

Tools for Assessment and Planning of Aquaculture Sustainability



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Inventory of available in-situ data sets

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SUMMARY

Key objective is to ensure best use of available long-term in-situ datasets that have been collected for regulatory monitoring or other purposes at aquaculture production sites across Europe. This report represents deliverable D7.1 and includes an inventory of existing and available datasets for aquaculture production sites which can be used for model validation in WP3, WP4 and WP5 as well as validation of Earth Observation methods in WP6 and in Task7.6. Relevant sources include data collected for regulatory monitoring of aquaculture operations, research activities including completed and ongoing EU projects, and (inter)national monitoring networks. These datasets will be evaluated for their spatial, temporal and thematic coverage as well as accessibility and usage conditions.

The information compiled in this deliverable will support partners to identify the gaps in datasets required to improve existing models and validate new ones. TAPAS partners were asked to select available datasets known to them which are required for the project and to define the method how these data are applicable for the TAPAS project objectives. If gaps in the required datasets are identified, the work in tasks 7.2, 7.3 and 7.4 will be tailored to fill these gaps.

The inventory is set up in 2 steps:

1. Survey of the available datasets known by TAPAS partners; in this document.
2. Description and evaluation of data-sets, and gap-analysis during the project period.

In the first step the 15 TAPAS partners reported information about available datasets, representing all project partner countries and abroad. NACEE as a TAPAS partner carried out a survey amongst its members and received relevant data from 4 East – European countries. The survey identified 39 available aquaculture or related data resources owned by the partners and 41 national and international collections of potentially available data.

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1 INTRODUCTION

The aim of the survey and the deliverable is to have an overview of all available datasets already measured or continuously monitored and related to the environmental impacts of aquaculture farms. From this a gap analysis was completed, to inform case studies of potential data gaps and identify where further data collection is required to improve existing or develop new environmental and management models. It is important that datasets collected by the inventory are relevant to the purposes and aims of the TAPAS project; therefore the Scope, Data Usage and its Accessibility were considered.

2 SCOPE, USAGE AND ACCESSIBILITY OF EXISTING DATASETS

In collating the inventory of existing available datasets the following was considered:

- Which available datasets are required for the TAPAS project to develop the models, tools and decision support systems?
- Where are the information gaps in the available data which can be filled by the case studies?

The TAPAS project requires a variety of data types:

1. Environmental impacts of aquaculture activities (water quality parameters, sediment characteristics, impact on the ecosystem etc.).
2. Data on the environmental parameters having an effect on the aquaculture production (wave and current data, meteorological data, environmental quality etc.)
3. Socio-economic data on aquaculture goods and services
4. Regulatory and licensing information

The aim of this deliverable to summarise the available existing data of 1 and 2 while 3 and 4 type data will be collected mainly in WP2

Data was collected by each partner within their own locality/region by completing a pre-defined table (See Appendix 1). The main sources and characteristics targeted were:

1. **Project Partner Datasets:** Data collected and owned by the project partners, which are available for general use by all TAPAS partners
2. **National datasets:** These aquaculture data are collected through national research and monitoring programs focusing on data which are important locally. In most countries there are monitoring programs for the aquaculture sites. These can be public domain data as published by many regulatory organisations or owned by the aquaculture industry. The latter can be sensitive to external use. The inventory allowed assessment of the availability of this information.
3. **International datasets:** These are available from international and EU projects and initiatives which collect data from various and often larger geographical areas, e.g.:
 - a. European and international programmes for monitoring the earth collecting data from various geographical areas like COPERNICUS, SEADATANET
 - b. Data generated with models or data from remote sensing
 - c. Past and present EU research projects with open access to the research data.

3 METHODS OF THE SURVEY AND USE OF THE RESULTS

Two separate questionnaires were created to collect information about datasets owned (and created) by the partners which are immediately available to the project and where the quality of the data can be confirmed or adjusted by the partners (Annex I.).

Partners were also asked to provide information about the available national and international datasets in another questionnaire, specifically focusing on some coded fields, making the database searchable according some parameters. This database was designed to be extendable if in the later stage of the project other countries should be involved in the survey (because of the discovered gaps in the data). The most important coded fields are:

- Country codes
- Monitored type of aquaculture or ecosystem (Marine, Freshwater or Both)
- Availability of datasets (ranked according to the instructions in the Annex I and II)
- Quality of the datasets (ranked according to the instructions in the Annex I and II)

In the other database fields the goal was to collect as much information as possible to support the database users identifying the most appropriate database for their work.

Further information provided by partners that could not be included in the inventory is provided in this document. The final deliverable consists of this report and the excel database including both type of datasets.

The summary report of the datasets owned by the partners is in Table 1, while the countries covered in the national and international dataset inventory are listed in Table 2.

Country	Number of available datasets
DK	4
EL	1
HU	6
IE	1
MD	1
MT	1
NO	3
UK	4
BY	1
International	17
Total	39

Table 1. Number of datasets owned by TAPAS partners or NACEE members

Country/International	Number of potentially available datasets
DK	1
EL	1
ES	6
FR	1
HU	2
MT	2
NL	1
NO	7
SE	1
UK	13
BY	1
UA	1
RU	2
INT	2
Grand Total	41

Table 2. Number of datasets known by TAPAS partners or NACEE members potentially available for the project

4 ADDITIONAL INFORMATION ABOUT AVAILABLE DATASETS OWNED BY PARTNERS

4.1 Aquaculture Stewardship Council (ASC) reported data series

ASC is the owner of numerous datasets which are available for TAPAS research activities. These data were considered as international data, because the sites are in different countries.

As part of its commitment to transparency ASC requires a number of data to be reported regularly during the production cycles under certification. There are now at least 200 salmon farms under the process in all the salmon producing regions.

For the TAPAS project the ASC data about salmon farms are the most relevant. The ASC has a number of metric requirements that all farms must comply with to be certified. Much of this data on metrics must be reported. The metrics relate to indicators which give an assessment of the environmental footprint of the farm and the criteria which must be met for certification. Numbers of farms per country approximately:

- Norway 40+
- West Canada 15+
- Chile 15+
- Scotland 3+
- Ireland 3+
- Australia 2+
- NZ 2+
- Faeroes 2+

The data can include all salmon species cultured in sea water but mainly considers *Salmo salar*. The reported data is still unsorted and un-compiled., to put them into a workable format of clean data. These monitoring data which has to be collected according to prescribed protocols to international standards. Most of analyses are carried out by accredited laboratories.

All are required to submit data which therefore provides a comparative global data set.

The data lines collected are segregated into related groups:

- Chemical and faunal indicators of sediment
- Chemical indicators of water quality
- Sea lice and parasiticide treatment
- Fish health
- Fish feeding efficiencies

Production information must also be provided, e.g. duration of cycle, harvest value (mt). The protocols for environmental sampling are also required. In addition, there have been ad hoc data collections particularly in the areas of parasiticide treatments and N/P water monitoring.

4.2 NIVA reported data series

4.2.1 Algaedatabase PhytoMar

The NIVA algaedatabase contains cell counts from water samples collected in Norwegian coastal waters. All analyses are carried out on an inverted microscope according to a modified Utermöhl's method (NS-EN 15972:2011). Upon submission to the database the biovolume of each species is calculated according to HELCOM 2006 (Olenina et al. 2006). The biovolume is hereafter used to calculate cell carbon according to Menden-Deuer and Lessard (2000). The database contains different datasets and the samples have been collected during research projects, at fish farms and mussel farms, and during various monitoring programs. The different datasets have different sampling frequency. The largest number of samples was collected as part of the Norwegian Food Safety Authority (NFSA) monitoring program of algae toxins in mussels and dietetic advice to the public. The aim of the NFSA program is to sample on a weekly basis, to advise the public on the risk associated with consumption of wild mussels. NIVA have made a full analysis of these samples (outside the species the NFSA is interested in). Data can be given on request.

4.2.2 WQ-database (Water quality database)

The WQ database contains samples from most Norwegian smolt production units as well as a few from the UK. The database contain inlet water quality (sampled during normal and flooding), water quality after water treatment and tank outlet quality. The database also contains gill metal concentrations on smolts before sea transfer (Al and Fe). All data is linked to production data (survival, growth and performance after sea-transfer). The sampling frequency is three times a year per farm. Data can be given on request.

4.2.3 Aquamonitor

Aquamonitor is a datportal ran by NIVA. The AquaMonitor contains data from monitoring stations in rivers, lakes, fjords and coastal areas of Norway. The portal contains many datasets and several different parameters. It contains data from analysis of water samples, sediment samples and biota samples. Some of

the data is transferred into “Vannmiljø” (see later in national datasets), and can be found there as well. Some data can be downloaded and some can be given on request.

5 ADDITIONAL INFORMATION ON THE NATIONAL AND INTERNATIONAL DATASETS

5.1 Malta

The main source of existing datasets are the monitoring reports of the fish production sites. As an environmental monitoring programme each fish farm have to make a full assessment on the impact of their activity. These reports are made by independent authorities or companies, but the data are owned by the farmers. From the 9 sites reporting data in Malta only 2 sites are purely sea bream producers and both are considered as potential case study sites for the TAPAS project. ABT started the negotiations with the farmers to get access to all data of the past 5 years reports, but if the case study requires earlier reports these also might be available for the project.

Fish farms have to submit a report about their impact on the water quality every year which include the following parameters: temperature, salinity, dissolved oxygen, chlorophyll, nitrogen, phosphorus, total bacteria count, ammonia, turbidity. Currents

Another report is submitted bi-yearly about the fish farms’ effect on the benthic ecosystems and sediment quality, containing data on: granulometry, organic carbon, organic nitrogen, extent and location of communities, species diversity.

5.2 United Kingdom

All UK historic and present open data are available through <http://data.gov.uk> . This can be searched and subject to filtering to target source data. An example of this is when filtering for the “Lyme Bay study area” – a TAPAS case study site – there are > 4000 datasets returns which include invertebrate, benthic and water column biological and chemical sampling: See https://data.gov.uk/data/search?q=&theme-primary=Environment&broken_links=OK&ext_bbox=-3.41%2C50.21%2C-2.59%2C50.70

5.3 Hungary

In Hungary all entities that release certain pollutants to surface waters or are required to meet certain criteria (specified in Article 27 (2) of Government Regulation 220/2004. (VII. 21.), on the rules of protection of the quality of surface waters), must provide data annually. All fish ponds fall under this regulation and fish farmers carry out their yearly sampling. These data sets are summarised in the Record 21. The reported data are available on the website of the authority.

The monitoring of the hydrochemical quality (Record 22) of surface and ground-waters under WFD is carried out in different intervals in the investigative, operational and surveillance monitoring points that have been set up from 2006 according to Water Framework Directive (WFD). Under the investigative and operational programs, measurements are carried out at 617 locations. In the national and regional water quality network, the forerunner of the WFD investigative monitoring, surface water quality has been

measured at about 240 sampling sites according to the type of water-related programs with monthly, bi-weekly (sometimes monthly or weekly) regularity since 1990. This monitoring is not directly related to aquaculture but may provide some data on water quality changes downstream of fish farms.

5.4 Norway

5.4.1 Data from the Aquaculture registry

The Aquaculture registry contains every aquaculture licence. On every licence the registry contains data on owner's name, species, geographic position of the sites where the licence is operated, and the maximum allowed biomass. The data can be downloaded.

5.4.2 Data from the compulsory monitoring program of fish farms; the B-survey (previously MOM-B) and C-survey (previously MOM-C)

According to the Aquaculture Act (passed in 2005), all fish farms have a duty to monitor how emissions from the farms are affecting the area under and around the farms. The purpose of the compulsory monitoring program is to ensure that the environmental impact is sustainable at any time, both at the individual site and in the region. The monitoring program contains two different surveys, the B-survey and the C-survey.

The B-survey is conducted as a trend survey, monitoring the environmental conditions in the immediate vicinity of the site. B-surveys examine the degree of impact on the seabed, through a set of simple measurements in the sediment (pH/Eh), qualitative assessment of sediments, related to colour, smell, grain size, and presence/absence of macrofauna.

The C-survey is a more thorough and extensive type of survey. It analyzes the level of impact in three defines areas: close to the site, at intermediate distance from the site (x number of meters) and at remote distance from the site. The C-survey includes fauna analysis (carried out according to NS-EN ISO 16665), hydrographic profiles (according to NS-EN ISO 5814 and NS-ISO 5813:1983), particle distribution (carried out according to NS-EN ISO 16665), TOM, TOC, TN (all according to NS-EN ISO 16665 and NS-EN ISO 5667-19), sediment pH/Eh and Cu (NS-EN ISO 11885). Both B-and C-surveys are following the requirements laid down in the Norwegian Standard (NS 9410:2016), and can only be carried out by accredited institutions. Data can be released on request from Fisheries Directorate, or in some cases (not fully updated geographically) from downloaded from the Norwegian Environmental Agency data hub, Vannmiljø (see description below).

5.4.3 Data from the Institute of Marine Research' (IMR) fixed hydrographic stations

In the period between 1935 and 1947 IMR established 8 regular hydrographic stations from Lista to Nordkapp . The aim was to establish a long-term series of monitoring coastal and marine climate. All stations measure water temperature and salinity in the selected measurement depth. Standard measurement depth at the stations are: 0 m, 5, 10, 20, 30, 50, 75 , 100, 125, 150 , 200, 250 and 300 m. Data can be downloaded.

5.4.4 Data from observation buoys for environmental data

Institute of Marine Research (IMR) collects information about natural environmental variations as part of their investigations related to fjord ecology and environmental impacts of aquaculture (spread of sea lice and pathogens, escape of farmed fish etc). Therefore there have been three buoys operating in Hardangerfjorden; Western Norway (Fig 1), the most aquaculture intensive area in Norway. The buoys have collected data on salinity, air temperature, water temperature and currents. Together the buoys covers the time period 2008-2013. The data was transferred regularly as 10-minute average values. The data from the buoys were operational, and did not undergo any form of quality check before they were published. Data can be downloaded.

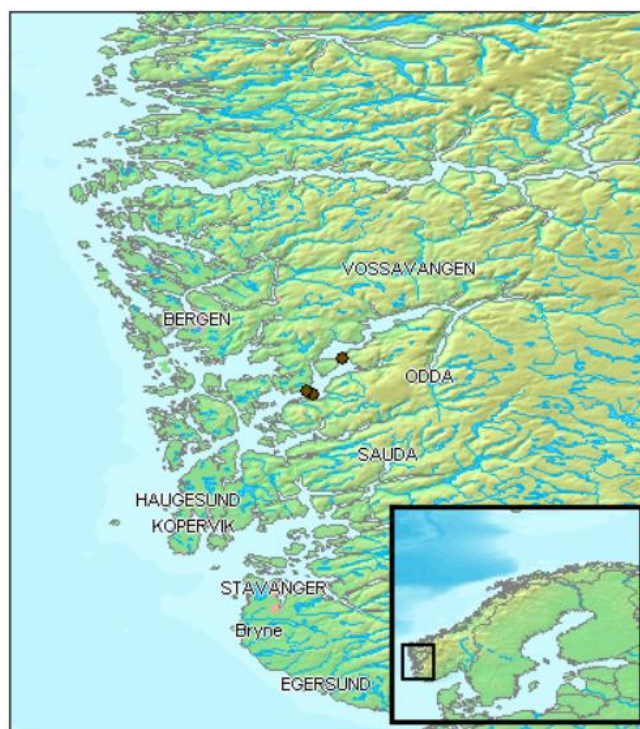


Fig 1. Map showing the observation boys in Hardagnerfjorden; western Norway.

5.4.5 Data from Norwegian Environment Agency data hub «Vannmiljø»

The Vannmiljø is the aquatic environmental authorities' specialized system for recording and analysis of the state of the water. It is a data hub with the purpose to provide an overall overview of ongoing and previous monitoring at national, regional and local level and ensure coordination with existing monitoring when planning new monitoring activity. Vannmiljø also plays a central role in planning and implementation of all monitoring activity imposed by the WFD. Vannmiljø contains all data subsequently submitted for OSPAR CEMP, HELCOM and RID monitoring programmes, and both sampling and analysis is carried out according to standards given in these respective programs. Data can be downloaded from <http://www.vannportalen.no/verktoy-og-kart1/vannmiljo/>

5.4.6 Data from IMR fjord cruises

IMR has collected data on nutrients-, oxygen- and chlorophyll a in Norwegian fjords from 1967 to date. The sampling frequency in this dataset is once or twice every year. The dataset contains pigments (chl a, phaeopigment), dissolved oxygen, nitrate, nitrite, phosphate and silicate. The samples are analysed using

accredited methods, but with the exception of oxygen data before 1981, which is of lower quality. Data can be released on request.

6 INTERNATIONAL DATASETS

6.1 International earth monitoring data

6.1.1 EMODNET (www.emodnet.eu)

The European Marine Observation and Data Network (EMODnet) is a network of organisations supported by the EU's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products. EMODnet is a long term marine data initiative developed through a step-wise approach. Currently, available data are being used to create medium-resolution maps of all Europe's seas and oceans, spanning all seven disciplinary themes – the initial stage was completed in 2014. The next phase of EMODnet involved the development of multi-resolution sea basin maps, which commenced in 2015.

EMODnet provides access to European marine data across seven discipline-based themes: Bathymetry, Geology, Seabed habitats, Chemistry, Biology, Physics, Human activities. User requirements are a priority in EMODnet, so a series of seabasin 'checkpoints' are started with the Mediterranean and North Sea in 2013. These mechanisms will identify whether the present observation infrastructure is the most effective possible, and whether it meets the needs of public or private users.

6.1.2 COPERNICUS (copernicus.eu)

Copernicus is a European system for monitoring the Earth. It consists of a complex set of systems which collect data from multiple sources: earth observation satellites and in situ sensors such as ground stations, airborne and sea-borne sensors. It processes these data and provides users with reliable and up-to-date information through a set of services related to environmental and security issues.

The Copernicus programme is coordinated and managed by the European Commission. The development of the observation infrastructure is performed under the aegis of the European Space Agency for the space component and of the European Environment Agency and the Member States for the in situ component. For the TAPAS project the most important is the Copernicus Marine Environment Monitoring Service (CMEMS). This provides regular and systematic reference information on the physical state, variability and dynamics of the ocean and marine ecosystems for the global ocean and the European regional seas. Many of the data delivered by the service (e.g. temperature, salinity, sea level, currents, wind etc.) can be useful for the project.

6.1.3 SeaDataNet project (www.seadatanet.org)

SeaDataNet is a standardized system for managing the large and diverse data sets collected by the oceanographic fleets and the automatic observation systems. The SeaDataNet infrastructure network and enhance the currently existing infrastructures, which are the national oceanographic data centres of 35 countries, active in data collection. The networking of these professional data centres, in a unique virtual data management system provide integrated data sets of standardized quality on-line..

6.1.4 AQUA-USERS project (www.aqua-users.eu)

The aim of AQUA-USERS is to turn earth observation data into services, providing user-relevant and timely information for the aquaculture industry.

The collection and integration of in-situ data into the database and application is an important part of this project. In close collaboration with the AQUA users, in-situ data is collected at the users' production sites. These data include optical WISP-3 measurements, Secchi depth, cell counts, concentrations of pigments, solids and coloured dissolved organic matter, data on phytoplankton composition, environmental physical conditions (temperature, oxygen levels et.) as well as the actual response of the aquaculture species (e.g. mortality, growth, yield, and fish behaviour). Also, data from various sources is integrated into the database, including Ferrybox systems, weather forecasts and met-ocean data (e.g. wave height). An important aspect is the development and application of methods for quality control of these data before they can be entered into the joint project database. The collected data is described in detail in Fargoso et al (2016).¹

6.2 Regional model output products from Earth Observation (EO) data

The products available are:

- Model output products North Atlantic and Nordic Seas, including Norwegian Sea (ROMS-ERSEM) (NIVA)
- Baltic Sea – North Sea including Danish waters and Kattegat (HD-AD-ECO Lab) (DHI)
- North East Atlantic (POLCOMS-ERSEM) (PML)
- Mediterranean Sea (POLCOMS-ERSEM) (PML)

In project will use four ecosystem models (or “far field models” in TAPAS terminology), which couple physical and biogeochemical modules, for simulations in the following regions:

1. North Atlantic and Nordic Seas, including Norwegian Sea (ROMS-ERSEM) (NIVA)
2. Baltic Sea – North Sea including Danish waters and Kattegat (HD-AD-ECO Lab) (DHI)
3. North East Atlantic (POLCOMS-ERSEM) (PML)
4. Mediterranean Sea (POLCOMS-ERSEM) (PML)

All the models will be applied in decadal simulations of recent years. HCMR will downscale model 4 through an intermediate model (POM-ERSEM) to provide boundary to local-scale models for Greece. University of Nantes will apply outputs of regional biogeochemical models to run models at regional coastal scale (to be confirmed as a function of the skill of the post-doc to be hired). Models 1, 3 and 4 will assimilate data from in situ observations (1) and ocean colour chlorophyll (3, 4). Models 1, 3, 4 will be used in future scenario simulations for years up to 2060 (1) and up to 2100 (3, 4).

¹ Fragoso, B., Icely, J., Poser, K., Ghebrehiwot, S., Dale, T., Huber, S. and Miller, T. (2016). " In situ datasets partners and users, dataset + description report", AQUA-USERS deliverable D5.3/D5.4, EC FP7 grant agreement no: 607325, 40p .

7 SUGGESTED METHODS FOR GAP ANALYSIS

Parallel with the preparation of the D7.1 summarising available existing datasets a collection of potential case study sites also was carried out in the TAPAS project. The final research focus of the case studies will be defined according to the requirement analysis of the stakeholders and opportunities of the case study sites. Having the final research plan and list of required data, partners will use the D7.1 to define what existing datasets could they use for the research and identify information gaps by filling up the Table 3.

Case study site	Required data (water quality, meteorological, toxins, hydrological, ...)	Data gaps (types)
Western Channel (PML)		
Central Mediterranean (ABT)		
Eastern Mediterranean - Aegean Sea (HCMR)		
Western Mediterranean (UM)		
Western Norway, Hardangerfjorden Region (NIVA)		
Carp ponds in Hungary (SZIU)		
Salmonid farms in 8 lake sites in Scotland (UOS)		
A shellfish ecosystem located south of the Loire estuary on the French Atlantic coast (UN)		
Clews Bay salmonid production site in Ireland (MI/UOS).		

Table 3. Suggested sheet to identify data gaps of development carrying capacity models for aquaculture

TAPAS survey of available datasets

Project partner:

Contact person and email:

Date of filling in:

Questionnaire 1. : Available datasets owned by the TAPAS partners (please provide information here only about datasets owned by your organisation)

Scope of the dataset	Type of the datasets	Related aquaculture technology, environment	Parameter	Units	Frequency	Size of the datasets	Weblink (if available)
<i>Please describe shortly the background of the data collection and the scope of it. E.g.: Monitoring of a fish farm within the framework of national project/EU research project.</i>	<i>Main focus of the measurements: water quality, benthic, general</i>	<ul style="list-style-type: none"> a. Marine cage b. Marine mussel or seaweed c. Marine hatchery or other land based d. Marine recirculation e. Freshwater pond f. Freshwater flow-through g. Freshwater recirculation <p><i>If it is more general just mark marine or freshwater.</i></p>	<i>E.g: * Monitoring TN, NH4, NO3 Parasiticide use Total feed</i>	<ul style="list-style-type: none"> <i>µg/ltr</i> <i>kg/kg fish</i> 	<i>Weekly, Monthly, yearly etc.</i>	<i>Number of sites monitored, number of sampling seasons, etc.</i>	

ANNEX 2

Questionnaire 2. : Available national datasets known by the partner

Scope of the dataset	Size of the datasets	Related aquaculture technology	Parameter	Units	Frequency	Availability of the datasets	Quality of the data	Weblink (if available)
<p>Please describe shortly the background of the data collection and the scope of it. E.g.: Compulsory monitoring program of fish farms because of the EU Water Framework Directive (WFD) or Marine Strategy Framework Directive (MSFD).</p>	<p>Number of sites monitored, number of sampling seasons, etc.</p>	<p>h. Marine cage i. Marine mussel or seaweed j. Marine hatchery or other land based k. Marine recirculation l. Freshwater pond m. Freshwater flow-through n. Freshwater recirculation</p> <p>If it is more general just mark marine or freshwater.</p>	<p>E.g: * Monitoring TN, NH4, NO3 Parasiticide use Total feed</p>	<p>µg/ltr kg/kg fish</p>	<p>Weekly, Monthly, yearly etc.</p>	<p>1. Easily available without any administrative burden 2. It takes time (1-3 months) and some administrative tasks to get the data from the owner 3. It is difficult to get the data but possible within 1 year. 4. TAPAS has to pay for the data to use them.</p>	<p>1. High quality data collected by using the latest scientific protocols. 2. Reliable data but the protocol of the data collection is outdated or not according to the scientific standards 3. Informative data but the protocol is unknown or very old etc.</p>	<p>4.</p>



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