriched with data on the activity location map, tidal tables, elements of local wisdom that must be known, and special conditions at the activity location; for example, it is the core zone of a marine conservation area or a lift site due to an earthquake or is a massive tourist area and other conditions.
3. The dive plan document is signed by the dive officer and conveyed to all team members.
4. The emergency plan includes an explanation of diving communication devices, ground communication devices, safety equipment owned, a list of emergency numbers, access to a high-pressure air room or hyperbaric chamber, and the nearest health facility as well as distance and travel time.
5. Have attended training and obtained a competency certificate issued by the Ministry of Manpower to carry out scientific diving of marine biology, which refers to SKKNI Number 139 of 2019 concerning Scientific and Technical Professional Services of the Main Group of Research and Development of Science in the Field of Assessment of Coral Reef Conditions.
6. Have a health certificate before diving. The letter must be based on an official and guaranteed recommendation from a doctor or hospital. Medical examinations are still required to thoroughly scan for all diseases so that a diver can be sure that he is completely healthy and ready to carry out scientific diving activities. This is not limited to examinations related to a history of decompression sickness or a history of illness caused by an accident while diving.
7. Have a certificate or have attended first aid training with cardiopulmonary resuscitation (CPR) in the last two years.
8. Have a dive log book. The book helps divers to record information on the intensity of the dive, time, and depth of the last dive performed by the relevant diver. It can illustrate that divers are still fit and trained to do diving activities. In the last year, at least

12 dives have been made (accumulative dives, it doesn't have to be one dive per month). Six of these are scientific dives with a total time of 240 minutes. Each dive must be recorded and signed on the dive logbook.

After the above administrative requirements are complete, the dive permit will be checked and issued by the dive officer and known by the person in charge of the activity. Documents 1—8 should be kept in a safe place, avoiding wind, wet or missing, easily visible, and accessible at all times if there is an inspection from the relevant officials. In addition, the document must be kept for at least two years to trace if there is a claim for compensation for occupational diseases diving.

B. Coordination System

1. Coordination of site activities

Coordination is carried out with the relevant agencies at the dive site. This is done as an effort to complete regional permits, efforts to collect initial or additional information related to implementation, and most importantly, as an effort to mitigate in the event of an emergency.

2. Coordination with the equipment manager

This party can be a dive center, related agencies, or other parties providing diving equipment for research activities. Coordination between the parties aims to ensure that the diving equipment is in good condition, well maintained, and calibrated. In addition, it also aims that the equipment provided is by the needs of the activity, both in size and quantity, so that diving research activities can run effectively.

3. Coordination with security and health authorities

Coordination with security and health parties occurs when a work accident occurs. However, the nature of coordination is also a permit and work accident mitigation effort. These parties include the nearest hospital, the SAR Agency, the naval base, the water police, the police, or the nearest police station. The list of telephone numbers of related parties can be printed and brought to the field when conducting diving research activities. However, these numbers must be verified in advance, and the activity notification letter has arrived at the relevant party before the dive research activity is carried out.

Table 1. An example of an emergency contact list

No.	Agencies/Service Units	Phone Number	Information
1	National SAR Agency	......	
2	Emergency ambulance	......	
3	Regional general hospital	......	
4	Local police	......	
5	Health department	......	
6	Regional Covid team	......	
7	Chamber facility phone number	......	
8	Poisoning information center	......	
9	Land contact	......	Hotel/ camp/ lodging

Source: Sari, N.W.P. (2020)

CHAPTER III

EQUIPMENT

The diving equipment used is equipment that can function properly, has safety standards, and is checked regularly so that the equipment can be used properly. In addition, in scientific diving activities, equipment is used outside the work equipment, namely supporting equipment for safety.

A. Diving Equipment

General diving equipment can be defined as equipment used by divers in general. This equipment has variations, both in terms of shape, size, color, and developed technology. For divers, one crucial thing that should be used as a guideline is to recognize the equipment to be used and ensure the diving equipment is safe for them. The safety of such equipment must be ensured by regular maintenance and inspections. The standard equipment that divers must use is as follows:

1. The masks used must be standard safety glass (tempered) accompanied by a snorkel.
2. The head protection (hood) should be used when diving and adjusted in size for convenience.
3. Use a wetsuit and drysuit made from neoprene that fits the size to avoid hypothermia.
4. SCUBA regulators must be inspected at least once every two years by an accredited equipment calibration body (licensed dive center). The regulator must have a *second stage* and an *alternate air source (octopus).* Regulatory equipment follows the safety standard norm EN 250.
5. The submersible pressure gauge (SPG) provides tube pressure and depth information that must be checked before use and inspected at least once every two years.
6. SCUBA tubes must be tested hydrostatically once every five years and visually inspected annually by an accredited authorized institution.
7. The diving tube should not be empty; if it is empty, it must be checked before filling.
8. Buoyancy compensator devices (BCD) are inspected at least once every two years.
9. Ensures positive buoyancy (no leakage) and is equipped with manual BCD charging by blowing.

10. The weight system must be equipped with a quick-release device or can be removed using only one hand.
11. Using a cutting tool in the form of a diving knife.
12. Using fin open heels accompanied by booties.
13. A dive computer, time logger, and dive depth during the dive process must be present in each dive.
14. A diving table in the waterproof paper should also be prepared during the dive.
15. First aid kits and emergency oxygen cylinders should be available at each dive site.
16. The air quality in the tube must be clean and dry with an oxygen percentage of 20—22%.
17. The dive tube filling compressor must be in good condition and inspected periodically, both machine inspection, air filter, service, and repair if it is damaged.
18. A surface marker buoy (SMB) is a marker of the presence of divers when rising to the surface.

B. Safety Equipment

Safety equipment in underwater work must be prepared during the performance of such work. Some of that equipment includes

1. first aid kit (medicines);
2. oxygen kit;
3. 20 m safety line and buddy line;
4. rescue tube (safeguard) or throwing float;
5. means of communication, such as cell phones, walkie-talkies, toa, signals;
6. marking buoy;
7. cutting tools;
8. diving flashlight;

9. throwing bag;
10. diver flag as a sign that there is a diving activity; and
11. emergency contact list.

C. High-Pressure Air Chamber

The high-pressure air chamber is a capsule-shaped room that is high pressure and filled with pure oxygen. Generally, this technique is used for divers who are at least suspected of decompression sickness for further treatment. However, this diving research activity should not be an activity that causes decompression conditions. High-pressure air chamber facilities are used in emergencies when conditions in the field are not as expected and lead to the safety of divers. The high-pressure air chamber facility is used in exceptional circumstances and as a final step, for example, if the diver has been diving for a long time and is forced to ascend quickly without a decompression stop (Howel et al. l, 2018., Liew, 2005., Naval Sea Systems Command, 2016). Therefore, dive planning, supervision from dive leaders, and dive supervisors/dive safety must be done correctly. In a high-pressure air chamber, scientific divers must ensure several things, such as the following.

1. Oxygen is available inside the high-pressure air chamber.
2. Communication from within the high-pressure air chamber to the operator is made possible visually and by speaking directly.
3. Escort personnel should be available for divers who need maintenance in the high-pressure air chamber.

Figure 1. Example of High-Pressure Air Chamber in Bhayangkara Hospital, Denpasar

Source: BRIN/Ni Wayan Purnama Sari

D. Marine Biological Research Diving Work Equipment

The working equipment in research diving activities determines the objectives and methods used. Before using research diving work equipment, divers should check the condition and feasibility of using the research tool and clearly understand how to operate the tool. Some tools commonly used in research dives include GPS trackers, cameras, underwater video, and scaled rolling tape. One of the special equipment for marine biological research is Diving PAM. This tool can measure the biota's rate of photosynthesis that is below the surface of the water. How it works and the techniques of operating Diving PAM must be well known considering that the equipment is sensitive and the price is relatively high.

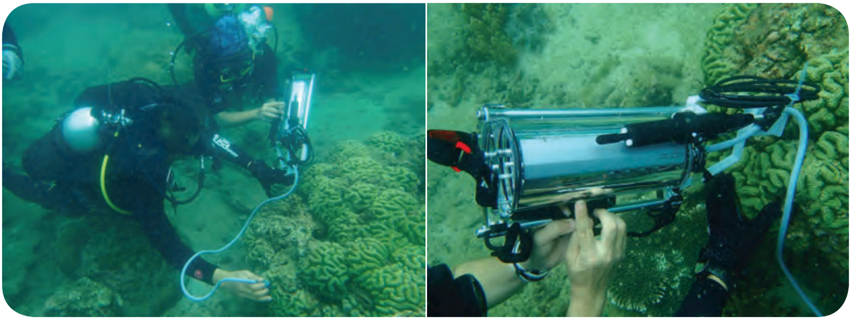


Figure 2. Data Retrieval Using Diving PAM II
Source: BRIN/Rikoh Manogar Siringoringo

CHAPTER IV

IMPLEMENTATION OF DIVING OPERATIONS

A. Organizing Scientific Diving Activities

The process of organizing scientific diving activities includes dive planning, dive execution, and dive evaluation. In that process, it is also necessary to implement occupational safety and health during scientific diving activities. Therefore, it requires formulating a research plan, a dive planning document, and a dive safety procedure document. The implementation of scientific diving activities has a hierarchy (level of position) related to the responsibility of carrying out activities. The order of posts in scientific diving is as follows:

1. Institutional leaders

The head of the institution is the official responsible for scientific diving activities. He assigns duties to a dive supervisor.

2. Dive supervisor

A dive supervisor is someone who has research skills, years of scientific diving experience, and understands the diving theory, as well as dive safety procedures. He is assigned to review the feasibility of scientific diving activity. The dive supervisor, in his duties, is accountable to the institution's leadership.

3. Dive leader

A dive leader is a scientific dive activity leader who masters the purpose of research and is responsible to the dive supervisor.

4. Diver

Divers are scientific divers who work under the coordination of the dive leader.

Sequentially, the procedure and stages of diving activities are presented in Figure 3. In the figure, it can be seen that institutions identify (if bottom-up project) or provide (top-down project) scientific diving tasks and work. Then, the head of the institution appoints a dive supervisor/dive officer to supervise or monitor the diving activities. Furthermore, the coordinator or dive leader will compile a general risk assessment document related to diving activities. Then, the document was submitted to the dive supervisor for scrutiny and inspection. Finally, suppose the dive supervisor approves the general risk assessment document that has been prepared. In that case, the dive supervisor will sign this document as a sign that diving activities can be carried out.

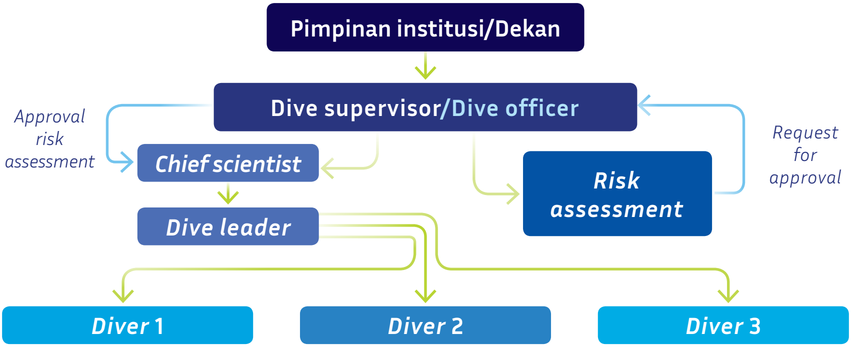


Figure 3. Procedures in Carrying Out Scientific Diving Activities

Source: Northeast Gulf Methods

B. Risk Assessment

Safety at work is the right of every worker. Salvation is not only for oneself but also for the safety of others around. Therefore, in carrying out the work should apply occupational safety and health (K3) procedures. The K3 regulation is contained in Law No. 1 of 1970 concerning Occupational Safety. The law regulates occupational safety in all workplaces, whether on land, on the ground, on the surface of the water, in the water, or in the air, within the jurisdiction of the Republic of Indonesia. The regulation aims to protect workers from staying healthy, both during work and after completion. Efforts to maintain the safety and health of workers can be carried out preventively, promotively, curatively, and rehabilitatively.

An assessment of the potential risks in a diving activity must be made in a document by the dive leader. The dive mission leader best prepares the document and is responsible for precautionary measures to ensure safety during scientific diving activities. This is done by identifying and reducing potential threats. In addition, the document serves as a general risk assessment and an assessment as a whole for the duration of the activity. Therefore, the document must be completed with a daily risk assessment that will be used for risk assessment every day.

Diving activities have a high risk of danger, resulting in accidents, illnesses, and even death. Therefore, hazards and assessment of possible risk factors that may arise in such activities must be identified. In addition, potential risks can occur when preparing for diving and diving activities until completion. For example, diving activities cannot achieve the expected results in a work accident. The various potential risks during preparation, diving, prevention efforts, and points in the risk assessment document can be seen below.

1. Potential risk hazards that will arise during preparation include
   a. heavy diving equipment;
   b. fragile research equipment;
   c. slippery roads or docks;
   d. slipping when walking on the ship;
   e. the small size of the vessel; and
   f. waves as well as currents.

   Prevention efforts that can be done include
   a. mutual assistance when lifting heavy equipment;
   b. take care in handling work equipment;
   c. be careful when walking on slippery roads;
   d. be careful when walking and give anti-slip carpets on the floor of the vessel;
   e. neatly arrange the equipment in the vessel and tie it with a rope so that it does not shake; and
   f. if the weather is cloudy and choppy, stop diving.

2. The potential risk hazards that arise during diving are
   a. bumped with another diver when back roll entry;
   b. tidal currents and reef currents;
   c. turbid water with limited visibility or low visibility;
   d. cold;

e. dehydration;
f. loss of balance when performing data retrieval;
g. stuck with the equipment carried;
h. stung by toxic biota;
i. disrupted by ship traffic;
j. communication that is not going well;
k. decompression and gas poisoning diseases; and
l. fatigue.

Prevention efforts that can be done are

a. looking at the tidal table;
b. looked down before going down and waiting for the aba-aba from the dive leader;
c. close to the meter or other signs so as not to lose direction;
d. wearing wetsuits;
e. bring drinking water and use a boat that has a roof;
f. use appropriate ballast;
g. carry research equipment of no more than two types;
h. avoid contact with encountered biota and use underwater working gloves;
i. use the alpha dive flag;
j. use a hand signal;
k. prepare 100% oxygen, then immediately to the high-pressure air chamber, facility or hospital, and prepare medicines for first aid in an accident; and
l. keeping the body fit.

3. The points contained in the risk assessment document are as follows:

   a. Basic information about planned dive operations

This information includes a description of the dive site, such as where the dive site is, what the water conditions are, and the location's characteristics. Based on that information, the need to perform work and things related to safety can be prepared.

b. Data on personnel engaged in activities

These personnel data show that the entire team is competent to carry out dives.

c. Potential hazards during the preparation of dive activities

When preparing for dive activities, it is necessary to identify and assess potential risks that may occur.

d. Potential hazards during diving activities

Potential hazards when carrying out diving work can be caused by equipment, human resources, and conditions of the aquatic environment.

e. Implementation of safety measures (rescue chain) in the event of an emergency

In the event of an emergency, the security and safety team can carry out emergency measures that can immediately help the victim quickly and precisely.

C. Emergency Management

Victims of diving accidents can happen to anyone. Therefore, the handling of emergency procedures must be planned and prioritized treatment. The dive leader is responsible for preparing dive emergency handling procedures, evacuation measures, and medical care at each dive site. This is also what the dive team must submit on a dive plan with a thorough risk assessment for each research dive activity.

1. Emergency management plan

The points presented in the emergency management plan are as follows:

a. The list of emergency contact numbers by dive location includes
   1) the contact number of the local SAR Agency;
   2) the contact numbers of local air water police;
   3) the contact number of the nearest naval base;
   4) the contact number of the local police station or police station;
   5) the contact number of the nearest hospital; and
   6) land contact number, for example, the number of the hotel where to stay. This needs to be done as a mitigation effort. For instance, if evacuation officers or medical personnel cannot be contacted during an emergency, then the ground contact of the team will be contacted. Please ensure the ground contact number above can be contacted before diving by contacting each number until it can be connected.
b. The name, phone number, and relationship of the person contacted for each diver in the event of an emergency.
c. Availability of the nearest high-pressure air chamber.
d. The nearest accessible health facility.
e. Access and means of transportation are available.

2. Emergencies on dives

Emergencies on dives include the following.

a. Unconscious divers. The handling procedure for that condition is as follows:

1) Ensure the victim's condition and the surrounding environment to avoid things that may endanger the victim, yourself as a helper and other people around you.

A (Airways), which is to examine the airways that aim to free and open the airway. This examination is carried out by opening the mouth and observing whether there are objects that have the potential to clog the respiratory tract or not.

B (Breathing), which is a breath examination that aims to find out whether the victim is breathing normally or not. This examination is carried out by bringing the helper's ears and cheeks closer to the victim's nose, and the helper's eyes are fixed on the victim's chest or abdomen. There are several procedures, namely a) starting the look procedure, seeing the movement of the chest or abdomen as the victim breathes; b) listening, that is, listening to the sound of the victim's breathing; c) feeling, that is, feel the gust of air coming out of the nose. If at this breath examination it is known that the victim is not breathing, start performing a CPR (cardiopulmonary resuscitation) procedure with method 30-2 (30 times compression and two blows).

C (Circulation) or circulation management aims to restore blood circulation by touching the carotid pulse for three to five seconds. If there is no pulse, continue the CPR until the evacuation officers and medics arrive.

Provide 100% oxygen in case of decompression and sinking diseases.

2) Suppose an emergency occurs to one of the members of the diver team. In that case, other members must immediately call the emergency number that has been prepared on the dive plan and emergency handling plan. Dive leaders are required to store emergency numbers in unlocked mobile phones that have sufficient credit and then call emergency numbers with the 5W principle, including the following:
   a) Who: Introduce yourself and explain that there were casualties in the diving incident.
   b) What: Explain what happened/dive emergency to the evacuation team and medics.
   c) When: Describe in detail the time of the incident because time is precious to the victim.
   d) Where: Describe the location of the incident clearly and in detail.
   e) Wait: Wait and do not hang up if you have any questions and follow-up instructions from the evacuation team or medical personnel.
3) Contact the hospital to report an emergency condition and emergency action plan.

Figure 4. Simulation of Emergency Handling in Diving
Source: BRIN/Rikoh Manogar Siringoringo

D. Missing Divers

1. Procedure for losing buddy/dive partner

Divers who are paired together but in a dive lose contact with each other during the dive then follow the following procedure:

a. As soon as they realized that contact with their partner had been lost for a while, each diver had to search in a circle with a 360-degree technique to search for his partner or through observation of the bubble trails of the fellow diver being sought by rising 3 to 5 m from the initial depth. The step should be carried out in no more than a minute.
b. If there is still no contact, each diver involved should come to the surface at a speed of no more than 18 m/min (maximum controlled ascent rate).
c. If the diver is found back to the surface, the dive can be restarted or stopped based on the dive leader's decision.
d. If a diver is missing for more than 5 minutes, the procedure for responding to the missing diver should be implemented.

Procedures for losing members of the research dive team should be conveyed and discussed in each research dive activity briefing.

2. Missing diver procedure

When the diver cannot be found after 5 minutes of the search process, the process that must be carried out is as follows:

a. As soon as a diver goes missing, the dive leader activates the emergency response plan by immediately contacting and asking the nearest SAR team for help, including notifying the institution's leadership of the ongoing situation.
b. Mark the last position of the missing diver with GPS and buoy sign.

c. If at any time someone sees a missing diver, they should maintain a visual focus on that position.
d. If the diver is still in the water, immediately call back using a pre-agreed signal.
e. Maintain contact with emergency connections through the emergency response plan.
f. All team members must be alert to divers on the surface through signs of diver air bubbles, or visual or diver sounds with emergency signals.
g. Use binoculars to make observations of the surroundings.
h. Pay attention to the wind direction and undercurrents.
i. If other dive team members can safely search for the missing diver, then the dive leader can decide on the team of divers to begin a search where the diver was last seen using an emergency marker buoy as a reference.
j. Ensure the search team has the capabilities and experience to perform appropriate search patterns.
k. Ensure that the search team can be recalled when needed.
l. Make a controlled descent (do not swim) to the bottom to find out the influence of the current.
m. Divers engaged in the search should avoid risks, such as decompression diseases.
n. If a diver is found, give appropriate measures to the victim's condition and contact medical personnel for more intensive treatment.
o. If the diver is not found, continue the search for as long as possible until the SAR team takes over the search and evacuation efforts.
p. Maintain communication with the competent authorities.

Before the research dive is carried out, this emergency response plan must be drawn up and submitted to all team members.

E. Flights after a Dive or Going to Altitude

The procedure of flight activity after a dive or going to an altitude (more than 300 m) includes the following.

1. Single dive without decompression: Divers must perform surface intervals before a minimum flight of 12 hours.
2. Repeated daily or multi-day dives: Divers must perform surface intervals before a minimum flight of 24 hours.
3. Dives that require a planned decompression stop: Divers must perform surface intervals before a minimum flight of 48 hours.

Before heading to altitudes above 300 meters (1000 ft) by ground transport, divers should follow the appropriate instructions for surface intervals before flying unless the decompression procedure has considered the increase in altitude.

F. Forming a Diving Team

A team of research divers can only carry out underwater research diving activities. Therefore, research diver teams are formed based on the activity's objectives according to the abilities and expertise possessed by each research diver. The research diver team consists of scientific dive leaders, data takers, and helper divers. Furthermore, the duties of members of the marine biological scientific dive are set according to the research plan that has been prepared.

1. Scientific dive leader (dive leader)

The diving officer will propose one person as the dive leader for each scientific diving activity. The person is usually the most experienced diver or with the most knowledge and skills for the task performed. The dive leader is responsible for directing the divers while above and underwater and making informed decisions to minimize the risk of diving for the entire team. If needed, the dive leader can become a scientific diver at the same time.

2. Data-taking divers (scientific divers)

All divers must have attended training and have experience following the requirements in this guide. Data-taking divers should also understand the operation of any diving equipment and the technical work performed during the dive. In addition, each diver must have a heightened awareness of the limitations of their experience and abilities and must use common sense when considering their involvement in any research dive activities.

If any diver is concerned about participating in certain scientific diving activities for any reason, they have the right to refuse to participate. To be able to carry out research diving activities, research divers must meet the following requirements:

a. Physical and spiritual health as evidenced by a valid health certificate.
b. Have protection or be covered by one of the occupational accident insurance associations.
c. It has been trained in one of the training institutions recognized by scientific diving associations in Indonesia.
d.. He has been trained in first aid at work in the past three years and trained in CPR and oxygen administration in the last 12 months.
e. Have an advanced level diving certificate or equivalent, with 50 hours of diving after completing the open water certification.

3. Helper diver or standby diver (safety diver or standby diver)

The standby diver is in charge of monitoring all activities and is ready in an emergency. Standby divers must also meet the qualifications of scientific divers. At the time of the activity, the standby diver was on board the ship and was in a standby state to make it possible to immediately enter the water in the event of an emergency to the research dive team.

4. Visiting scientific diver

Visiting scientific divers are allowed to dive for a limited period as part of institutional diving operations and are involved in research dives. The diving activities they carry out are considered to meet the competence of the dive coordinator's policy. If this guest diver is from abroad, the diver needs permission from the Coordination Team for Granting Foreign Research Permits. The management of the permit can be done online through the website portal that has been prepared (http://frp.ristek.go.id/). In addition, guest scientific divers must attend training or equalization of competency certificates based on the SKKNI for Marine Biological Scientific Diving.

G. Dive Location Determination

The dive location is determined based on the purpose, habitat representation factor (stratification), safety factor when diving, and access to the location; in determining the location, using GPS equipment that stores the coordinated position. In addition, natural signs can also be used as a reference if one day they will return to the location. In determining the location of the dive, in addition to the representativeness of the habitat, it is also the depth. Depth will affect how long it is allowed to not be subject to decompression.

H. Dive Procedure and Planning

The pressure that occurs due to diving will affect the physiological changes in the diver's body. With each addition of a depth of 10 meters, the pressure rises by 1 atmosphere. With these additions, the laws of physics apply so that the gas smoked by divers increases and affects the physical condition of divers. To minimize the impact of disease on divers, you must know the correct and safe diving procedures, among others,

1. the physical condition must be fit and healthy;
2. make a dive plan and carry out the dive as planned;
3. rise to the surface slowly at a speed of 10 m / min (1 m / 6 second);
4. conduct a safety stop for 3 minutes at a depth of 3 m; and
5. not holding his breath as it rises to the surface.

In carrying out the dive, the dive leader is responsible for preparing the dive plan. The things that are considered in diving planning include

1. water conditions (diving environment);
2. estimate a good time when diving (looking at the tidal table);

3. determine the limits of depth and length of dive time (maximum bottom time);
4. calculate air consumption;
5. carry out the division of tasks for each diver; and
6. recall safety procedures in case of emergencies.

I. Log Dive

Every diver taking data must prepare a scientific diving log book that records diving activities with the following information:

1. date;
2. dive sites;
3. coordinate position;
4. depth;
5. start time and time out of the water;
6. work performed; and
7. the name and signature of the dive supervisor.

J. Diving

The depth limit in marine biological scientific diving activities is 40 m. Dive leaders should consider the experience and ability of individuals to make deep dives. The dive leader does not allow diving if it endangers the divers. Dive leaders can stop activities in the field if:

1. requested by divers;
2. there was an accident against one of the members of the diver team;
3. incomplete team;
4. necessary equipment, especially those related to safety, is damaged;
5. bad weather occurs (storms and lightning in the middle of the sea); and
6. in case of a change in dive location that endangers the diver.

In planning, a dive can be calculated how long it will take to dive at a certain depth. In addition, it can be known how much each diver uses for air consumption. The formula for calculating the dive time and air consumption can be seen as follows:

Based on the NOAA Diving Standard and Safety Manual (NOAA, 2017), the calculation of the time limit for working underwater follows the following formula:

SAC = (VT x VC) / (P x T)

SAC = Surface air consumption (underwater diving workers are generally 25 liters per minute)

VT = Total volume of dive tubes used (in liters generally, the dive tubes used are 11 liters)

VC = Air pressure consumed during diving (in bars) must leave 50 bars for safety, especially when doing a safety stop

T = Duration of the dive (in minutes)

P = Depth pressure when working underwater (in atm), on the surface of the water = 1 atm, towards a depth of every 10 m will increase by 1 atm

Case studies:

If you want to do a dive at a depth of 10 meters, how long will it take according to the safe underwater work dive procedure?

Formula:

SAC = (VT x VC) / (P x T)

25 = (12 x (200 - 50) / (2 x T)

T = 33 minutes

Calculating air consumption:

Air consumption = (Bar) x tank volume/depth (atm) x time

100 bar x 12/2 atm x 30 minutes = 18,33 liters/minute

CHAPTER V

DATA RETRIEVAL METHODS

Data retrieval is the primary goal in a marine biological scientific diving activity. This data collection will undoubtedly be helpful information for marine biology research and the world of education. The data collection uses various methods adapted to the study's purpose, especially to find out data on marine life populations, community structures, biodiversity, and even to measure damage to biota habitats under the sea. There are many underwater data retrieval methodologies in use to date. These methodologies generally include transect methods, visual observation, underwater documentation, damage measurement, and sampling. The data retrieval methodology will continue to evolve following technological developments and research issues that also continue to evolve. In general, some techniques or methods of data retrieval are presented below.

A. Transect Installation Technique

Transects are auxiliary lines placed on a specific habitat to collect data from particular biota. The data collection was carried out to estimate the presence of these biotas in a population. The line can be formed using a nylon rope or a rolling meter. The use of a rolling meter is more advisable considering that in the roll meter tape, there is a size (in units of cm units) so that it can be known precisely the length of the line to be drawn, as required in transect data collection. For example, for observation of coral reefs using the underwater photo transect (UPT) method, the length of the transect line is 50 m.

On underwater observations, the transect line is laid out by diving at a certain depth, as required by the sampling method. Then, the transect is laid on the base of the substrate and drawn parallel to the coastline along the desired transect line. To ensure that the transect is installed at the same depth, the transect line puller must use a depth meter or depth meter to control the depth when laying the transect line.

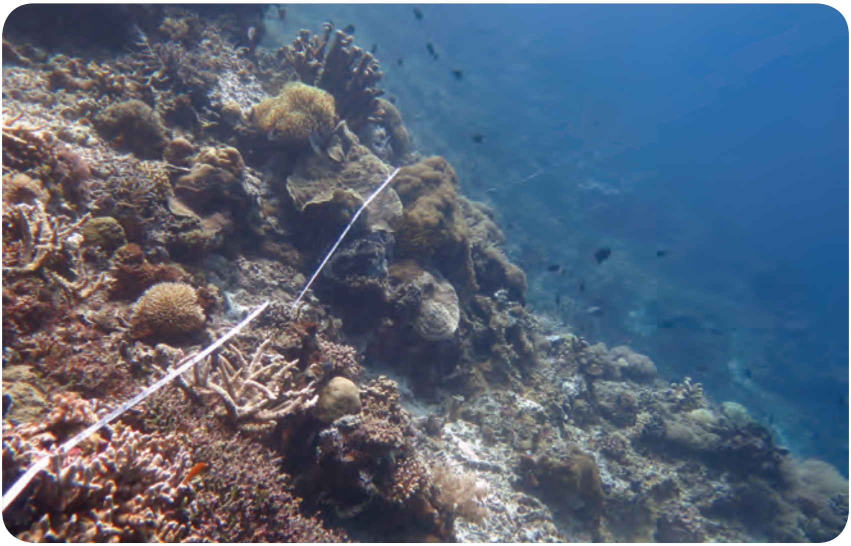


Figure 5. Example of Transect Line Installation
Source: BRIN/Giyanto

Underwater squared transect methods, one of which can be carried out for the collection of coral tillering data (recruitment). In size, coral saplings are limited to the stage after larval pasting, starting from the colony size that can be observed with an eye to the maximum colony diameter of 10 cm (Obura & Grimsditch, 2009). Collecting coral sapling data was collected in a 1x1 meter squared plot placed on a transect 70 m long parallel to the coastline at a depth of 5-8 meters. A total of 6 sampling squares at each station were randomly placed systematically at points 0, 10, 30, 40, 60, and 70 m (Figure 6). Diving with the data collection of these coral saplings requires accuracy in the observation and measurement of small-size samples. In addition, underwater photos of coral sapling colonies are needed for identification and data analysis, so the ability of underwater photographs with small objects is also required. Several types of equipment, such as stationery, squared frames, rulers/calipers, and cameras for data collection of coral saplings, are also considered in mobilization during diving.

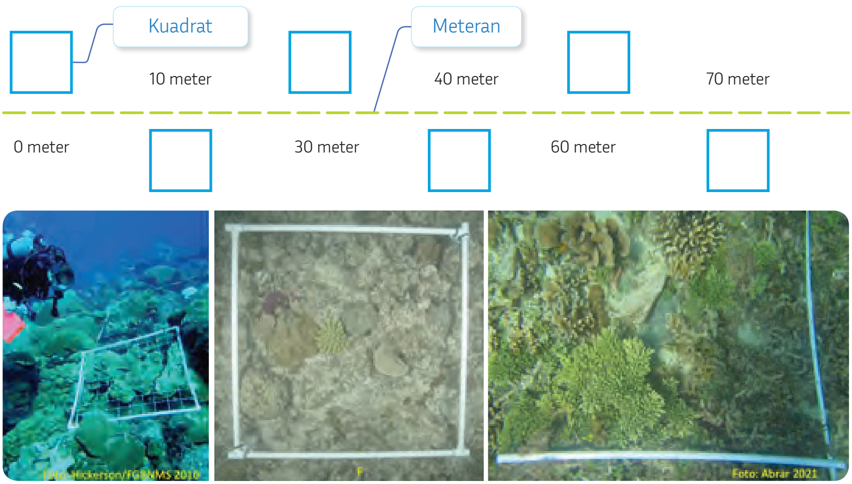


Figure 6. Coral Quadratic-Tillering Transect Scheme (Recruitment)
Source: BRIN/Muhammad Abrar

B. Visual Observation Methods

Underwater visual observation is a fast, effective, and environmentally friendly ecological approach that aims to measure or study the diversity, abundance, benthic cover, or behavior of various biota in shallow water habitats (Davis et al. 2014; Pais & Cabral 2018). Despite this, it is a must for a marine life researcher to have the ability to dive, in addition to the branch of marine biological science itself.

Underwater observations for the data collection on the diversity of biota (e.g., reef fish and corals) can be done by the cruising method, namely by diving down to the depth limit or the deepest location of the coral reef area still be reached by diving techniques. They slowly rose to shallow waters (Allen & Erdmann, 2011). Species encountered during diving are recorded with a pencil on waterproof paper. Visual surveys for this diversity are commonly combined with specimen collection for biota types requiring more detailed identification in the laboratory. For example, fish that are cryptic or difficult to see due to their small size, or those that hide in the crevices of corals or rocks, are collected using a small amount of clove oil solution or chemicals such as quinidine and rotenone.

In addition to the free cruising method, underwater visual observations can be categorized into three engineering approaches: the stationer point method, transect, and swimming within a specific period. In the stationary point method, a stationary diver in the same place then observes within a certain radius (Bohnsack & Bannerot, 1986). In transects (line or belt transects), divers swim in a straight line to reach a certain distance and to calculate or observe organisms within a predetermined transect area (Brock 1954). By swimming in a specific period, a diver swims along a random path or changes direction at specific intervals to calculate organisms along the path traveled (Jones & Thompson, 1978).

Each of these techniques has its advantages and disadvantages and will probably be more suitable for the purpose or target of a particular species so that the criteria for choosing a visual method depend on the research question, the purpose, or the species to which the observation is targeted. For example, live coral cover data can be collected using a combination of line transects and photo transects (English et al., 1997; Suharsono & Sumadhiharga, 2014; Madduppa et al., 2013). On the other hand, visual observations to study the abundance and biomass of reef fish and megabentos can be made using belt transects (English et al., 1997; Suharsono & Sumadhiharga, 2014). In addition, fish are actively moving animals, so several other things must be considered, namely that most reef fish are diurnal and active during the day. Meanwhile, only a tiny percentage of reef fish are active at night, so the ideal visual observation approach is carried out in the morning to evening (between 09.00-16.00) (Madduppa et al. 2013). The time approach also needs to consider tidal conditions, where water conditions towards low tide often cause heavy currents and high turbidity, so the ideal time for reef fish observation is at the time of the water heading towards the tide and when the fish go out to forage.

C. Underwater Documentation

The underwater documentation method is the most commonly used method for assessing the biodiversity and potential of underwater benthic biota. The most common documentation includes photography that produces digital images and videos that produce recordings of conditions at the time. These two methods have different targets. Underwater video transects are used for studies on fast-moving objects such as fish (Boland & Lewbel, 1986, Michalopoulos et al., 1992, Tessier et al., 2005, Pelletier et al., 2011), while photo documentation is more commonly used for sedentary or immovable objects such as Bentos (e.g., algae or corals). Digital photo documentation techniques can be used in most dive conditions, even when visibility is limited, and are an easy method for competent divers to learn (Jonker et al., 2008). Meanwhile, the advantage of the video method is that the subject can be recorded while moving, which can help identification in the laboratory and reduce the possibility of duplication of calculations (Bortone et al., 1986; Harvey et al., 2010; Waternberg & Booth, 2014).

Video and photography methods both have the advantage of saving time to retrieve data in the field and can minimize bias because the data is stored and can be traced if it is to be analyzed further. However, there are also disadvantages of the photo and video method, including dependence on underwater cameras and videos, the quality of photos or footage produced during murky conditions, the possibility of camera damage when used, longer analysis time, and additional costs needed for the purchase and maintenance of cameras as well as video in the laboratory (Tessier et al., 2013; Giyanto et al., 2017)

D. Underwater Area Measurement Method

The underwater area measurement method described is limited to the measurement method carried out through diving activities, so there are limited area areas that depend on the capacity of the tube. It is realized that various methods are more accurate in calculating the area of underwater areas, such as sonar and drones that can still record the appearance of objects to a certain depth (>5 meters).

The underwater measurement method is simple. The process optimizes the equipment used during diving activities and is slightly modified by adding GPS. The details of the equipment used in this method can be seen in Table 2.

Table 2. Equipment for underwater documentation

No	Tool name	Function	Figure
1	Diving equipment (SCUBA)	The leading equipment for conducting underwater activities	
2	Depth meter	Measuring into relatives	
3	Compass	Define orientation	

No	Tool name	Function	Figure
4	Handheld GPS	Record geographic positions	
5	Reel strap (minimum 50m)	Connecting the position of the diver at the bottom of the water with the GPS position on the surface of the water	
6	Torpedo buoy	Maintains the GPS position above the water level so that it can still record the geographical position of the slander, which is perpendicular to the rope at the bottom of the water	

No	Tool name	Function	Figure
7	Ballast	Maintaining the stability of the body torpedo	
8	Waterproof box	Protects handheld GPS from water	
9	Duct tape	Attaching a GPS box to a torpedo buoy	

No	Tool name	Function	Figure
10	Slate board	Record information of points to be mapped	
11	Underwater camera	Recording the condition of underwater objects that are useful as binding points in map creation	

Source: Hafizt, M. (2016)

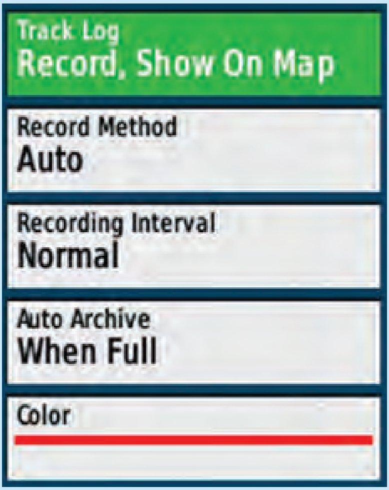
Measuring area through diving activities is carried out in water areas with a depth of more than 5 m and in areas with low water visibility. On the other hand, suppose the mapped area has a depth of fewer than 5 meters with good visibility conditions. In that case, measurements can still be taken by utilizing drone photos, and then mosaics are made into an image with a geographical reference. The stages carried out to calculate the estimated area of the area under water is as follows.

1. Preparation of the tool

In preparing the tool, the thing to do is to set up automatic coordinate recording by adjusting the time between the underwater camera and the GPS. Then, place the GPS that has been protected inside the airtight box on the torpedo buoy. Furthermore, the buoy will be carried by being pulled by a diver who is at the bottom of the water using a roller rope.

The following table shows how to perform the automatic coordinate tool tuning.

Table 3. Automatic coordinate recording device tuning

	The automatic coordinate recording setup is in the "SETTINGS: Tracks" menu, then selecting "Time" in the "Record Method" menu so that the GPS will record the position of each specific time lag that can be set every 5/10/15 seconds, depending on the level of activity underwater. When the "Track Log" is in the "Record Show On Map" position, the GPS has started recording the position, and then the GPS can be inserted into the protective box and affixed to the buoy using duct tape.

	Time equalization to facilitate the identification of positions at the bottom of the water is done by equalizing the time on the underwater camera with the time on the GPS.
	The addition of GPS to divers by tying buoys equipped with active GPS using a reel rope.

Source: Hafizt, M. (2016)

2. Data capture (photo, depth, distance, and direction)

Data collection for the needs of estimating the area consists of

a. photographic data that serves as a point at the bottom of the waters with a position on the surface through the equation of time;

b. the depth that can be interpolated, so that counter information is obtained,

c. distance; and

d. angles that are useful for evaluating the results of the calculation of the estimated area of GPS-recorded points on the surface.

In retrieval, each point that functions as a connective point is attempted to be perpendicular to the position of the GPS rope on the surface. This is done to minimize position errors due to water currents.

3. Data processing

It begins with 'data clearing,' which eliminates the recording coordinates every 5 seconds that are not needed (Figure 7). The captured point data is only data close to the time of taking each photo underwater. The information references the connective point of the area at the bottom of the water. The management of the data required to calculate the estimated size can be followed in Table 4.

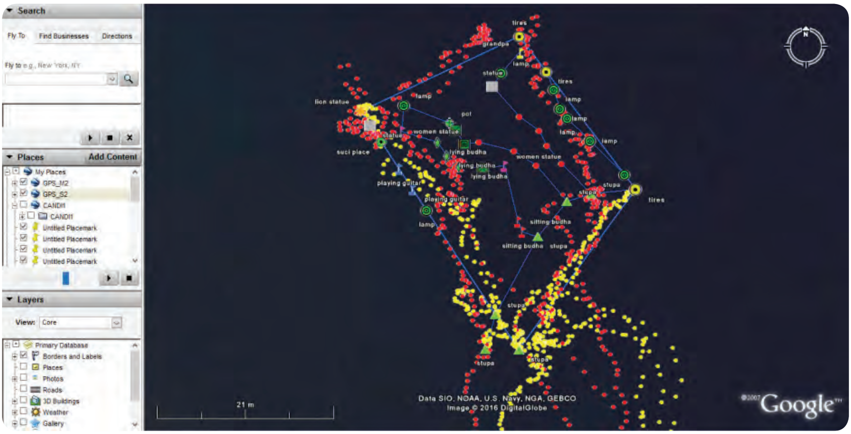


Figure 7. Automatic GPS Recording Results Every 5 Seconds
Source: Screenshot from DigitalGlobe Map App/BRIN/Muhammad Hafizt

Table 4. Information needed for the calculation of the working area underwater

no	time	x	y	z (m)	z tide	distance (m)	disstance information	object information	collector	GPS
1	15.25.51	345288,95	9084745,10	7,10	6,8	0	starting point	stupa	reza	GPS S
2	15.33.11	345291,15	9084753,10	9,70	9,4	12,5	1 to 2	sand	reza	GPS S
3	15.30.21	345299,47	9084763,86	18,80	18,5	12,5	2 to 3	tires	abrar	GPS M
4					-0,3	9,3	3 to 4	tstatue	abrar	GPS M
5				19,00	18,7	10,7	4 to 5	tires	abrar	GPS M
6	16.23.34	345281,90	9084783,81	18,00	17,7	4	5 to 6	tires	idham	GPS M
7	16.24.29	345273,40	9084777,39	10,00	9,7	10,8	6 to 7	sand	idham	GPS M
8	16.23.59	345267,71	9084771,18	9,00	8,7	10,8	7 to 8	stupa	sari	GPS S
9					-0,3	13	8 to 9	stupa	sari	GPS S
10	16.29.24	345282,37	9084751,03	9,00	8,7	13	9 to 10	box	sari	GPS S

Source: Hafizt, M. (2016)

Time: The time at the GPS point close to the photo's time in the object information column.

X: Longitude (UTM coordinate system).

Y: Latitude (UTM coordinate system).

Z: Depth measured using the depth meter on the regulator.

Z tide: The corrected depth of the waters is high.

Distance: The distance between the underwater objects in the photo.

Object information: Object description (shape, size, height, etc.).

Collector: A diver who takes measurements, carried out when several people carry out the work.

GPS: A GPS code when using more than one GPS in taking measurements.

Data processing, as in the table above, can be done using a spreadsheet application, where the transfer of data from GPS into a laptop or computer can be done via a data cable. Furthermore, the information in the table above can be displayed in charts or maps through ArcGIS and QGIS applications (Figure 8).

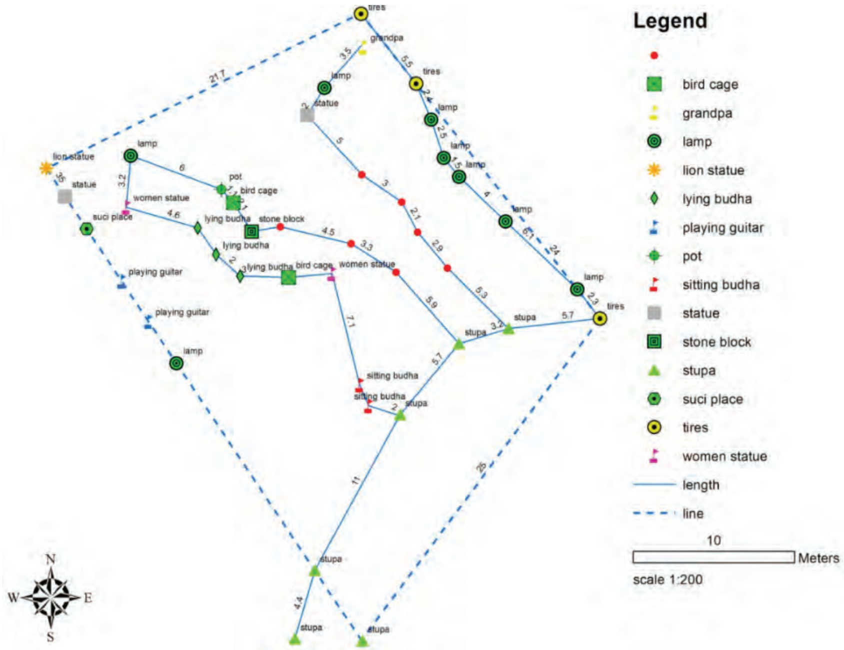


Figure 8. The Chart or Map Depicting Underwater Conditions along with Working Area Coverage

Source: Screenshot from ArcGIS App/BRIN/Muhammad Hafizt

The figure above shows the position of each object at the bottom of the water, where the area of the work area can be calculated quickly through the QGIS application using calculate geometry. Based on the results of measurements through diving activities, the area in the picture above (dotted blue line) is 723.6 meters^2.

The depth data can be used to model the three-dimensional appearance of the work area. Then, with the addition of altitude information from each seabed object that becomes a binding point, a three-dimensional impression of the site and mapped things can be produced, as shown in Figure 9.

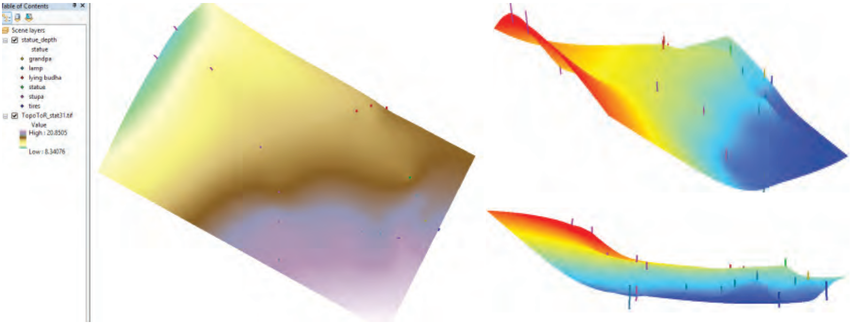


Figure 9. Results of Processing Depth Data from Depth Meter on Diving Regulator

Source: Screenshot from ArcGIS App/BRIN/Muhammad Hafizt

E. Biological Sampling Methods

In general, the thing that must be considered in this sampling is the safety aspect. This aspect can be studied from two perspectives: work behavior and the diving environment. Work behavior includes the diving skills of the sampler and the use of tools and materials in the sampling. Diving proficiency refers to a diver's ability to control and master diving situations well. Those skills include good buoyancy, underwater orientation, and low visibility deep diving or diving ability if needed. Meanwhile, the diving environment refers to the parameters of the waters that divers must consider in sampling. Things that must be regarded in the diving environment, including the depth of the seas to be targeted, the shape of the water topography, currents, temperature, waves, and physical parameters of other waters, as well as awareness of the environment, including dangerous animals.

The sampling method in scientific diving depends on the study field, for example, pelagic, planktonic, benthic, or sedimentary samples. The determination of tools and materials is also influenced by the object to be sampled. One thing and another will differ regarding sampling, sample handling, tools, and materials used. Then, the SCUBA tool to be used must meet several aspects, including

1. in excellent and comfortable condition;
2. equipped with other diving control aids; and
3. the selection, handling, and use of tools and materials must be accessible and safe.

Therefore, it is necessary to pay attention to the type, size, and several tools, and materials to be carried. Thus, the diver is not disturbed by his diving movements, is not burdensome, and does not take concentration of the diver continuously. This can help divers to focus on the quality object/sample they want to take.

In benthic sampling, coral or sea cucumber sampling, for example, it is necessary

1. cutting tools;
2. basket/sample holder; and
3. tongs to take samples.

Pelagic and planktonic sampling requires a net and a sample bin, according to their individual needs. If needed, sample bottles with a large mouth size are also used to take large enough samples. Meanwhile, although, in general, the use of sediment cores and sediment grabs is carried out from above the surface of the water, through diving, sediment cores and sediment grabs, as well as sample bags, can be carried into the water. Therefore, the technique was adapted to diving conditions (Pardo, 2014).

Biological sampling in scientific diving activities requires more effort and continuous high concentration, given the presence of tools and materials carried during the dive and the need for the quality of the samples taken. For this reason, this sampling should be carried out in a small team consisting of a leader who is responsible for taking samples, a buddy who helps with selection, and a safety diver who is in charge of supervising sampling; monitoring the dive environment for the dangers of being stung by poisonous animals, dragged by currents, exceeding the limits of the depth and length of the dive, or being hit by corals and other hazard risks (Haddock & Heine, 2005., Pardo, 2014).

BIBLIOGRAPHY

Allen GR, Erdmann MV. (2011). Keragaman Ikan Karang di Perairan Bali, Indonesia, P. 17–71. Dalam Mustika PL, Ratha IMJ, Purwanto S (Eds): Kajian Cepat Kondisi Kelautan Provinsi Bali 2011. RAP Bulletin of Biological Assessment 64. Dinas Perikanan dan Kelautan Provinsi Bali, Balai Riset dan Observasi Kelautan Bali, Universitas Warmadewa, Conservation International Indonesia, Denpasar.

Bohnsack JA, Bannerot SP. (1986). A Stationary Visual Census Technique for Quantitatively Assessing Community Structure of Coral Reef Fishes. NOAA National Marine Fisheries Service, USA.

Boland GS, Lewbel GS. (1986). Estimation of Demersal Fish Densities in Biological Surveys Using Underwater Television Systems. Oceans 2: 9−13.

Bortone SA, Hastings RW, Oglesby JL. (1986). Quantification of Reef Fish Assemblages: A Comparison of Several in Situ Methods. Northeast Gulf Sci 8:1–22.

Brock VE (1954) A Preliminary Report on a Method of Estimating Reef Fish Populations. Journal of Wildlife Management, 18:297–308.

Davis T, Harasti D, Smith SDA. (2014). Compensating for Length Biases in Underwater Visual Census of Fishes Using Stereo Video Measurements. Marine and Freshwater Research. Http://Dx.Doi.Org/10.1071/MF14076.

English SA, Wilkinson CR, Baker VJ. (1997). Visual Census of Reef Fish: Long-Term Monitoring of the Great Barrier Reef. Australian Institute of Marine Science, Townsville.

Haddock, Steven, H, D. And Heine, John, H. (2005). Scientific Blue-Water Diving. California Sea Grant College Program. California.

Harvey E, Fletcher D, Shortis M, Kendrick G. (2004). A Comparison of Underwater Visual Distance Estimates Made by SCUBA Divers and a Stereo-Video System: Implications for Underwater Visual Census of Reef Fish Abundance. Mar Freshwat Res 55:573–580.

Howell, R. S., Criscitelli, T., Woods, J. S., Gillette, B. M., & Gorenstein, S. (2018). Hyperbaric Oxygen Therapy: Indications, Contraindications, and Use at a Tertiary Care Center: 1.3 Www. Aornjournal.Org/Content/Cme. *AORN Journal*, *107*(4), 442–453. Https://Doi.Org/10.1002/Aorn.12097.

Jones R, Thompson M. (1978). Comparison of Florida Reef Fish Assemblages Using a Rapid Visual Technique. Bulletin of Marine Science, 28:159–172.

Jonker MJ, Bray PE, Johns KA, Osborne KO. (2020). Surveys of Benthic Reef Communities Using Underwater Digital Photography and Counts of Juvenile Corals. Long Term Monitoring of the Great Barrier Reef - Standard Operational Procedure Number 10, 2nd Ed. Australian Institute of Marine Science, Townsville, Australia. 36 Pp. Https://Doi.Org/10.25845/Jjzj-0v14.

Madduppa, H.H., Subhan, B., Suparyani, E., Siregar, A.M., Arafat, D., Tarigan, S.A., Alimuddin, D.K., Rahmawati, F. & Bramandito, A. (2013). Dynamics of Fish Diversity Across an Environmental

Gradient in The Seribu Islands Reefs off Jakarta. *Biodiversitas*, *14*(1), Pp.17-24.

Michalopoulos C, Auster PJ, Malatesta RJ. (1992). A Comparison of Transect and Species-Time Counts for Assessing Faunal Abundance from Video Surveys. Mar Technol Soc J 26: 27–31.

Naval Sea Systems Command. (2016). U.S. Navy Diving Manual. Revision 7. Publication SS521-AG-PRO-010. Washington DC.

Obura, D. and G. Grimsditch. (2009). *Resilience Assessment of Coral Reefs : Rapid Assessment Protocol for Coral Reefs, Focusing on Coral Bleaching and Thermal Stress*. IUCN. Gland. Switzerland. 70 Pp.

Pais MP, Cabral HN. (2018). Effect of Underwater Visual Survey Methodology on Bias and Precision of Fish Counts: A Simulation Approach. Peerj, 6: 1–19.

Pardo, A. (2014). A Scuba Diving Direct Sediment Sampling Methodology on Benthic Transects in Glacial Lakes: Procedure Description, Safety Measures, and Tests Results. *Environ Sci Pollut Res* 21, 12457–12471. Https://Doi.Org/10.1007/S11356-014-3011-8.

Pelletier D, Leleu K, Mou-Tham G, Guillemot PN, Chabanet P. (2011). Comparison of Visual Census and High Definition Video Transects for Monitoring Coral Reef Fish Assemblages. Fish Res 107: 84–93 .

R. Wartenberg & A. J. Booth. 2014. Video Transects are the Most Appropriate Underwater Visual Census Method for Surveying High-Latitude Coral Reef Fishes in The Southwestern Indian Ocean. Mar Biodiv. DOI 10.1007/S12526-014-0262-Z

SKKNI Penyelaman Ilmiah Biologi Laut. Kemenaker. (2019).

Subhan B., Khair M, Madduppa H, Nurjaya IW, Ardiwijaya RL, Prabuning D, Anggoro AW, Arafat D. (2015). Terumbu Karang Tulamben. Bogor, IPB Press 170 Pp.

Suharsono dan Sumadhiharga OK. (2014). Panduan Monitoring Kesehatan Terumbu Karang: Terumbu Karang, Ikan Karang, Megabenthos dan Penulisan Laporan. Pusat Penelitian Oseanografi LIPI, Jakarta

Tessier A., Pastor J., Francour P., Saragoni G., Crec'hriou R., & Lenfant P. (2013). Video Transects as a Complement to Underwater Visual Census to Study Reserve Effect on Fish Assemblages. Aquatic Biology. Vol. 18: 229–241, 2013. DOI 10.3354/Ab00506.

Tessier E, Chabanet P, Pothin K, Soria M, Lasserre G. (2005). Visual Censuses of Tropical Fish Aggregations on Artificial Reefs: Slate Versus Video Recording Techniques. J Exp Mar Biol Ecol 315: 17–30.

Van Liew, H. D., & Flynn, E. T. (2005). Direct Ascent From Air and N2-O2 Saturation Dives in Humans: DCS Risk and Evidence of a Threshold. *Undersea & Hyperbaric Medicine : Journal of the Undersea and Hyperbaric Medical Society, Inc*, *32*(6), 409–419.

APPENDIX

Appendix 1. General risk assessment

Case studies:

You will observe the condition of coral reefs in Raja Ampat, Papua. An example of a general risk assessment that you can compile is as follows.

Risk Assessment for Scientific Project
Reef Health Monitoring Raja Ampat Regency ....

This document is best prepared by the dive leader who is responsible as a precautionary measure to ensure safety during scientific diving activities. This is done by identifying and reducing potential threats. This document also provides relevant measures and information to organize safety measures in case of emergency and should be accessible during dive operations.

The points listed below are risk assessment points and dive preparation which are reference points to ensure safety during the "Monitoring the Health of Coral Reef Ecosystems and Related Ecosystems" (hereinafter referred to as RHM) activities of 2021. This document serves as a general risk assessment and an assessment as a whole for the duration of the activity. Therefore, the document must be completed with a daily risk assessment that will be used for risk assessment every day.

The points written below represent some of the potential threats. The task of the dive leader is to identify further potential threats and develop mitigation measures to reduce risks and ensure safety at every point in time of diving activities. These risks and mitigations should then be included in each of these areas, both in the daily work risk assessment and the general assessment of this project. The dive leader presents a work risk assessment document to the entire dive group in detail before the dive is carried out and provides information on safety measures and effective emergency measures to be taken.

1. Basic information about planned dive operations

1	Activity name	Reef Health Monitoring Raja Ampat Regency 2021
2	Research objectives	Knowing the current condition of coral reef conditions
3	Time	April 21—May 1, 2021
4	Maximum depth	The maximum depth is 10 m. Depth will be adjusted to dive planning
5	Types of breathing apparatus (gas) used	Compressed air (0.21 O2, 200 bar), filled in the Raja Ampat Explorer Liveaboard (LOB) Ship
6	Plan the number of dives	12 dives
7	Tasks performed during the dive	There are four areas: UPT for corals; UVC for reef fish; Belt transects for megabentos; underwater sampling, and installation of permanent transects (iron stakes and nangsi ropes as signs)

8	Description of the dive site	The dive site is on the coast of Salawati and Batanta Islands, Raja Ampat Regency, West Papua Province. Maps and coordinates are attached. Diving is carried out using LOB. To reach the dive site, two tender boats were used, each with six people. The distance from the tender boat to lob Raja Ampat Explorer is a maximum of 2 miles (trying to be as close as possible)
9	Are there malaria-endemic locations?	Yes, low-dose antibiotic drugs have been prepared
10	Is it prepared for a free day?	Yes, while analyzing data and equipment preparation.

Location map

The coordinate position of the research site

SWBC	01 131.13312	0.99476	North of Warir Island, Salawati
SWBC	02 131.12479	0.92609	Yefman Island, Salawati
SWBC	03 131.14466	0.95859	Mataan Island, Salawati
SWBC	04 131.05798	0.92664	Kapatlap Island, Salawati
SWBC	05 131.02689	0.89485	Rifle Island, Salawati
SWBC	06 130.99180	0.92096	Waipelet Village, Salawati
SWBC	07 130.88062	0.84609	East of Batanta Island
SWBC	08 130.91031	0.79980	Northeast of Batanta Island
SWBC	09 130.85230	0.76173	Cape Alauket, Batanta
SWBC	10 130.77098	0.75523	Peev Island, Batanta
SWBC	11 130.66929	0.77449	Run Island, Batanta
SWBC	12 130.64483	0.80200	Insaway Island, Batanta

2. Personal data

This activity is a scientific diving activity. Therefore, all participating divers must meet at least the following requirements:

a. diving certificate of at least CMAS Two Star or equivalent;
b. valid medical examination for diving (no more than 12 months);
c. certificate of first aid; and
d. CPR training in the past year, more than 50 dives.

No.	Name	Certificate	Experience
1	...	...	...
2	...	...	...
3	...	...	...
4	...	...	...
5	...	...	...
6	...	...	...
7	...	...	...
8	...	...	...
9	...	...	...

3. Potential hazards during the preparation of dive activities

Concerning the means used for diving (e.g., boats), is there any potential danger causing personal injury or damage to diving equipment during dive preparation? If so, what measures are being taken to prevent the threat?

Yes, small boats, slippery docks, undulating seas, and heavy equipment.

Measures to avoid potential hazards during the preparation of dive activities are as follows:

- securing equipment on the ship by fastening the tank to iron or mast on the ship;
- tell divers to be extra careful when transporting equipment to or from the ship;
- mutual assistance in loading/unloading heavy equipment (load sharing);
- the leader of the dive mission will arrange the space on the ship;
- the dive will not be carried out during adverse conditions (choppy or current sea); and
- all divers should listen carefully to the dive leader during the briefing.

4. Potential hazards during diving activities

a. Is there any danger from slippery floors (caused by, for example, working with water on deck) during the preparation or execution of operations?

Yes, wet equipment and seawater will probably make the deck/floor slippery.

Measures to avoid potential hazards during diving activities are as follows:

- inform the diver of the risks and make sure that the equipped diver remains seated;
- always wear either a life vest or wetsuit;
- ensure positive buoyancy if it falls into the sea;
- divers will be notified of slippery deck conditions; and
- movement in the boat is reduced to a minimum.

b. Does the dive operation take place under the influence of powerful tides? (if it is, describe the appropriate safety measures, for example, mention the tide period and indicate the dive duration during this period).

The tidal distance is significant (>2 m); using the tidal table when the water moves towards the highest tide is an excellent time to dive.

c. Is the water current estimated to be strong? (If so, what precautions are being taken? For example, should the dive be stopped at speeds of >3 m/s?)

No, dive sites are rarely exposed to strong currents. However, if there is a strong current or violent sea, the dive depth/time will be limited, and if necessary, the diving activity will be canceled. However, it is essential to emphasize that waves can complicate the boat's position, and diving is not allowed unless it is placed safely. In addition, divers will be informed of the risks of diving in shallow waters close to the rocks, as large waves can push divers towards the rocks. If the giant wave is too strong, the diver will be told to avoid shallow areas (<3 m). Therefore, divers are only allowed to work in the transect's deeper areas (> 3 m).

d. Is it expected that there will be greater heat and dehydration?

Dehydration is always a risk when diving. Therefore, divers must stay hydrated and bring drinking water to the dive site.

e. What if the water conditions are murky?

If the waters are murky, divers will still be tried to descend. However, if it is not possible, the dive will be canceled.

f. Is there a specific potential hazard at the dive site due to carrying some scientific equipment?

Yes, when working with equipment, divers may be able to get wrapped around, distracted, or out of focus; even equipment can be damaged or lost.

Measures to avoid such potential hazards are as follows:

- the dive plan should be clear and straightforward;
- divers will not get more than two pieces of equipment to carry;
- divers get no more than three tasks per dive; and
- these tasks will be adapted to the experience of the diver.

g. Is there a threat of danger by fishing gear or activity at the dive site?

Yes.

Measures to avoid the threat of such dangers, namely that divers will be told to be aware of the possibility of being entangled by fishing gear at the dive site and sharp objects that may be at the bottom of the water.

h. Is there a possibility of encountering predators or poisonous animal species?

Yes, the risk of encountering predators is possible in the area—similarly, the risk of encountering another toxic biota, such as stone fish or other animals.

One way to avoid this possibility is that divers will be told to avoid interactions with the animal if encountered. In addition, divers will be told to avoid any contact with poisonous biota and must wear gloves.

i. Are dives done around shipping operations? (If so, what measures are being taken to prevent this harm?)

Yes, the dive site is in the ship traffic area, both passenger ships and fishing boats.

Measures to avoid the threat of such harm are as follows:

- the alpha flag (dive flag) is the top priority and will be installed so that it is visible from a distance;
- diving activities will be informed to the passengers on the passenger ship;
- the dive leader will be told to be careful when approaching the dive site; and
- the signal line was raised to indicate that there were divers in the water.

5. Emergency plan (see appendix 4)

I at this moment affirm that I have read the prepared risk assessment. Therefore, according to my knowledge and conscience, this document meets the necessary precautions to ensure maximum safety during diving activities at rhm Raja Ampat monitoring activities 2021.

Jakarta, ...	....	______________________
Place and date	*Name*	*Signature, Dive officer*

Jakarta, ...	....	______________________
Place and date	*Name*	*Signature, Dive Leader*

Divers:

I now confirm that I have fully understood the above risk assessment and will take the appropriate steps.

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Name: .... Signature: _______________ Date: ___________

Appendix 2. Daily risk assessment

Daily Risk Assessment Documents

Implementation of activities

Date/time	Team leader (name and certificate)	Phone/VHF-channel
Dive site		

Executor of activities

Ground contact:		HP:
Diver 1 (name and certificate)	Diver 2 (name and certificate)	Diver 3 (name and certificate)
Diver 4 (name and certificate)	Diver 5 (name and certificate)	Diver 6 (name and certificate)
Ship:	Ship captain:	HP:
Contact with relevant organizations (coast guard, SAR, and others) 112 emergency numbers and channel 16 VHF		

Dive plan

Depth:	Maximum time:		Water temperature:		
Types of breathing apparatus	Diver 1	Diver 2	Diver 3	Diver 4	
Tube filling station	Diver 1	Diver 2	Diver 3	Diver 4	
Other types of clothing/ clothing used	Diver 1	Diver 2	Diver 3	Diver 4	
Table/dive computer:	Respiratory gas used: Air (21% O2)		Communication via: HP		
Tube pressure:					

Description of dive assignments

Activities in general:

Checklist

- ☐ Dive flags
- ☐ Ascending stairs
- ☐ Oxybox
- ☐ Material first aid
- ☐ Tools for summoning divers
- ☐ HP
- ☐ VHF and walkie talkies
- ☐ Buddy line
- ☐ Life line
- ☐ Rescue net
- ☐ Contingency plan
- ☐ Drinking water
- ☐ Warm clothes/blankets
- ☐ Dive tables
- ☐ Emergency line
- ☐ Research equipment
- ☐ Esktra tank
- ☐ ...
- ☐ ...

Risk assessment

The risks that can arise are associated with scientific diving activities:	
(See risk assessment in general)	
Dive site (weather, water, and water bottom conditions):	
Level of experience of divers (**experienced or not**):	
Division of research tasks among the team of divers:	
Use of BCD/life line/buddy lines:	
Access to dive points (boats and others):	The position of the ship during the dive: Anchors lowered or stationary on the beach
Communication with others in the dive area:	
Specific tasks discussed during the briefing: **Procedures in case of emergencies, division of duties, and underwater signals**	

Specific assignments for emergency handling procedures: (See risk assessment in general)	
Time to dock by ships:	Time is taken by ambulance to high-pressure air chamber (decompression chamber)/hospital:
Landing sites for emergencies for ships: Ambulance pick-up points for emergencies:	

Appendix 3. Daily log dive

Daily Log Dive

Date/time :
Dive leader :
Location :
Lat/long :

No	Name	Press air in	Press air out	Time in	Time out	Total time	Max depth	Job description
1								
2								
3								
4								
5								
6								

Appendix 4. Emergency plan

Case studies: You will observe the condition of coral reefs in Raja Ampat, Papua. An example of an emergency plan that you can compile is as follows.

Emergency Response Plan

1. Is the function of the emergency response plan guaranteed during the dive activities carried out? Yes, the emergency response plan works and is ensured to proceed according to procedures during all dive activities.
2. Provide a detailed explanation of the emergency response plan, including a step-by-step explanation of the mobilization of divers experiencing emergencies safely from the bottom of the sea to the surface, then to the ship or the shore, all the way to the medical facility!

   A detailed step-by-step explanation can be seen below.

   - Step 1

     Bringing divers to the surface, assisted by safety divers (always on standby on boat, with a response time of ~1 minute).

   - Step 2

     Putting divers into the boat, either through the rescue net or by pulling the diver into the ship (everyone on board will help lift the injured diver into the boat).

- Step 3

  Check for symptoms, provide first aid and CPR, and give O2 if necessary (oxy boxes and P3K boxes are available on board). Dive leaders must ensure space on board to carry out procedures or inform the crew that they will carry out the procedures above on land.

- Step 4

  If necessary, paramedics will be notified by calling 112 and asking them to meet at the Sorong Port pier (15-minute ETR).

- Step 5

  Take divers to the nearest pressurized room/ chamber, such as the Sorong regional public hospital (RSUD) (ETR 45 minutes)

3. Explain the duties and roles of team members, standby divers, dive leaders, and ship captains in an emergency! (The tasks given vary depending on the assignment given by the dive leader during the briefing)

   a. Dive leader tasks
      - Cancel activities in the event of an emergency that requires severe treatment.
      - Maintain communication with the SAR team and or paramedic team.
      - Contact the dive officer or head of the institution and report the emergency.

   b. Standby diver or safety diver duties.
      - Immediately lift or evacuate divers experiencing emergencies.
      - We are positioning such divers in safe conditions or environments.

- Provide the necessary assistance according to the victim's condition (for example, providing treatment if the victim is injured or CPR if the victim is unconscious and not breathing).

c. Diver task 1
   - Make an emergency call to the medical party or the SAR.
   - Alternately perform CPR with a standby diver every five compression cycles until the evacuation team or medical team arrive at the location.

d. Diver task 2
   - Record and document emergencies that occur.
   - Picked up the ambulance car when it came to the location area.

4. Explain the distance to travel from the dive site to the boat trip or from the dive site to the beach entrance and ambulance access!
   - The diving activity's site to the boat is about 50 m.
   - From the point of the boat to the nearest pier is about 750 m.
   - From the pier to the ambulance pick-up (access) point, about 150 m.
   - From the ambulance, access to the hospital is about 2.5 km.

Appendix 5. Important/emergency contact numbers in West Papua

Important numbers relating to the smooth running of diving activities are presented below. The important number is printed on laminated paper, placed in an accessible place, and seen and close to a cell phone that is unlocked and has credit. These emergency numbers should be called in advance to make sure they are active and can respond to emergency calls, while also conveying that there are dive activities underway. Here are important/emergency contact numbers in West Papua.

- Sorong SAR: 0951-3102316, 0951-323816
- Mako Lantamal XIV Sorong: 0971-321789/0951-3170338
- West Papua Regional Police: 0986-211253
- West Papua Regional Police Ditpolair: 085243469475
- Sorong City Health Office: (0986) 212817
- Indonesian Red Cross (PMI): 021-4207051
- Emergency Ambulances: 118 and 119
- Sorong Regional Hospital: 0951321850 (Covid-19 referral hospital)
- Manokwari Hospital: 0986-215133/211440 (Covid-19 referral hospital)
- Ground contact 1: The Belagri Hotel Puncak Arfak Ms. Michiko (+62811488760)
- Ground contact 2: Grand Komodo Mrs. Tian (+6281338683683)

GLOSSARY

Advance diver: The second level of diving education.

Alternate air source (octopus): A device shaped the same as a *second stage* and used in an emergency to help other divers who are already short of air or out of the air in their tanks. An alternate air source is usually yellow to distinguish it from the *primary second stage/second stage.*

ArcGIS: A software package comprising geographic information system software products manufactured by Esri.

Archaeology: A science that studies past cultures through systematically studying left-behind material data.

Bottom time (BT): The total time a diver is underwater.

Briefing: A short meeting to convey more detailed information or instructions.

Buddy line: A strap that physically ties two divers together underwater to avoid separation under low visibility conditions.

Buddy system: A pairing system implemented in diving activities that is useful for preventing risks from occurring.

Buoyancy: Buoyancy force in the water.

Buoyancy compensator device (BCD): One part of the diving equipment used by divers to regulate and control buoyancy to allow divers to obtain perfect floating conditions (neutral buoyancy).

Cardiopulmonary resuscitation (CPR): Cardiac massage pumps blood and provides respiratory stimulation.

Colony: A set of microorganisms that have similar properties, such as shape, arrangement, surface, and so on.

Communication tools: Tools or means used to convey messages from the communicator to the communicant or recipient of the message.

Controlled ascending rate: The speed of rising to a controlled surface.

Cryptic: Hidden among others.

Cutting tools: Cutting tools for use underwater.

Decompression sickness: A disease in diving caused by rapid pressure changes so that nitrogen dissolved in fluids in body tissues turns into gas bubbles. It results in blockages in blood vessels.

Decompression stop: A pause in a diver's ascent is created to allow the body to expel the dissolved gases in the blood. Without the cessation of decompression, these gases will expand, turn into bubbles, and cause decompression disease.

DGUV (Deutsche Gesetzliche Unfallversicherung e.V) R-2112: Regulation for health and safety on scientific diving work activities in Germany.

Dive computer: A dive computer to find out the depth and time of the dive that informs the diver's boundaries are not exposed to decompression.

Dive leader: A scientific diver leader who has done scientific dives at least 30 times is in charge of supervising and assisting divers in marine biological scientific diving activities.

Dive plan: The process of planning an underwater dive operation that aims to make the dive run safely and reach the destination.

Dive supervisor/dive officer: A person responsible for reviewing the feasibility of a diving activity that has the theoretical ability of diving and has experience with a minimum of 100 scientific dive activities with at least 60 hours of total diving.

Diver flag: A dive flag to inform you there are dive activities.

Diving flashlight: One of the instruments that serve for lighting in the water, be it freshwater or the sea

Emergency response plan or rescue chain: A series of activity plans to anticipate disasters in an organized manner using appropriate measures.

Equalization: Equalization of pressure on the ear cavity as it descends from the water's surface.

ESD (European Scientific Diver): Divers who can act as members of the scientific diving team through field training and experience under the supervision of the European Scientific Diver panel.

ETR (Estimated time required): The time it takes to travel a certain distance.

First aid kit: A place or container containing first aid kits that can be used in the event of an emergency or injury to a person and to prevent the occurrence of higher severity of the injury.

Geology: One of the branches of earth science that studies the earth and everything in it.

Guest scientific divers: Scientific divers from abroad who must follow the equalization of competency certificates follow the Indonesian National Work Competency Standards (SKKNI) through competency tests.

Habitat stratification: Habitat grouping.

High-pressure air chamber/decompression chamber: A pressure room that serves for healing and therapy due to decompression disease.

Hydrostatic: The pressure caused by the force present in a liquid against a compressive plane area at a certain depth.

Limnology: A branch of biological sciences that studies inland waters.

Marine biology: The science that studies the life of organisms in the ocean includes behavior and its interaction with the environment.

Marking bouy or surface marking buoy: A marker float on the water's surface.

Material transfer agreement (MTA): A legal instrument governing the requirements for the transfer of tangible biological material between two or more parties.

Occupational divers or worker divers: Divers who earn wages for their work.

Occupational Safety and Health (K3): Areas related to the health, safety, and welfare of human beings working on an activity or institution.

Oceanography, oceanology, or marine science: A branch of earth science that studies oceans or oceans.

Oxygen kit: A set of oxygen units prepared for a response to emergencies in divers.

QGIS: A cross-platform, free, open-source desktop geographic information system application that provides data display, editing, and analysis

Quick release mechanism: A system mechanism to open or close a locking system quickly and without tools because it has a clasp mechanism to lock a component.

Repetitive dive: A dive carried out before the release of nitrogen gas is completed.

Rescue tube or rescue buoy or torpedo buoy: One of the equipments used in the rescue in water. This flotation device can help support the weight of victims and rescuers to facilitate the rescue process.

Research Center for Oceanography (RCO): One of the research centers under the Earth and Maritime Research Organization is the National Research and Innovation Agency.

Residual nitrogen time (RNT): A mathematical calculation of the amount of nitrogen absorbed by body tissues after a dive expressed in minutes in the dive table.

Risk assessment: Identifying potential hazards and analyzing what can happen if possible hazards occur.

Safety diver/standby diver: A helping diver who has done scientific dives at least 30 times is in charge of supervising and assisting divers in marine biological scientific diving activities.

Safety line: One of the diving equipment used by SCUBA divers to return to a safe starting point in conditions of low visibility, water currents, or difficult guiding situations.

Safety stop: A standard dive procedure performed for each dive under 10 meters (32 feet) for 3 to 5 minutes at a depth of 5—6 meters (15—20 feet) that allows the diver's body to decompress after the time spent at depth.

SAR (search and rescue): Efforts to search, rescue, and rescue of emergencies experienced, both human and other valuable property.

Scientific divers: Divers have attended training and competency certification in marine biological scientific diving.

Scientific diving: Diving activities by scientific divers use specific methods and tools based on research objectives.

SCUBA (self-contained underwater breathing apparatus): A breathing apparatus carried directly by a diver.

Second stage/primary second stage: Part of the regulator used by divers to breathe air through the mouth.

Sediment core: A technique used in underground or subsea exploration and search, containing pieces of the subsurface layer of the seabed in the shape of a rough cylinder taken with a special drill and brought to the surface for inspection.

Sediment grab: A device for sampling sludge or small biota of sediments, seas, lakes, rivers, wells, and others.

Ship grounding or ship stranding: A ship landing event or stranded ship occurs when an ocean liner runs aground or contacts the bottom of a body of water.

SKKNI Scientific Diving of Marine Biology: Formulation of workability that includes aspects of knowledge, skills, or expertise as well as work attitudes that are relevant to the implementation of duties and requirements for the position of a marine biology scientific diver.

Stationary: Fixed; unchanged; steady (about quantity, value, size, position, etc).

Submersible pressure gauge (SPG): One part of the diving equipment used by divers to measure and show the amount of air pressure remaining in the air tank.

Surface interval (SI): The length of the rest period taken before making the next dive on the same day.

Throwing bag: Standard rescue equipment uses a rope that is loosely crammed into the bag so that it can be removed through the top easily when the bag is thrown at a diver who is experiencing an emergency.

Transect: A narrow line or path for distribution research, the presence of creatures along an area or experiment, and other observations.

Underwater engineering work: Work related to the installation, construction, or vessels performed underwater and underwater work of a unique nature, i.e., the use of underwater equipment operated from the surface of the water.

Underwater journalism: Activities to collect news, find facts, and report events from underwater.

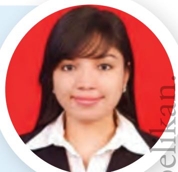
Underwater photo transect (UPT): One of the methods of observing coral reef health. This method utilizes digital camera technology as well as computer software.

Visibility: Visibility in water.

INDEX

AUTHOR'S BIOGRAPHY

Rikoh Manogar Siringoringo, S.T., M.Si. He is a researcher in the field of coral reef ecology at the Research Center for Oceanography, National Research and Innovation Agency. He completed his master's degree at the Bogor Agricultural Institute in 2009 and joined the Marine Ecosystem Health Research Group until now. In 2014, he became a Two Star-CMAS diving instructor. Then, in 2016, he attended ESD (European Scientific Diving) training and certification in Germany and Sweden. The author has been involved in COREMAP-CTI activities since 2005 and has been the Reef Health Monitoring activities coordinator in the ADB (Western Indonesia) region from 2015 to 2017. From 2005 to 2021, the author was active in coral reef monitoring research activities in the COREMAP-CTI area. In 2020, the author coordinated the ICRG (Indonesian Coral Reef Garden) location determination survey activities in Nusa Dua Bali. The author can be reached by email: riko001@brin.go.id



Ni Wayan Purnama Sari, S.Si, M.Si. She is one of the coral reef ecology researchers at the Research Center for Oceanography, National Research and Innovation Agency. She completed his bachelor's and master's education at Airlangga University Surabaya in 2004 and 2012. She started diving activities in 2009 and reached the rescue diver level in 2016. The author also participated in the Scientific Diving Training Program held by LIPI and ZMT Bremen in Bali in the same year. The author has been involved in COREMAP-CTI activities since 2014 and has coordinated Reef Health Monitoring activities several times from 2016 to 2021. The author is also one of the trainers and competency assessors for the Competency Certification of Coral Reef and Related Ecosystem Condition Assessors at the BRIN Pusbangkam and BRIN Professional Certification Institution. In addition, the author is also active in CITES activities for the field of ornamental corals and also acts as an auditor for ornamental coral breeding in Indonesia. The author can be reached by email: niwa006@brin.go.id or nwp.sariayu@gmail.com

Dr. Giyanto, S.Si., M.Sc. He is one of the researchers at the Research Center for Oceanography, National Research and Innovation Agency. He completed his doctoral program at the Marine Technology Study Program, Bogor Agricultural University (IPB), in 2010. His involvement in coral reef research activities made him do much diving in many Indonesian waters, ranging from Aceh to Papua. The author began actively participating in the health monitoring activities of COREMAP coral reefs after completing his master's program education at Vrije Universiteit Brussels in late 2000. The author can be reached by email: giya002@brin.go.id

Muhammad Abrar, S.Si, M.Si. He is a researcher at the Research Center for Oceanography, National Research and Innovation Agency. He completed his master's program at the Marine Science Study Program, Bogor Agricultural University, in 2011. Currently, he is a doctoral candidate in the Marine Science Study Program of IPB University. He has been a member of the RCO-BRIN Coral Reef Ecosystem Health Research Group until now. The author has scientific diving expertise at the Four Star (A4-Dive Master) POSSI-CMAS diving level. The author coordinates several underwater research activities, including the monitoring program for the condition of Indonesia's coral reefs, COREMAP-CTI (period 1997-2021), and coral reef bioecology research (period 2000 to present). In addition, the author is also the Head of the SKKNI Drafting Team for the Assessment of Coral Reef Conditions and the Secretary of the SKKNI Scientific Diving Drafting Team in the Field of Marine Biology. In the field of authorship, he has written books and training modules on scientific diving in marine biology. The author can be reached by email: abrarcoral@gmail.com and muha058@brin.go.id

Kunto Wibowo, S.Si., M.Fish.Sc., Ph.D. He is a researcher in the field of iktiology at the Center for Biosystematics and Evolution Research, BRIN. He completed his doctoral program at The United Graduate School of Agricultural Sciences, Kagoshima University, Japan. He gained knowledge and expertise in the field of diving from his participation in the Scientific Diving Training Program in 2014 held by LIPI and ZMT Bremen, Germany, in Bali. In addition, the author is also a certificate holder of A3-Three Star Scuba Diver CMAS. The author actively conducts dives to uncover fish diversity and find out the status of coral fish conditions in assessing coral reef ecosystem health in Indonesia. The author can be reached by email: kunt003@brin.go.id

Dr. Eng. Puji Rahmadi. He is a researcher in ecological engineering and ecosystem valuation at the Research Center for Oceanography, National Research and Innovation Agency. He completed his undergraduate education in 2005 at the Marine Science Study Program, Faculty of Fisheries and Marine Sciences, Diponegoro University. Later, he obtained a master's degree in 2010 and a doctorate in 2013 at PKNU, South Korea. The author has had a career in marine and fisheries for over ten years. Prior to joining LIPI in 2018, the author had a career in educational institutions and private companies, including as a lecturer in the Ocean Engineering Education Study Program, Indonesia University of Education (UPI); teaching staff at the Fisheries Study Program, Djuanda University; R&D Manager at PT Charoen Phokpan; and MSC Technical Reviewer at PT PCU Indonesia. Currently, the author serves as Chair of the Coastal Ecological Systems Research Group at the Research Center for Oceanography, National Research and Innovation Agency. The author can be reached by email: puji011@brin.go.id

Oksto Ridho Sianturi, S. Kel. He is one of the researchers at the Research Center for Oceanography, National Research and Innovation Agency, in the field of marine plankton. He underwent his undergraduate education at the Faculty of Fisheries and Marine Sciences, Diponegoro University, in the Oceanography Study Program in 2013. The author began to pursue diving activities when he joined the diving club UKSA-387 UNDIP. The author is involved in several expeditionary and research diving activities and attending scientific diving training at PMBC, Phuket, Thailand. The author has been a researcher at LIPI since 2015 and studying marine biology at the University of Bremen. The author can be reached by email: okst001@brin.go.id

Irfan Kampono, S.T., M.M.Tr. He is an engineer at the Research Center for Oceanography, National Research and Innovation Agency. Undergraduate education is obtained from the Mechanical Engineering Study Program, Darussalam University, Ambon. Then, the master's program was obtained from the Marine Transportation Management Study Program at the Trisakti Institute of Transportation and Logistics (ITL) in 2017. The author has been involved in phase III of the Coral Reef Rehabilitation and Management Program (COREMAP-CTI) project activities. From 2018-2022, the author was responsible as the Head of the COREMAP-CTI Environmental Social and Safeguard Team. The author is directly involved in monitoring the activities of Safeguarding The Health of Coral Reefs and Related Ecosystems, as well as the rehabilitation of coral parks, mangroves, and seagrass beds. The author can be contacted by email: irfa005@brin.go.id

Dr. Ir. Munasik, M.Sc. He completed his undergraduate education at the Marine Science Study Program, Diponegoro University, in 1992. He earned his Master of Science degree from the Graduate School of Science, University of the Ryukyus, Okinawa, Japan, in 1999. Then, in 2008, he completed a doctoral program at the Faculty of Biology, Gadjah Mada University, Yogyakarta. Since 1993, he has been a teaching staff at the Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Diponegoro University. He teaches Diving Expertise, Koralogy, and Marine Resources Conservation courses in undergraduate and postgraduate programs. He has taught at the Fisheries Study Program of Gadjah Mada University for fisheries resource conservation courses since 2009. The author actively participated in Reef Check Indonesia (1997—2019) and has been a member of the Indonesian Coral Reef Study Group since 1995. The author is involved in Reef Health Monitoring activities in South Lampung, Sikka (NTT), and Karimunjawa, Central Java (COREMAP-CTI, 2016—2021). The author is also a competency assessor at RCO-BRIN Professional Certification Institution. Currently, the author is listed as Deputy of Scientific Diving at the Association of Diving School International (ADSI) Indonesia and is the coach of the Marine Diving Club (MDC), Diponegoro University. The author can be reached by email: munasik@lecturer.undip.ac.id

Dr. Beginer Subhan. He has been a lecturer at the Department of Marine Science and Technology, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, since 2005. This coral reef researcher from IPB University completed his doctoral program at the Marine Science Study Program, IPB University. He has been the founder and Head of the Scientific Diving Laboratory at IPB until now. In addition to being a teacher, the author also has several additional competencies, including a diving instructor, and a competency assessor for the Coral Reef and Related Ecosystem Condition Assessor Competency Certification (RCO-BRIN Professional Certification Institution) and a Coral Finder Trainer instructor. The research activities include marine ecology, coral reef restoration, marine genetics (barcoding, population genetics, and eDNA), and bioprospection of marine organisms. The author has two patents related to the coral reef restoration method. The author can be reached by email: beginersubhan@apps.ipb.ac.id

Muhammad Hafizt, S.Si., M.Sc. He is one of the researchers at the Research Center for Oceanography, National Research and Innovation Agency. Undergraduate and master's education was obtained from the Faculty of Geography, Gadjah Mada University, in the Cartography and Remote Sensing Study Program in 2013 and 2015. Subsequently, he joined LIPI in 2015 and currently serves as Head of the Spatial Ecology Research Group at the Research Center for Oceanography, National Research and Innovation Agency. The author can be reached by email: muha138@brin.go.id

Raden Sutiadi, S.Kom. He is an engineer at the Research Center for Oceanography, National Research and Innovation Agency, with expertise in the IT field. He joined the Coral Reef Rehabilitation and Management Program (COREMAP) project from phase I in 2004 to COREMAP phase III (COREMAP-CTI) in 2022. The author often involves coastal ecosystem monitoring activities in several COREMAP locations. In addition, the authors also developed several platforms for information systems and coral reef databases. In 2006, the author became one of the management of the Loligo Diving Club at P2O-LIPI and participated in teaching diving certification activities for CPNS at the Research Center for Oceanography, National Research and Innovation Agency. From 2021—2022, the author was involved in safeguard activities. He is tasked with monitoring the team conducting coral reef ecosystem monitoring activities. He is also one of the oceanographic teams for the initial survey of determining the location of coral reef planting in the International Coral Reef Garden activity in Bali. The author can be reached by email: rade016@brin.go.id

GUIDEBOOK

Scientific Diving of Marine Biology

and Underwater Occupational Safety Health

Scientific diving has been going on for decades in Indonesia. One of the scientific diving activities is monitoring coral reef ecosystems, better known as the coral reef condition assessment methodology. However, the vastness of Indonesia's waters is challenging to monitor coral reefs together. Therefore, one coral reef monitoring strategy is creating nodes or regional representation in various regions in Indonesia. Furthermore, strengthening the capacity of human resources through various basic training activities and advanced training. After obtaining a license, this training begins with diving training, followed by coral reef monitoring materials. The fields taught are coral reefs, coral fish, and another benthic biota

BRIN
BADAN RISET DAN INOVASI NASIONAL

Published by:
BRIN Publishing, member of Ikapi
Directorate of Repositories, Multimedia, and Scientific Publishing
Gedung B.J. Habibie, Jln. M.H. Thamrin No. 8,
Kb. Sirih, Kec. Menteng, Kota Jakarta Pusat,
Daerah Khusus Ibukota Jakarta 10340
E-mail: penerbit@brin.go.id
Website: penerbit.brin.go.id

DOI: 10.55981/brin.720

ISBN: 978-623-8052-46-2

9 786238 052462