

Major field of study

Marine Animal Taxonomics for Smart Fishery Resource Management

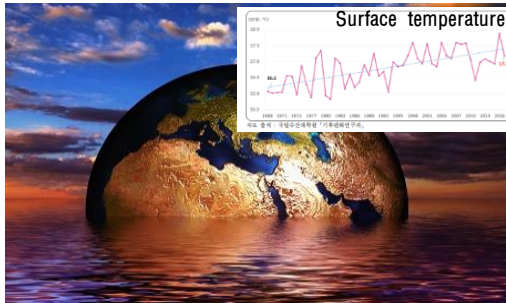
Prof. Jeong, Man-Ki

Background

Due to **overfishing** and **climate change**, fishery production **continues to decline**



Growth overfishing / High fishing intensity



Climate change

	1970년		2017년
전갱이류	21	11,200% ▲	2,373톤
명태	11,411	100% ▼	1톤
꽁치	22,281	96.7% ▼	725톤
도루묵	13,767	64.4% ▼	4,907톤
살오징어	67,922	52.2% ▼	32,500톤

(Kostat, 2018)

Paradigm shift in fisheries

Quantitative Growth of Fisheries



Management Considering Ecosystems

Prepare countermeasures
after specific issues

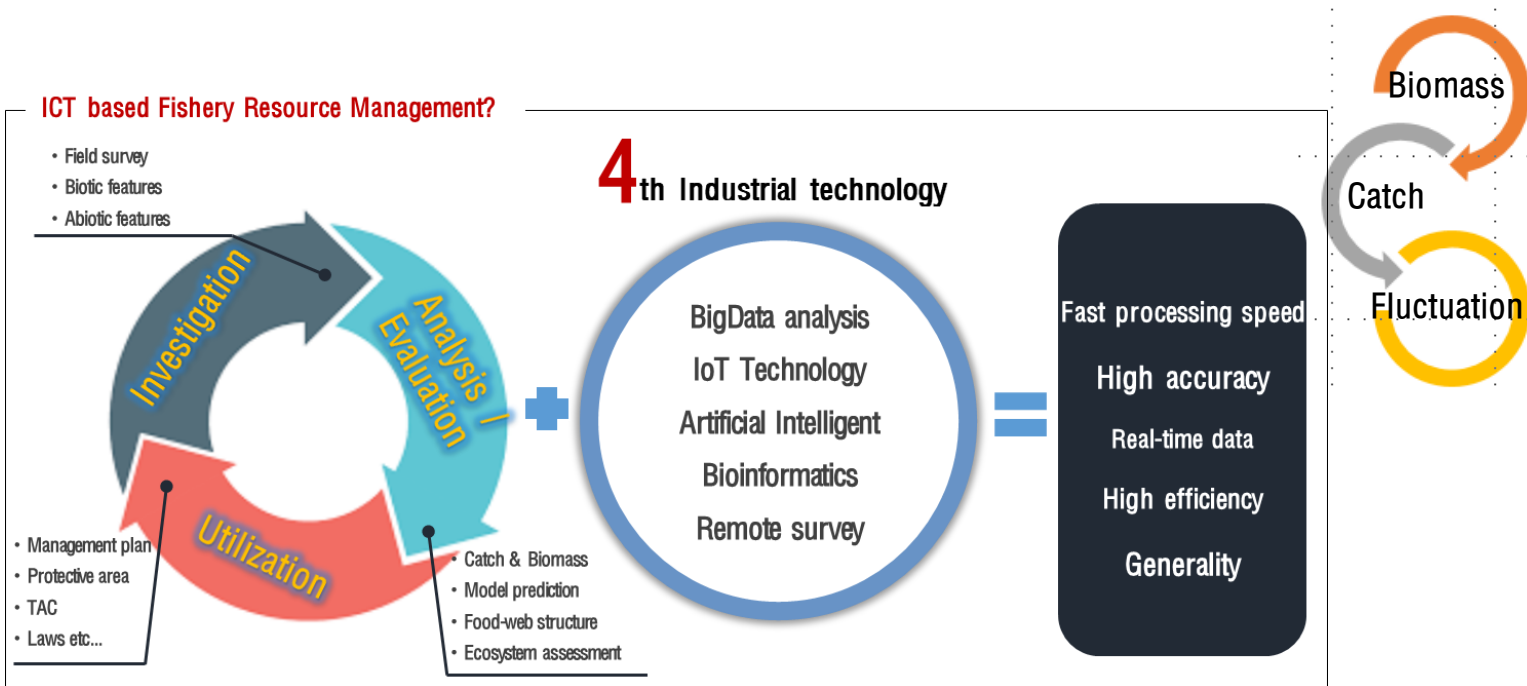


Prediction and prevention

Background

What we need to know for **Fishery Resource Management**

▷ **Biomass** in marine ecosystem + Fishery **catch** → predict fishery resource **fluctuations**



Background

Problems in traditional fishery resource management

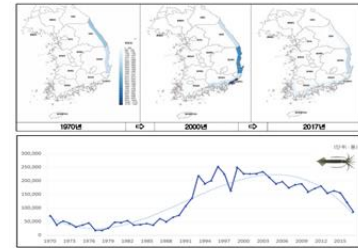
Biomass



Catch




Fluctuations & Prediction




(Kostat, 2018)

Problems for each part

- Time consuming 
- High cost
- Need specialists
- Local / temporary survey

+

- Inaccurate data 
- high labor force
- illegal fishing

- No standardized data 
- No Big Data
- Use only limited factors (temp. / Chl a / Catch etc..)

Previous problems : local scale, inaccurate and insufficient data

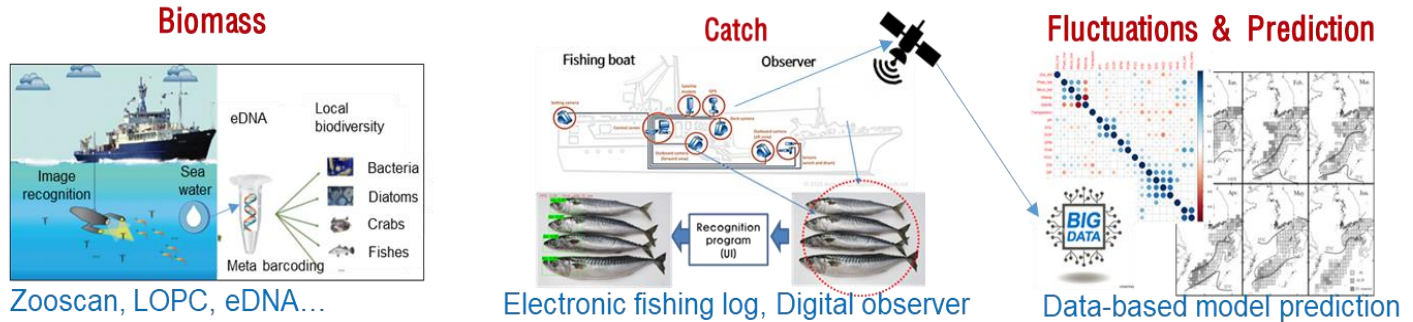
→ Large-scale, precise, and automated analysis

ICT is suitable for producing large and accurate data.

* ICT = Information and communication technology

Background

How does **smart technology** apply to the **fisheries**?



Step1

- Species specific Image data
- Species specific DNA data
- Species specific ecological data (Distribution, food, development...)
- **Comprehensive Data library**

Step2

- Solve labor problems
- Produce accurate catch data (location, species, amount...)
- **Real-time data transmission (5G)**

Step3

- Broad, accurate and large data
- Meaningful pattern analysis (relation between factors without bias)
- **Improvement in prediction accuracy**

Basic process is important to produce **large and accurate data**

The first step "**Biomass**" = directly related to "Marine animal **Taxonomics**"

Definition of Marine Animal Taxonomics

What is the **Marine Animal Taxonomics**?

: Next generation taxonomists for marine animals

Org Divers Evol
DOI 10.1007/s13127-016-0287-1
FORUM PAPER

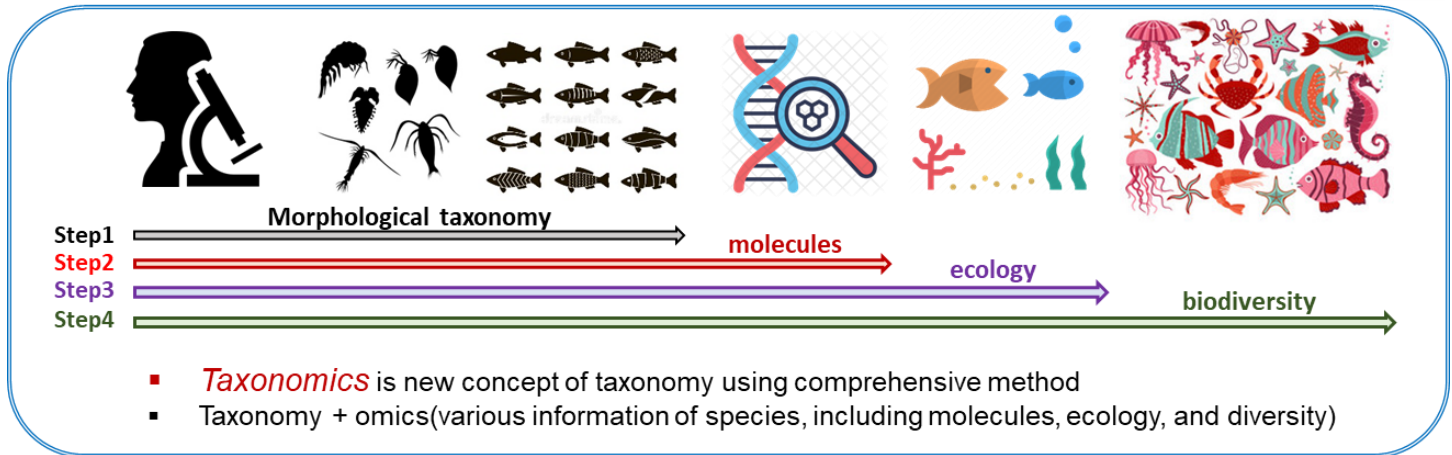


ORGANISMS
DIVERSITY &
EVOLUTION

Taxonomics—next-generation taxonomists

Ana Sofia P. S. Rebelo¹ · Henrik Enghoff¹

(Sofia et al. 2016)



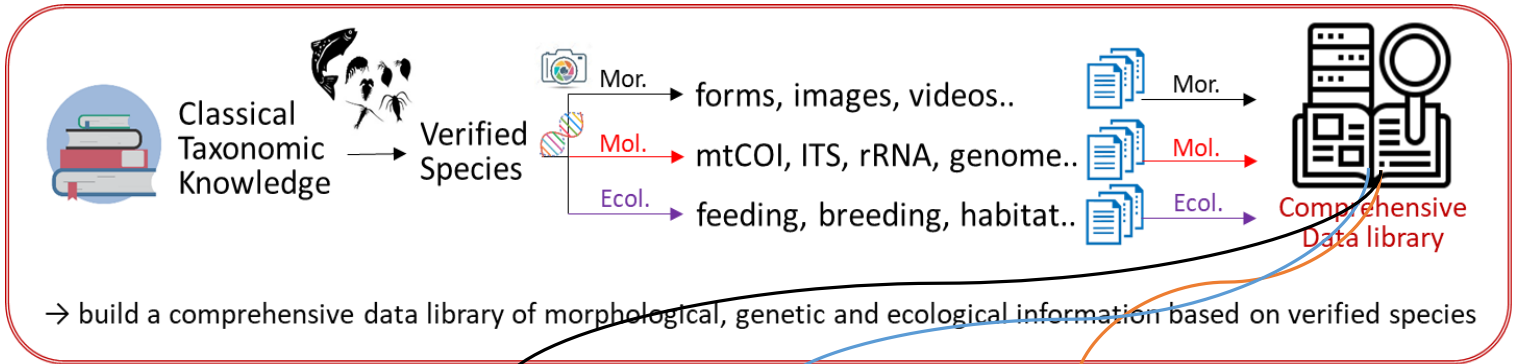
Past taxonomy = limited information for identification

Recently the diversity of biological data has become important

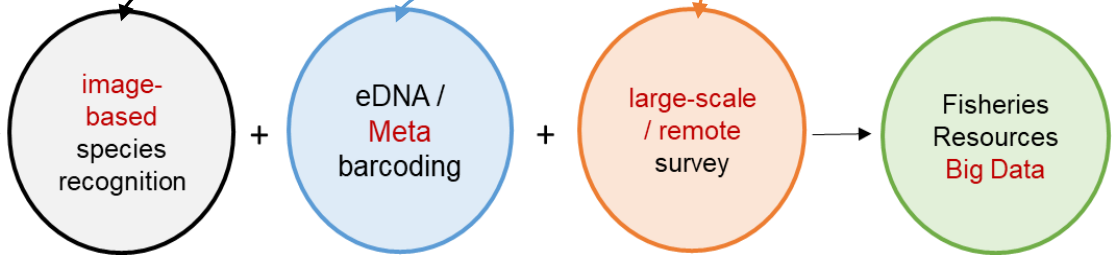
Taxonomics can play a key role in fishery management (= various & accurate data)

Features of Marine Animal Taxonomics

What can we do with Marine Animal Taxonomics?



If we apply it to fishery..



→ These **core technologies** enable **high capacity & efficiency**, and **fast speed analysis**

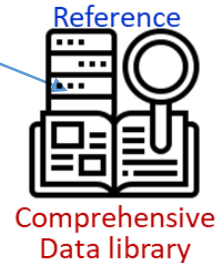
Marine Animal Taxonomics for Biomass Estimation

I. Morphological methods

II. Molecular methods

III. Ecological methods

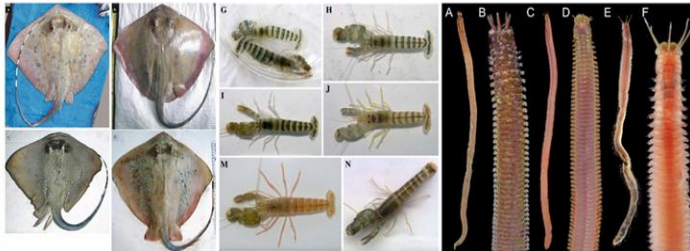
IV. Future study plan



Morphological methods

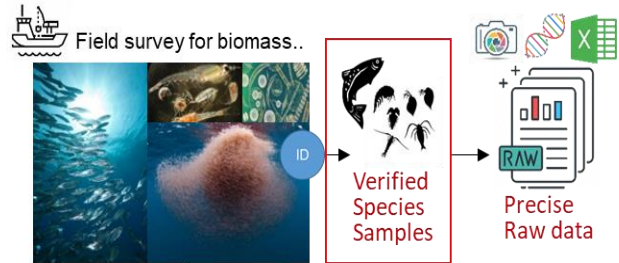
Importance of **morphological experts** and **verified species sample**

Who's who? – species complex



maskray species complex (Borsa 2018) shrimp species complex (Mathews 2009) *Marphysa* species complex (Abe 2019)

Similar species are difficult to distinguish at species level



Without morphology, precise raw data could not exist

For precise raw data, **we need morphologists** (copepods, shrimps, fishes...)

Morphological verification = very essential, but time consuming

Reference DBs (morphology → molecules → ecology)

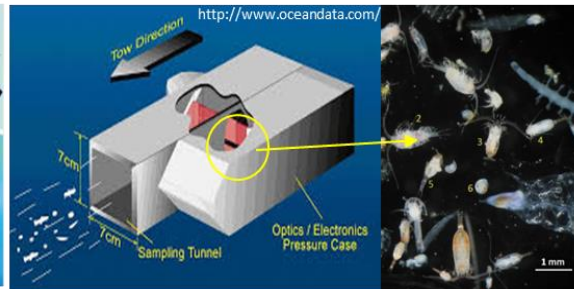
Morphological methods

Recent issue in morphological methods? Image based species recognition

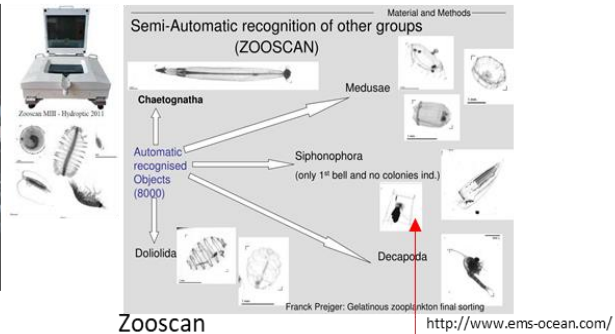
Large-scale image analysis (LOPC / Zooscan) : effective for biomass estimation



bada.ocean.pusan.ac.kr



Laser optical plankton counter(LOPC)



Zooscan

Accuracy of current **image recognition systems** = **order level** (80-95%)

+ optimized for European species (No Korean reference DB)

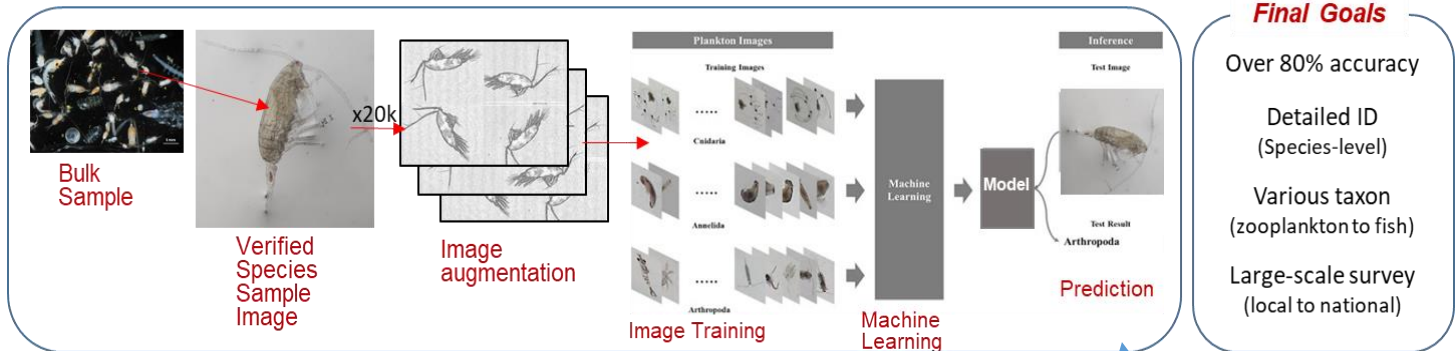
Species-level image DB → speed and accuracy will be improved



No reference data
for Korean species

Morphological methods

Ongoing work: **Deep learning based** Image recognition



Early stage research : **image** analysis on **major copepods** in Korea

System **recognizes a species** based on **machine learning** process (CNN)

Problems : low accuracy (20-40%) & time consuming (10-20 hours)

→ **Goals** : 80% ↑ accuracy, species-level identification etc...

→ **Extra results** : automated ID, **abundance**, **distribution**, **length**...

*CNN: Convolutional Neural Network

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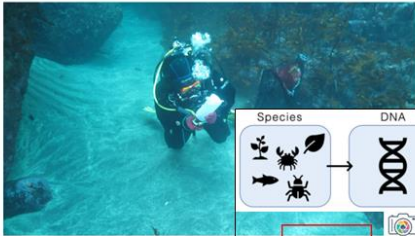
Comprehensive
Data library

Molecular methods

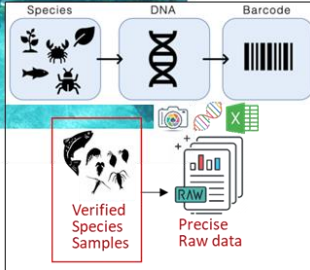
DNA barcoding, "global bio-identification system"

뉴스룸 | 최진재

독도에 어떤 물고기를 사나..환경DNA 분석결과 64종 확인



환경 DNA 분석 위해 배설물을 채수하는 장면
[국립수산물과학원 제공]



국립수산물과학원 | 수산생명자원
정보센터

관리번호	생물분류	학명	국명	유전자염	등록자	등록일자
NF-AA-FI-04125190	수산동물	<i>Oplegnathus fasciatus</i>	줄돔	1	김용균	2020-11-09
NF-AA-FI-04125053	수산동물	<i>Foetorepus atrovirens</i>	도리양태	1	김용균	2020-11-09
NF-AA-FI-04125184	수산동물	<i>Minous monodactylus</i>	말지말락살치	1	김용균	2020-11-09
NF-AA-FI-04125185	수산동물	<i>Minous monodactylus</i>	말지말락살치	1	김용균	2020-11-09
NF-AA-FI-04125186	수산동물	<i>Minous monodactylus</i>	말지말락살치	1	김용균	2020-11-09
NF-AA-FI-04125181	수산동물	<i>Lophus iluon</i>	돔아귀	1	김용균	2020-11-09
NF-AA-FI-04125182	수산동물	<i>Lophus iluon</i>	돔아귀	1	김용균	2020-11-09
NF-AA-FI-04125183	수산동물	<i>Lophus iluon</i>	돔아귀	1	김용균	2020-11-09
NF-AA-FI-04125117	수산동물	<i>Zalilagus nipobobles</i>	복섬	1	김용균	2020-11-09
NF-AA-FI-04125150	수산동물	<i>Johinus grypsus</i>	민태	1	김용균	2020-11-09
NF-AA-FI-04125051	수산동물	<i>Tarphop thersops</i>	네알면치리	1	김용균	2020-11-09
NF-AA-FI-04125124	수산동물	<i>Tarphops elegans</i>	좁납치	1	김용균	2020-11-09
NF-AA-FI-04125140	수산동물	<i>Tarphops elegans</i>	좁납치	1	김용균	2020-11-09
NF-AA-FI-04125060	수산동물	<i>Siemba imberbis</i>	송갈머기	1	김용균	2020-11-09
NF-AA-FI-04125063	수산동물	<i>Pleuronichthys cornutus</i>	도다리	1	김용균	2020-11-09
NF-AA-FI-04125055	수산동물	<i>Acropoma japonicum</i>	반디물결표지	1	김용균	2020-11-09
NF-AA-FI-04125285	수산동물	<i>Thunnus orientalis</i>	참다랑어	1	김용균	2020-11-09
NF-AA-FI-04125286	수산동물	<i>Thunnus orientalis</i>	참다랑어	1	김용균	2020-11-09
NF-AA-FI-04125287	수산동물	<i>Thunnus orientalis</i>	참다랑어	1	김용균	2020-11-09
NF-AA-FI-04125288	수산동물	<i>Thunnus orientalis</i>	참다랑어	1	김용균	2020-11-09

DNA barcoding : use of specific genes to identify species

Target : Mega fauna such as birds, mammals and fishes

Usage : Distribution and biodiversity research

[North Sea] Most crustaceans can be identified (97%)

Limited DNA barcodes for Korean species

Available barcodes : only 4K in 36K species (11%)

Major fishery resource Barcodes : only 200 in public DB

* Fundamental reason = lack of verified marine samples

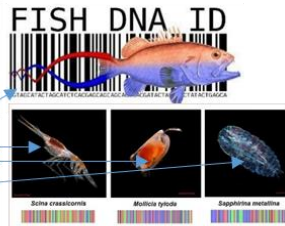
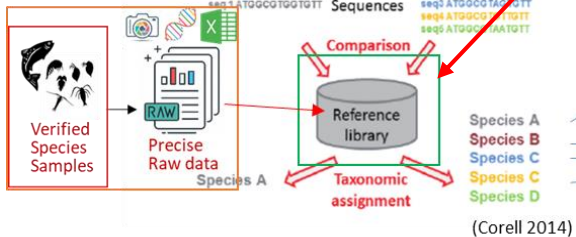
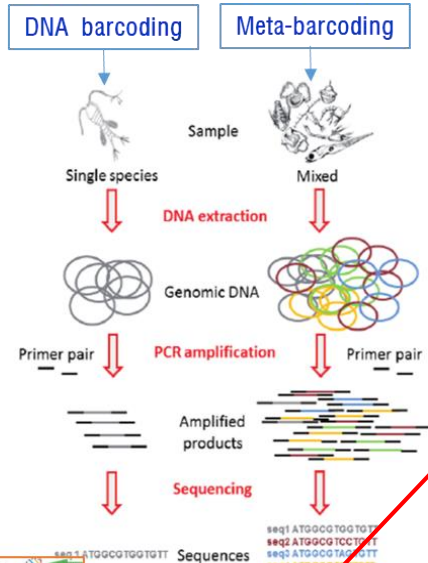
Molecular methods

eDNA / meta-barcoding, high speed and accuracy

eDNA / Meta-barcoding analyze distribution (in large area)
applied to soil, seawater & mixed samples

Difficulties in DNA barcoding

- Precise quantitative analysis (?)
 - **Errors in DNA database** → misidentification
- **Identification & sequencing** : performed at the same time
for securing **reliable database**



Molecular methods

Ongoing work: application to benthic ecosystem



Past

Capitellid polychaetes

3 species (1978-2017)

mtCOI, 16S, 18S, H3
DNA barcoding

12 species (2017-2020)

On-going

Field work

difficult and fragile

Sediment sample

DNA Barcoding

Benthos sample

DNA data base (104/350 Korean polychaetes)

Family	Genus	Species	Korean	18S rRNA	MtCO1
Phyllodoctidae	<i>Alucla</i>	<i>ornata</i>	죽부채말갯지렁이		
	<i>Eteone</i>	<i>longa</i>	작은부채말갯지렁이	partial sequence, 1814bp	partial cds; 666
	<i>Alucla</i>	<i>ornata</i>	죽부채말갯지렁이		
	<i>Aluclidon</i>	<i>japonicum</i>	달개부채말갯지렁이		
Eulalia	<i>viridis</i>	녹색불꽃부채말갯지렁이		partial sequence, 1763bp	partial cds; 666
	<i>bilineata</i>	두줄불꽃부채말갯지렁이		partial sequence, 1633bp	
Phyllodoce	<i>maculata</i>	네모부채말갯지렁이		partial sequence, 1736bp	partial cds; 666
	<i>chinensis</i>	중국부채말갯지렁이			
	<i>koreana</i>	한국부채말갯지렁이			
<i>Nereisphila</i>	<i>castanea</i>	남작수염부채말갯지렁이		Genetylis castanea	partial cds; 636
<i>Eumida</i>	<i>sanguinea</i>	심장부채말갯지렁이			partial cds; 656
Paralacydonidae	<i>Paralacydon</i>	<i>paradoxa</i>	은갯지렁이	partial sequence, 1705bp	
Glycendae	<i>Hemipodia</i>	<i>venouensis</i>	반다미갯지렁이	<i>Hemipodius venouensis</i>	
	<i>Glycera</i>	<i>capitata</i>	콩마미갯지렁이	partial sequence, 1700bp	partial cds; 611
	<i>onomichiensis</i>	오노미치미갯지렁이		partial sequence, 1610bp	partial cds; 611
	<i>alba</i>	흰머리아미갯지렁이		partial sequence, 1737bp	partial cds; 656
	<i>tridactyla</i>	간야미갯지렁이		partial sequence, 1786bp	partial cds; 556
	<i>dentibranchia</i>	다발야미갯지렁이			
	<i>subaenea</i>	정동야미갯지렁이			
	<i>unicornis</i>	어리미갯지렁이			
	<i>chironi</i>	차로미갯지렁이			
	<i>decipiens</i>	잠미갯지렁이			
Goniadidae	<i>Goniada</i>	<i>japonica</i>	큰갈매고리갯지렁이		
	<i>maculata</i>	작은갈매고리갯지렁이			

BLAST: Basic Local Alignment Search Tool

Nucleotide BLAST

BLASTn

Problem : Damaged or lost sample through the washing process

Advantage : applied to damaged samples or sediments

Goal : Building a **reference library** about verified benthic sample

Estimate distribution and diversity of benthic species



Marine Animal Taxonomics for Biomass Estimation

I. Morphological methods

II. Molecular methods

III. Ecological methods

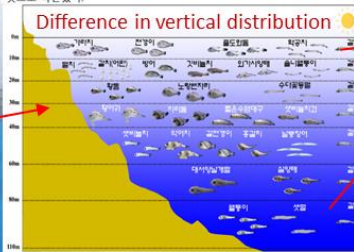
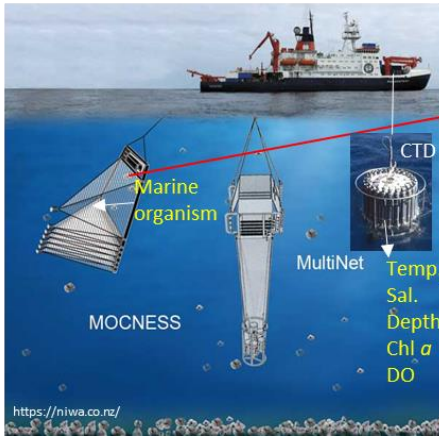
IV. Future study plan



Comprehensive
Data library

Ecological methods

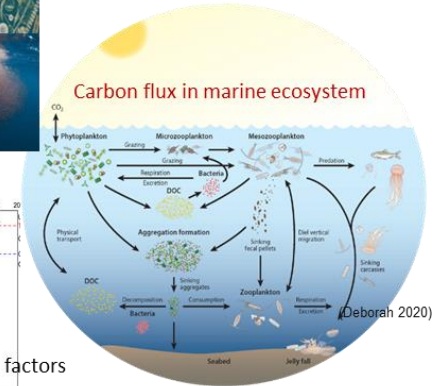
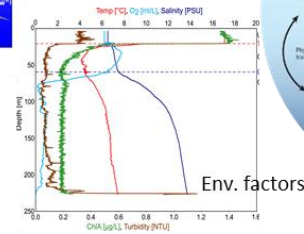
Biomass estimation based on individual carbon content



제주 주변 해역에 서식하는 주요 어종물고기의 분포 수심(계수부 수심과외한



Marine organism



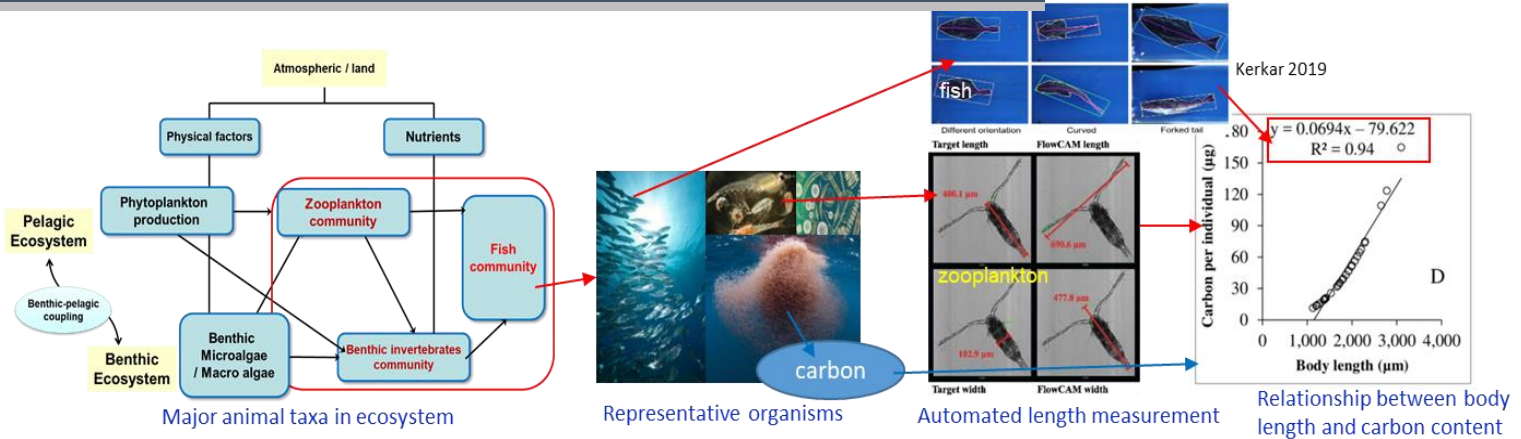
Mentioned **image & DNA methods** provide large data of **abundance** and **distribution**

Measurement of carbon content accurately estimates **biomass**

→ Abundance of a species X carbon content of a individual = carbon biomass of a species (fishes, shrimps, copepods..)

Ecological methods

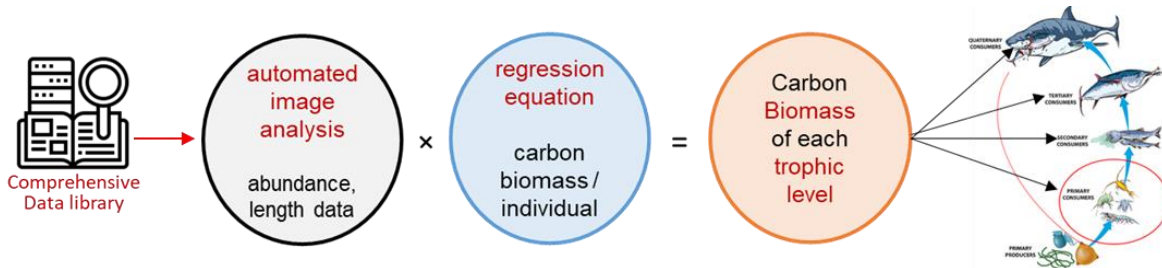
Carbon biomass of trophic levels in an ecosystem



Regression : estimated from individual length & individual carbon content

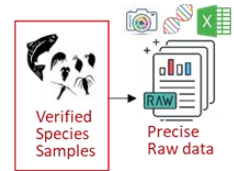
Goal : Securing regression equation for each major Korean taxon (by development, season...)

Automated image analysis → large data on abundance and length → determine carbon biomass

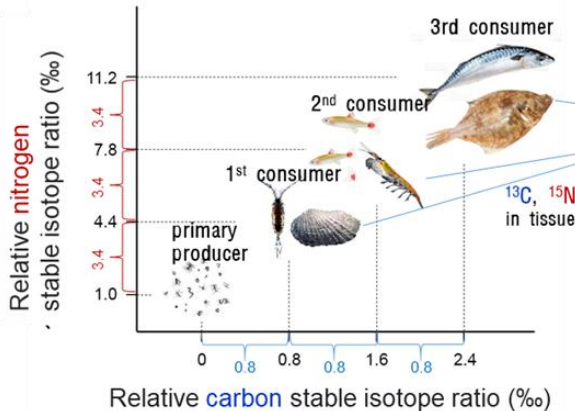


Ecological methods

Estimation of trophic relationship in an ecosystem



Stable isotope analysis



Biochemical reference database

Stable isotope ratio (^{13}C , ^{15}N) + Carbon contents

- Particle organic matter (POM) in sea water
- Phyto-pl. (nano/micro), benthic phyto-pl.
- 1st consumer (micro zoo-pl., bivalves..)
- 2nd consumer (macro zoo-pl., small fishes..)
- 3rd consumer (large fishes, top predator..)

Food web

Nitrogen and **Carbon** isotope : **tracer of the trophic relationship** in an ecosystem

→ In the upper trophic level, carbon (^{13}C) = 1‰, nitrogen (^{15}N) = 3-4‰ increased

Understand changes in food of major taxa (by season, development, and environment)

Biochemical DB for major taxa reveals feeding ecology of major fishes

→ Carbon contents : Biomass, C-N Stable isotope ratio : trophic relationship

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Marine Animal
Taxonomics



Comprehensive
Data library

