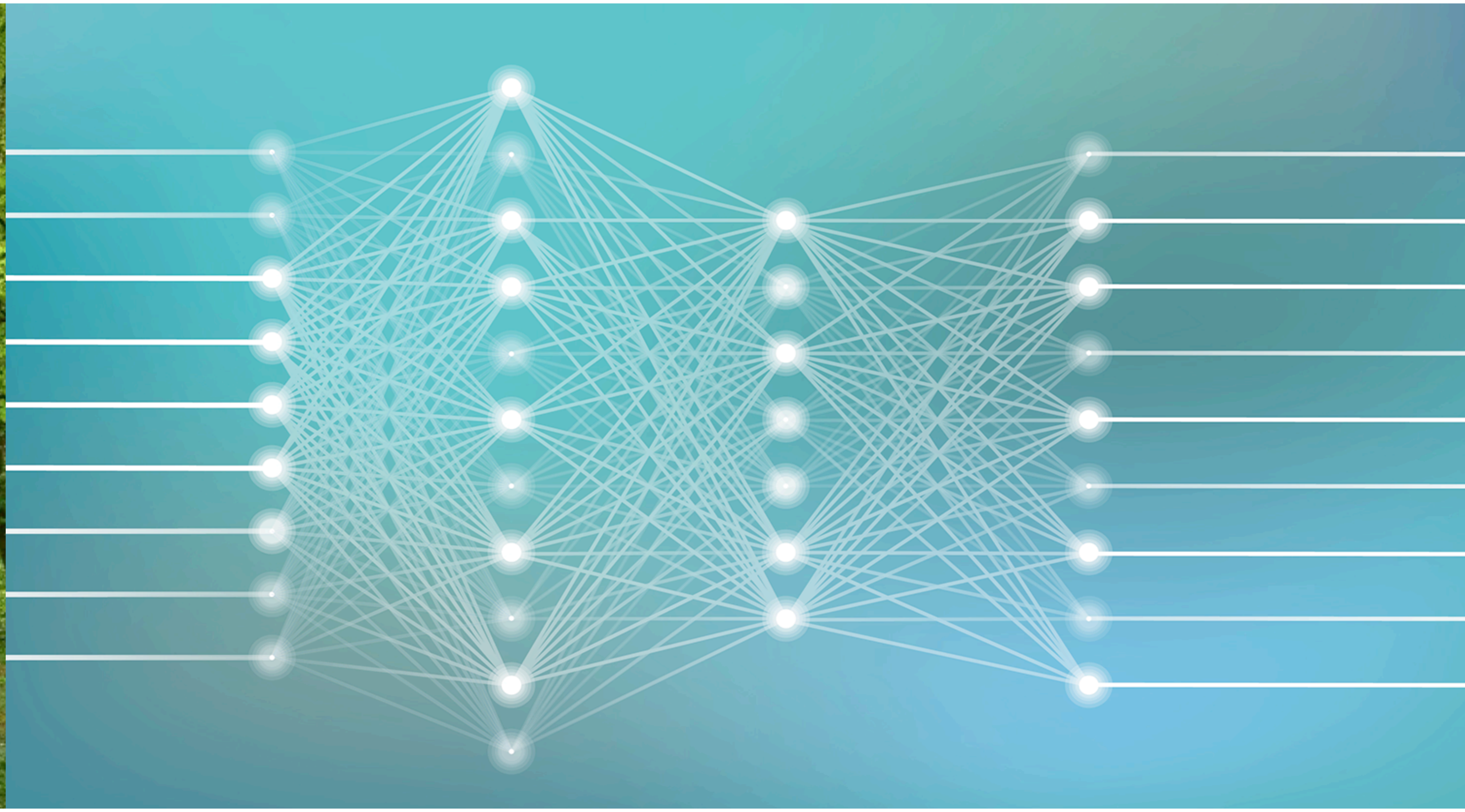
Benchmark of plankton image classification: CNN improve detection of rare taxa

T Panaïotis, G Boniface-Chang, G Dulac-Arnold, T Biard, B Blanc, L Caray--Counil, C Desnos, A Elineau, L Jalabert, R Kiko, F Lombard, M Picheral, JB Romagnan, L Stemmann, JO Irisson

ASLO 2021 Aquatic Sciences Meeting



LOV LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE

Thelma Panaïotis
06/28/2021

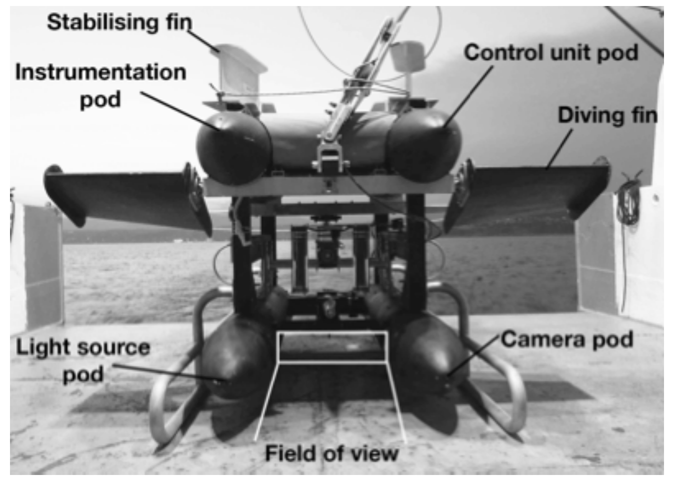
Context

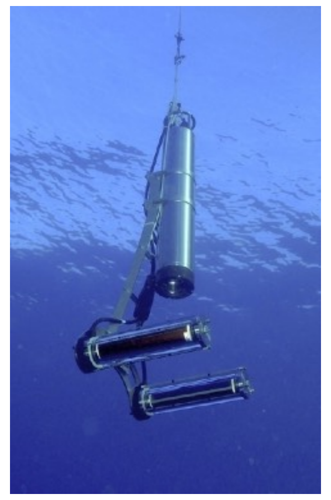
Plankton imaging

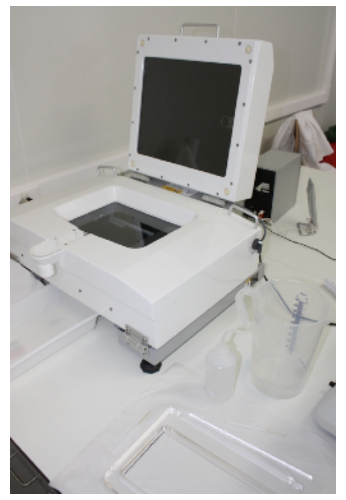
Context

Plankton imaging

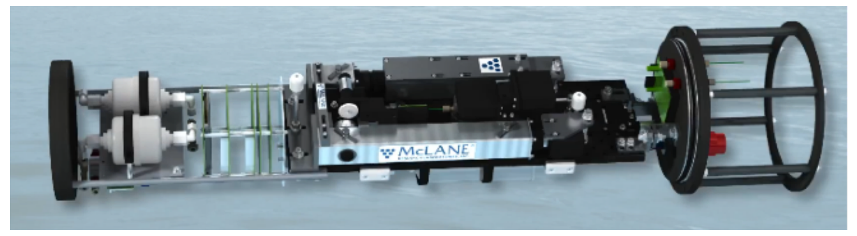
More instruments


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view





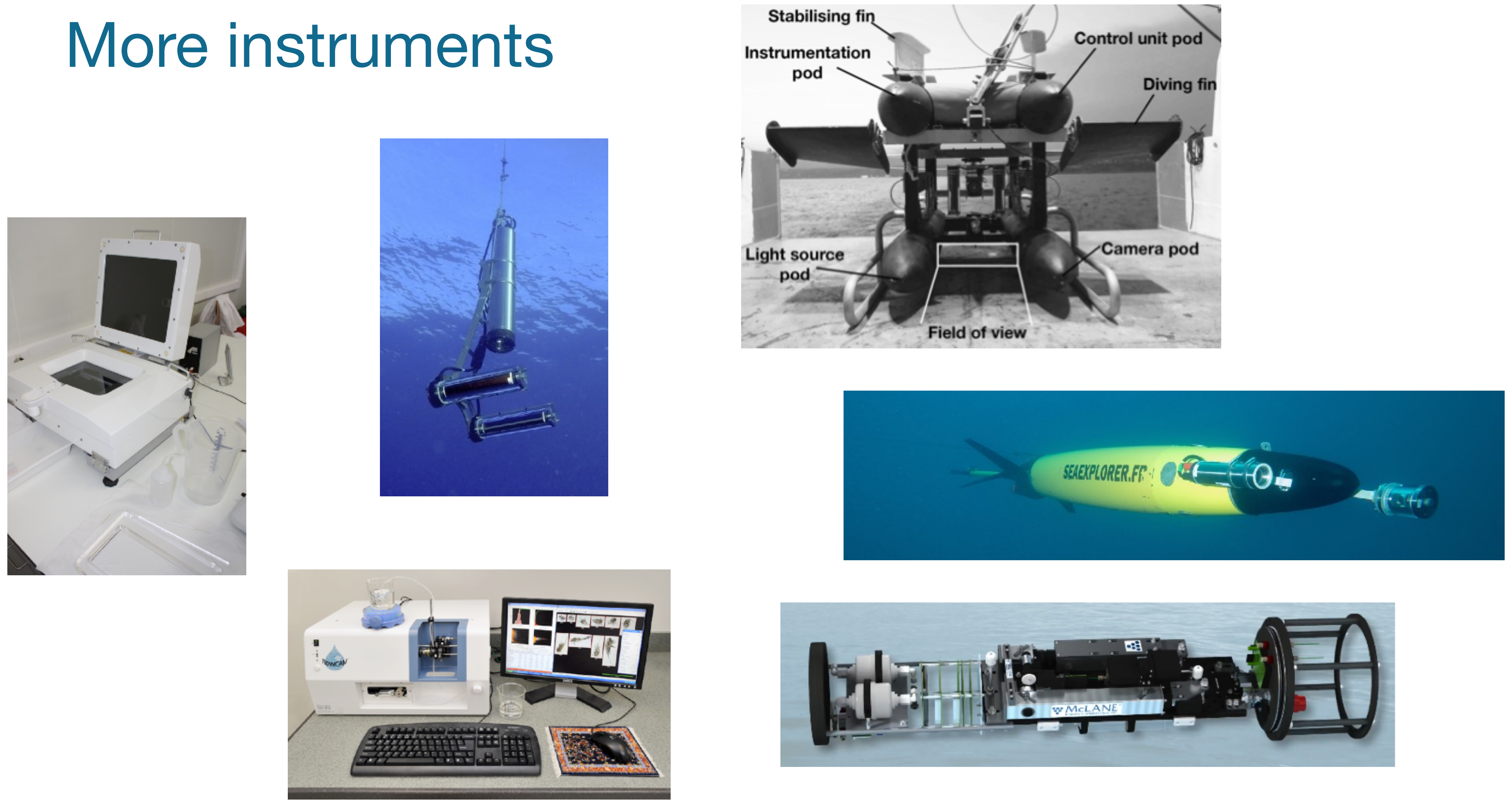
SEAEXPLORER.FR



Context

Plankton imaging

More instruments

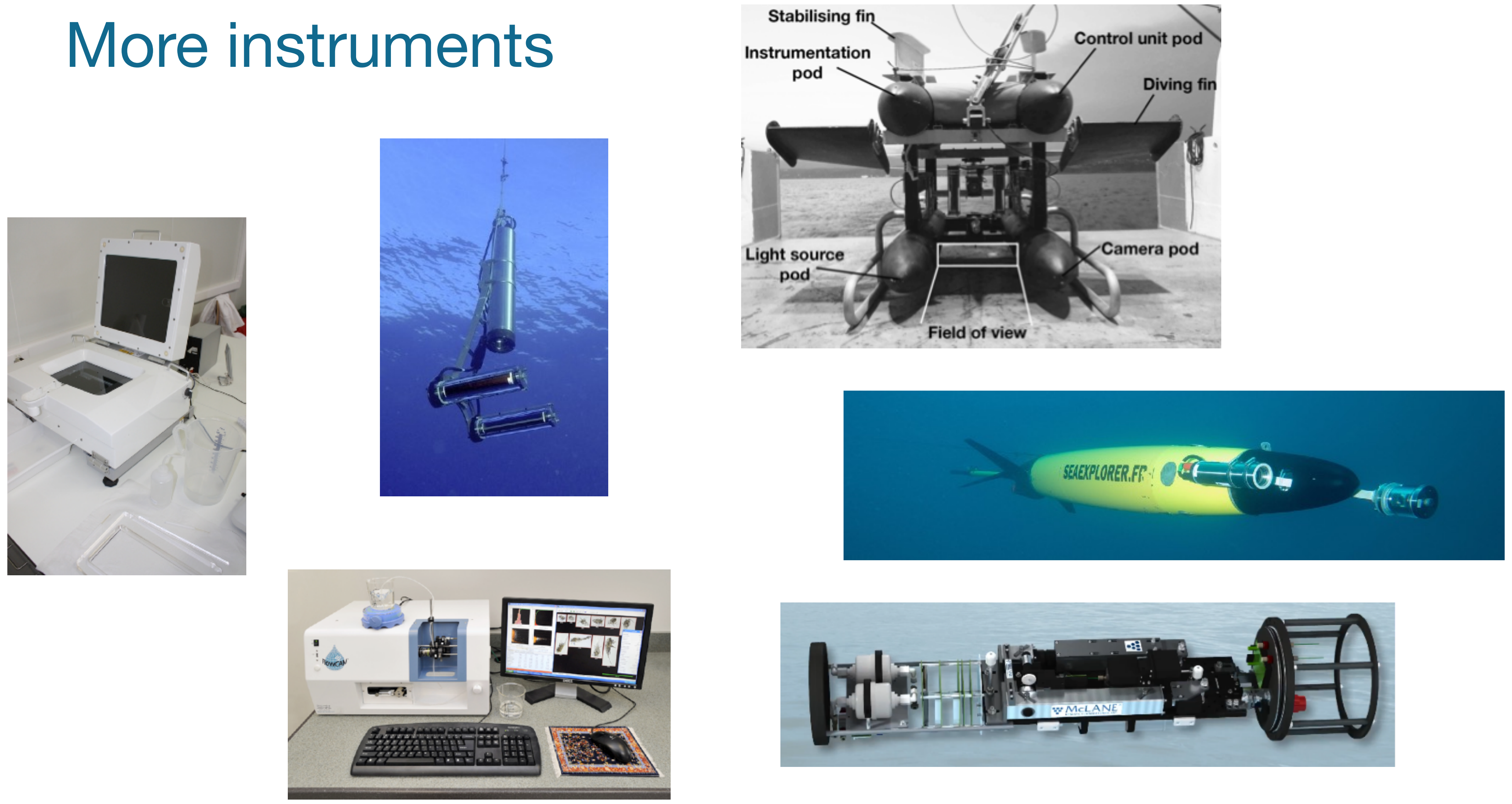

Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER.FT

More data

Context

Plankton imaging

More instruments

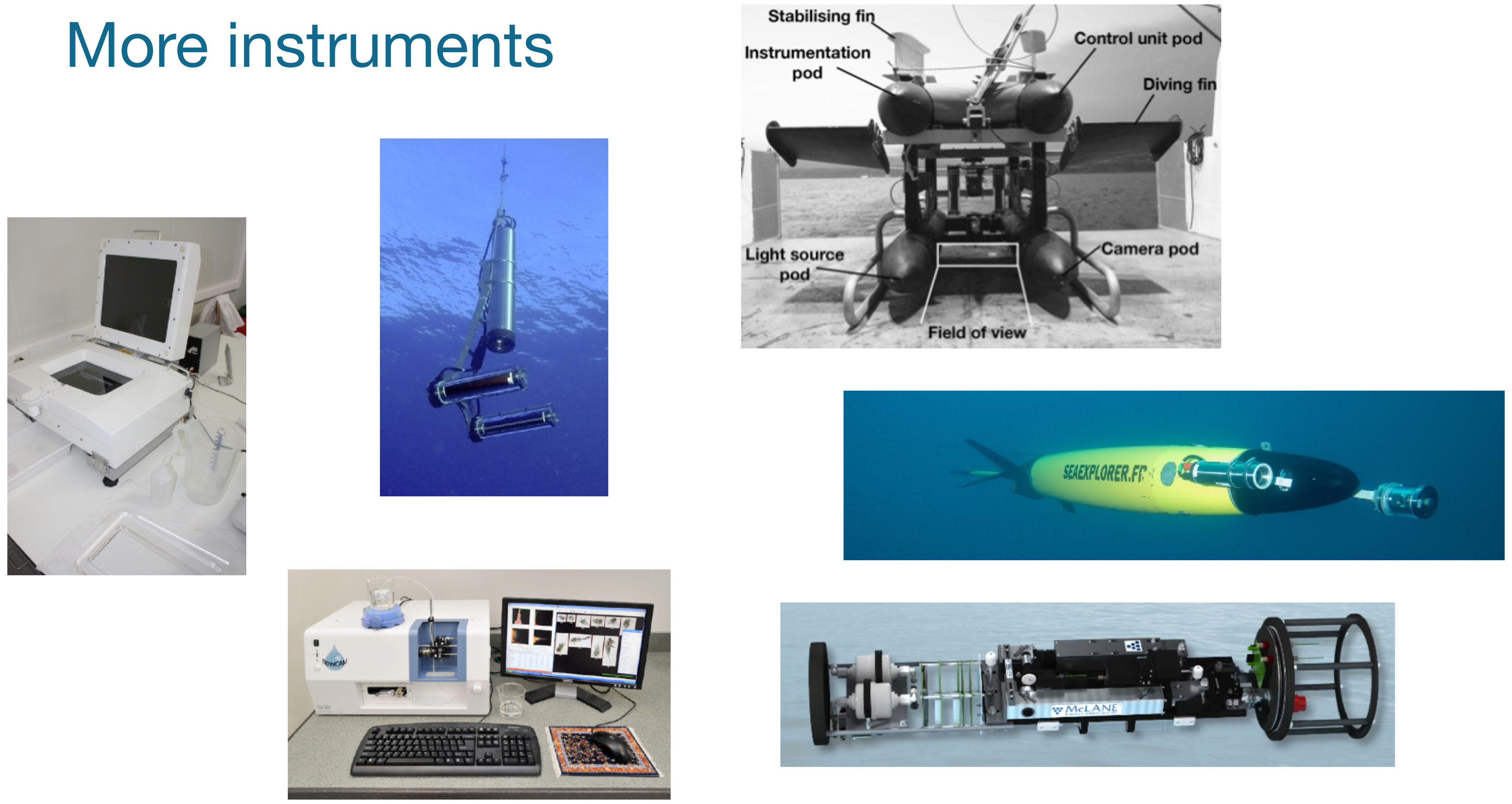

Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER.FT
McLANE

More data

Context

Plankton imaging

More instruments


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER
McLANE

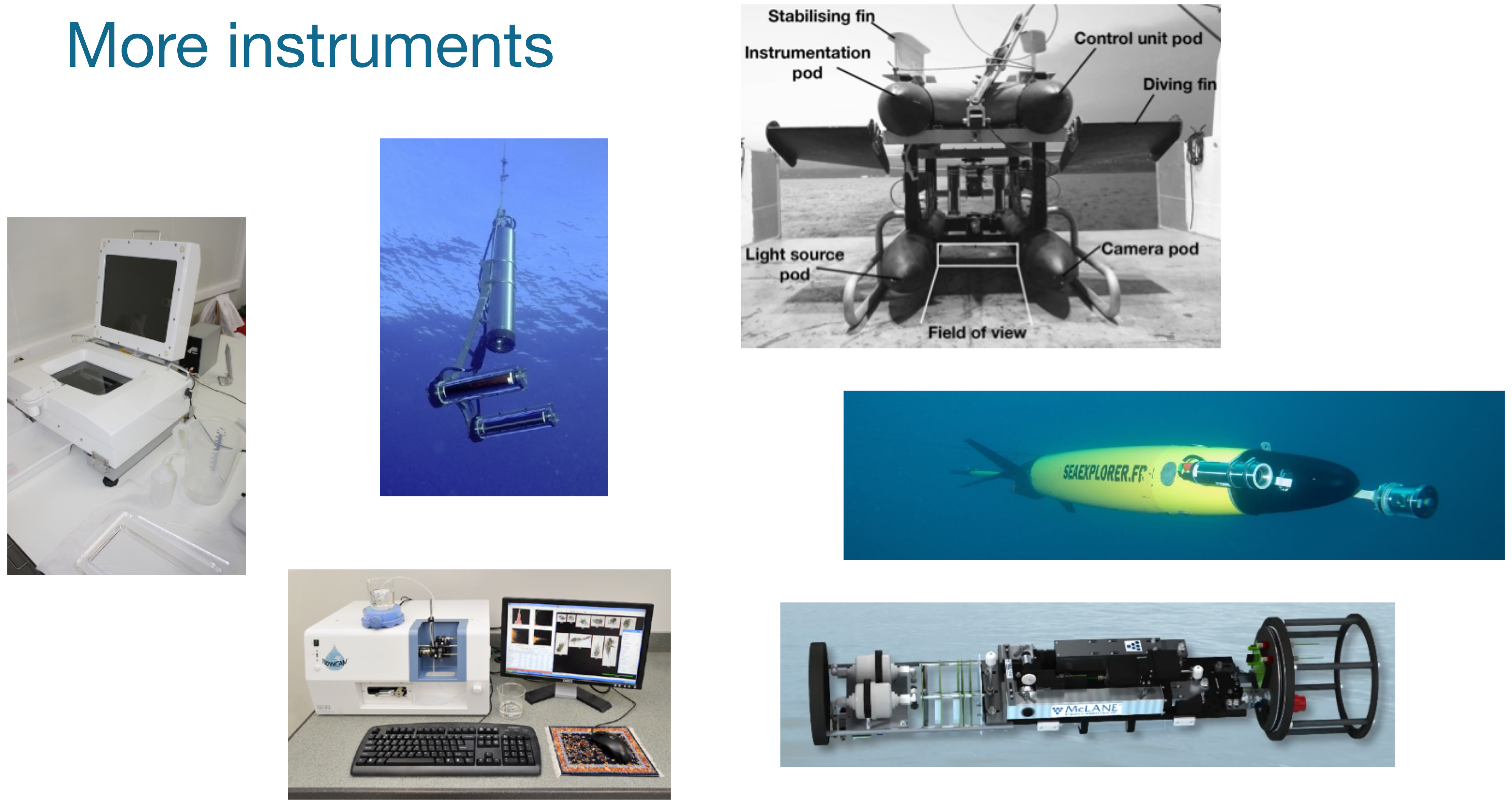
More data

Data processing bottleneck

Context

Plankton imaging

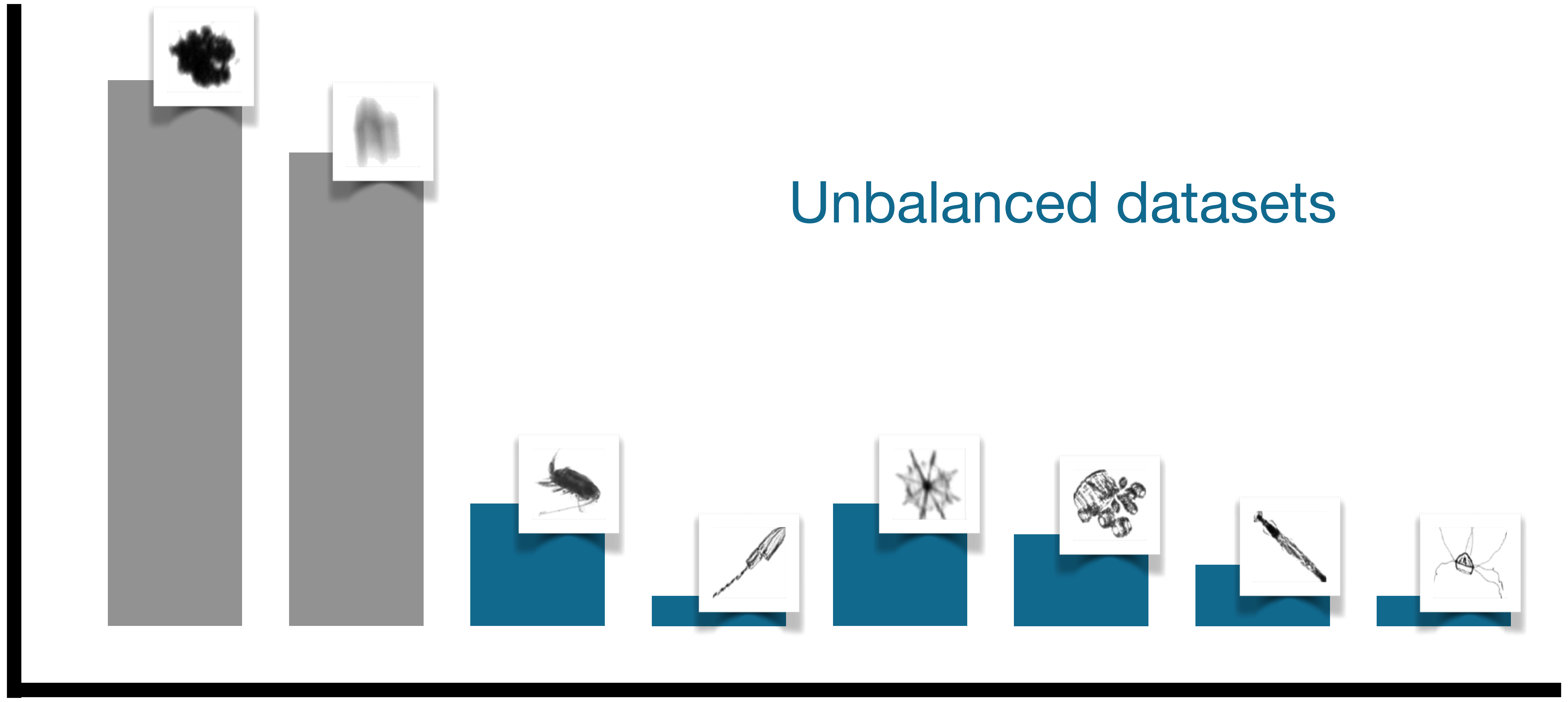
More instruments


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER.FT

More data

Data processing bottleneck

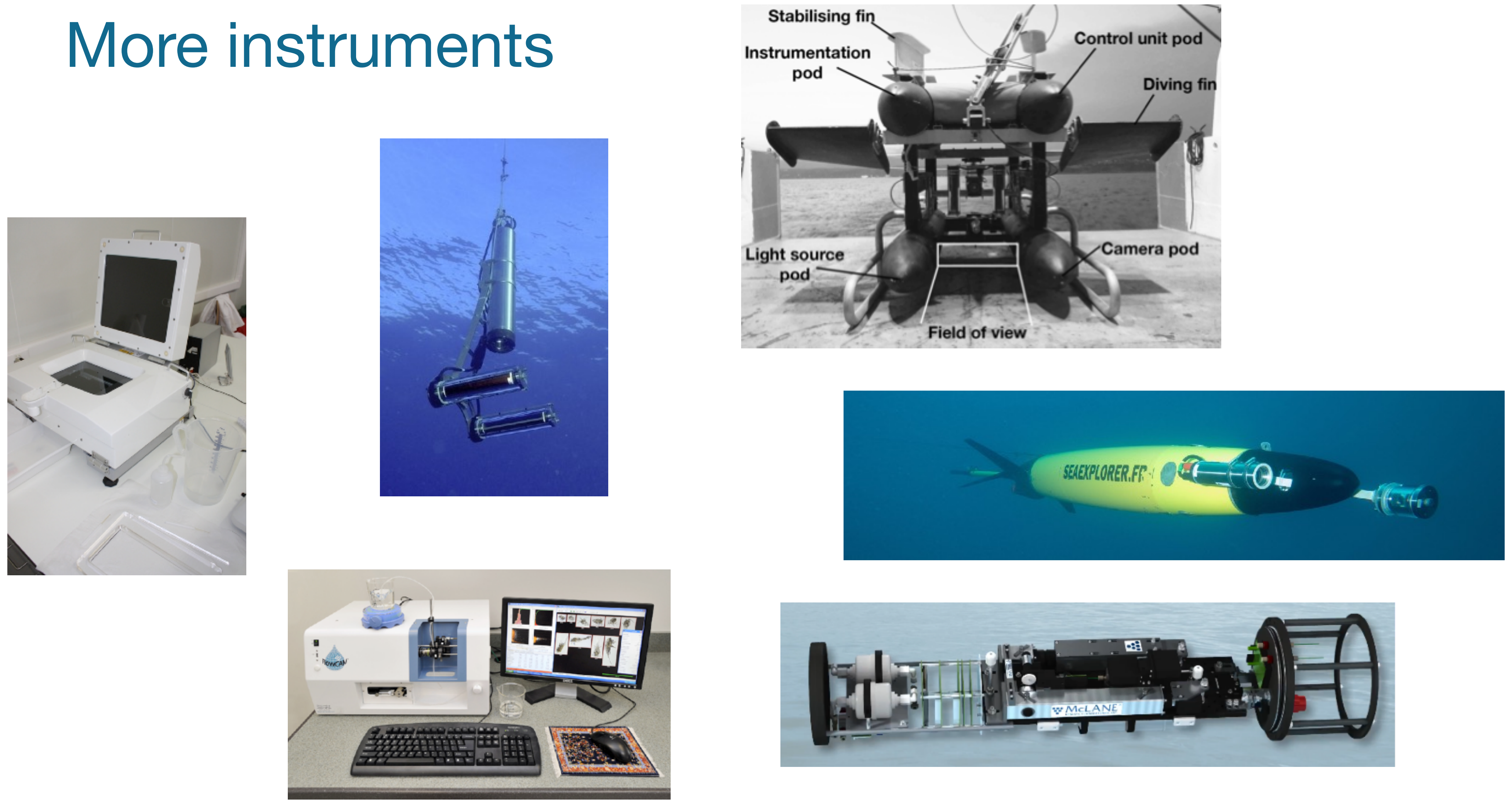
Unbalanced datasets



Context

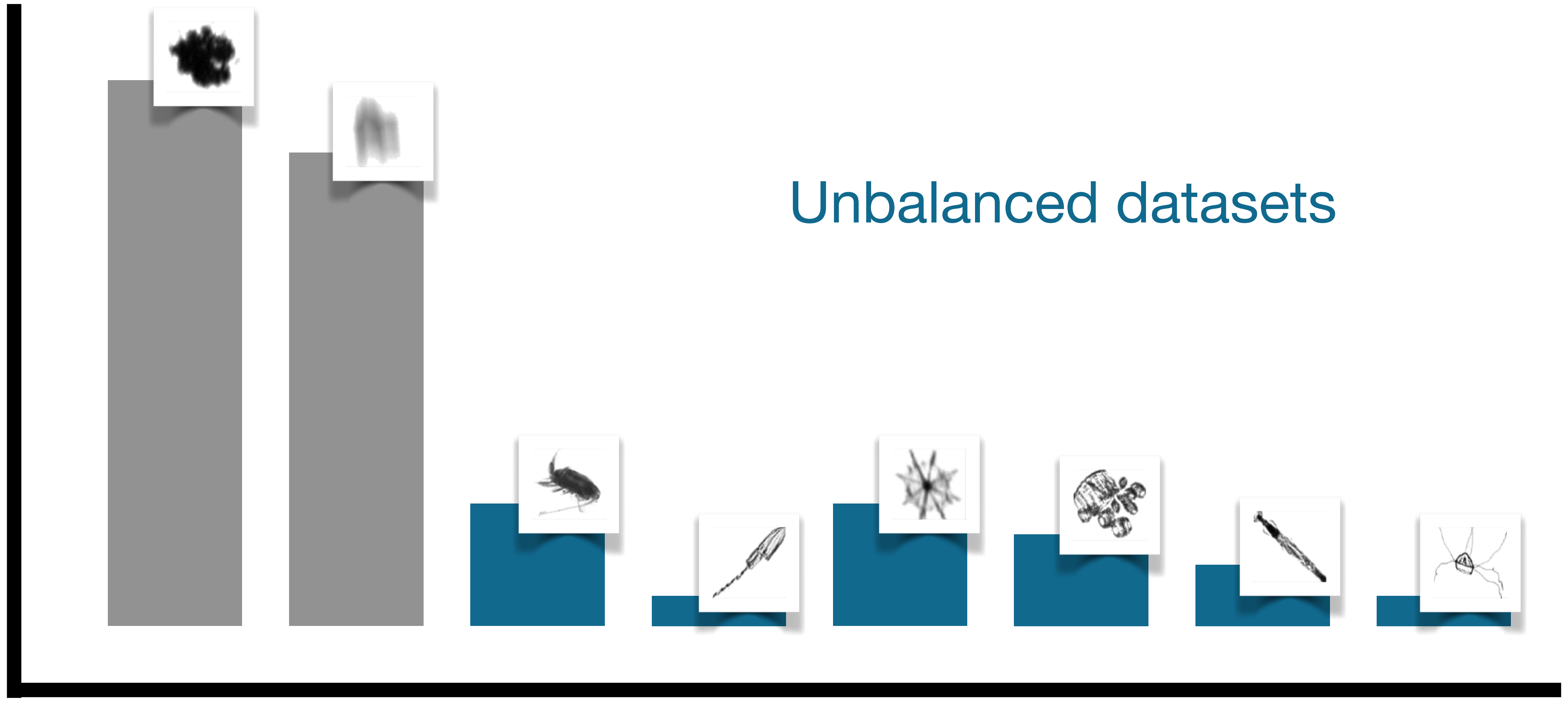
Plankton imaging

More instruments


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER.FT

More data

Data processing bottleneck



Unbalanced datasets

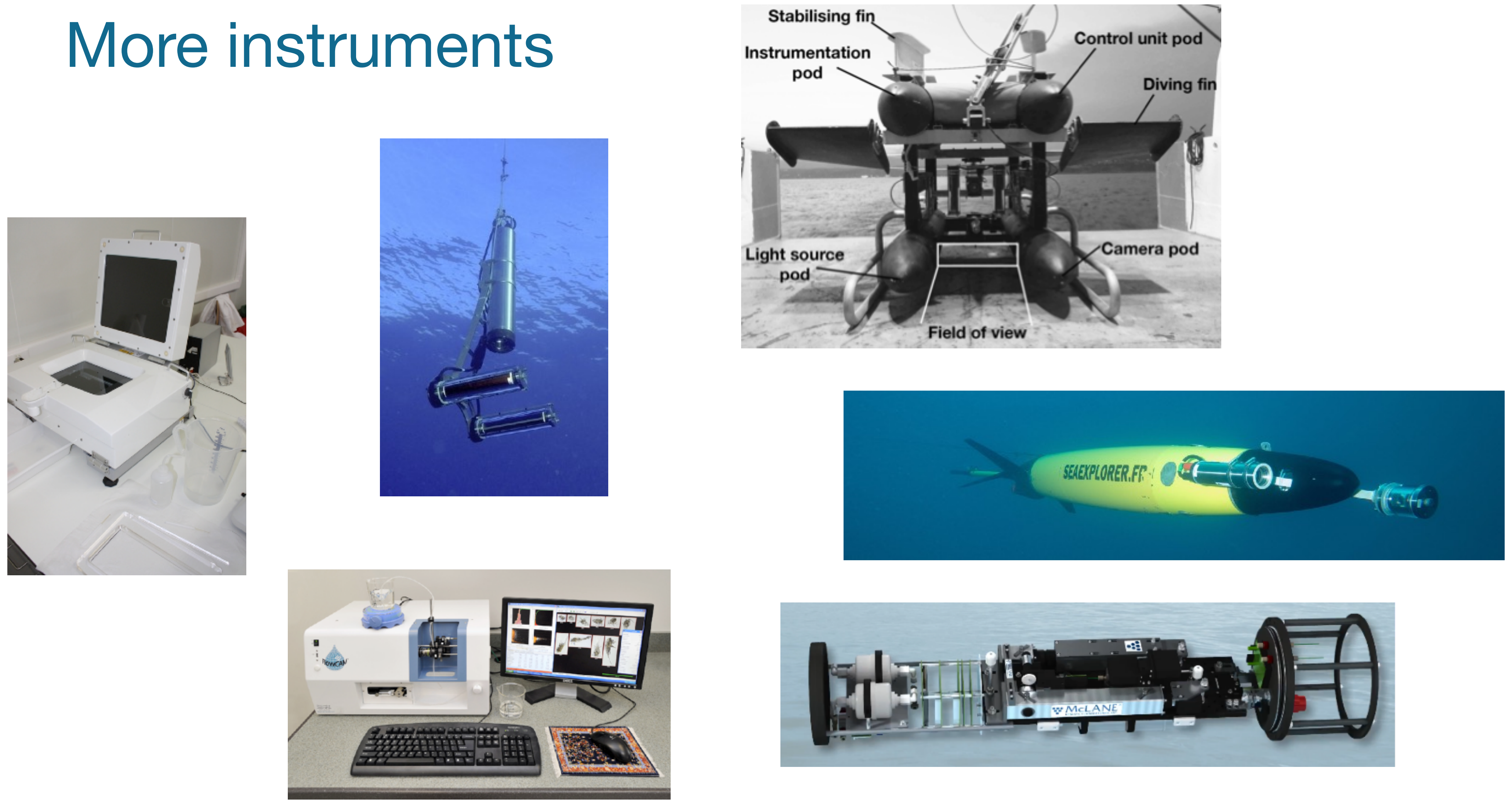
174 papers

3 benchmark datasets

Context

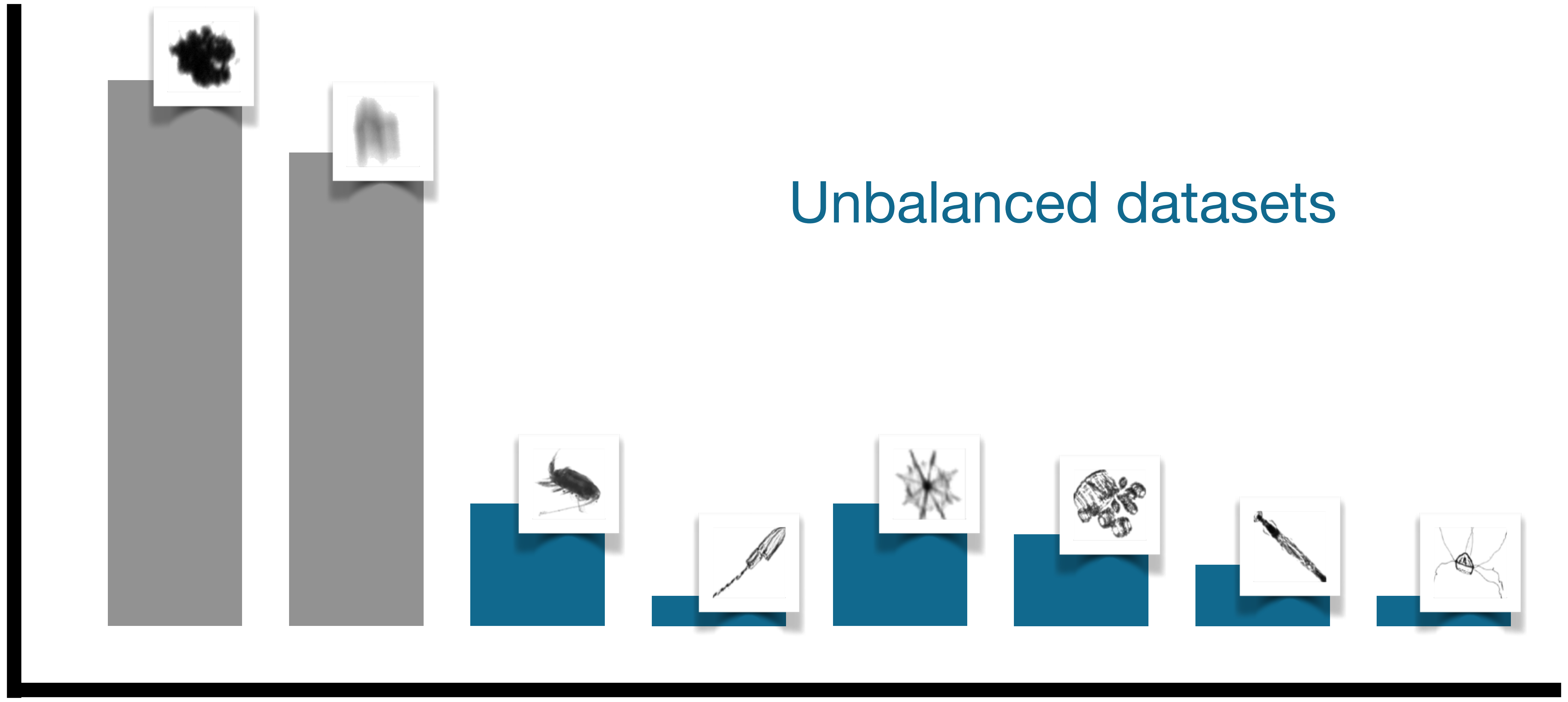
Plankton imaging

More instruments


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view
SEAEXPLORER
McLANE

More data

Data processing bottleneck



Unbalanced datasets

174 papers

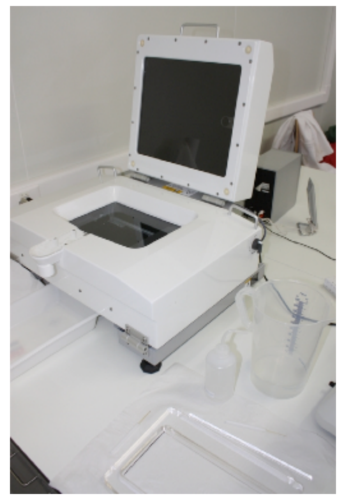
3 benchmark datasets

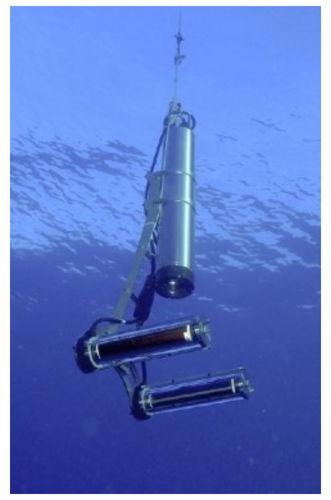
Lack of inter-comparison

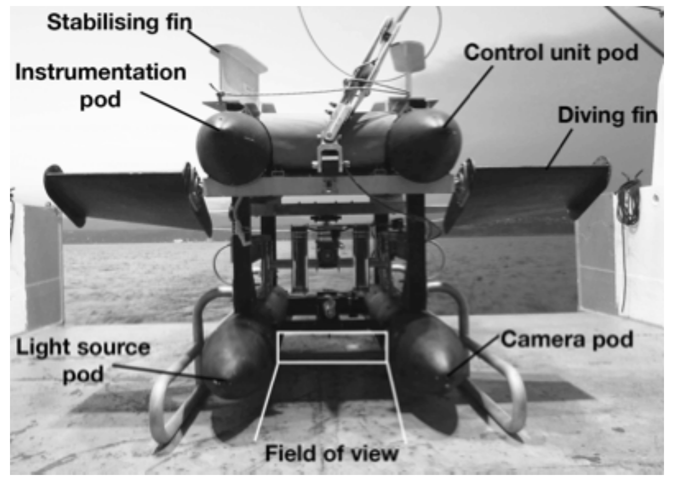
Context

Plankton imaging

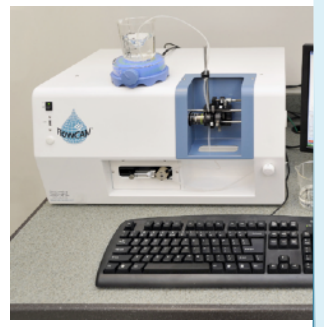
More instruments






Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view

SEAEXPLORER

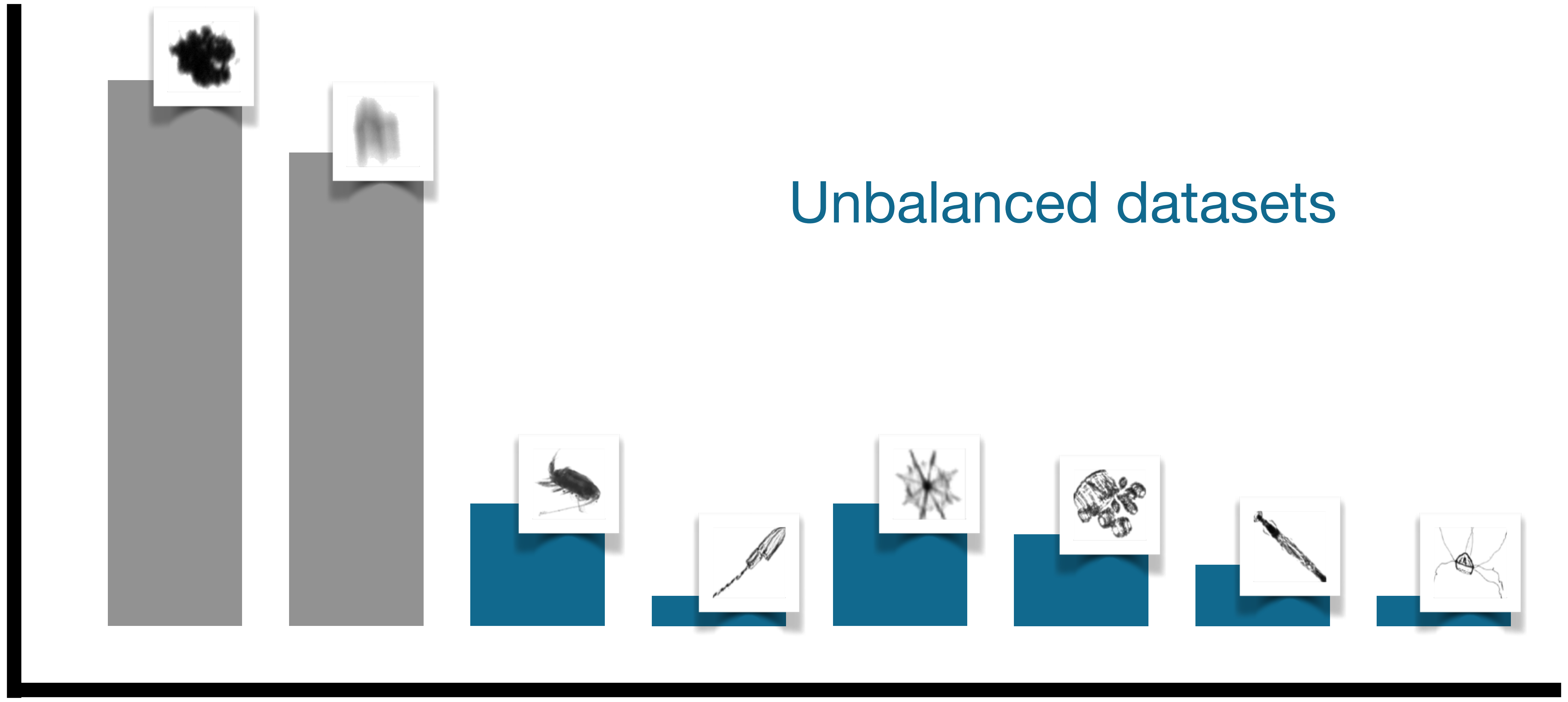


More data

Data processing bottleneck

➤ Report performances of two classification approaches

➤ Provide baseline results for future comparisons



Unbalanced datasets

174 papers

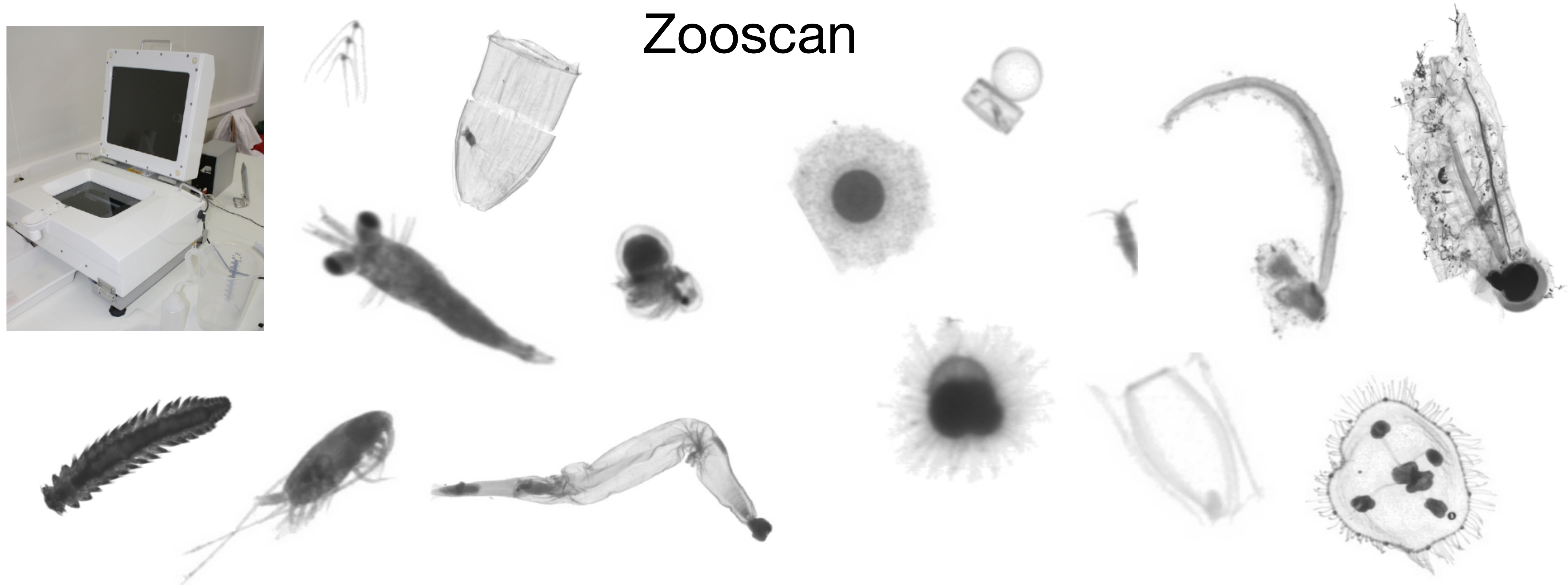
3 benchmark datasets

Lack of inter-comparison

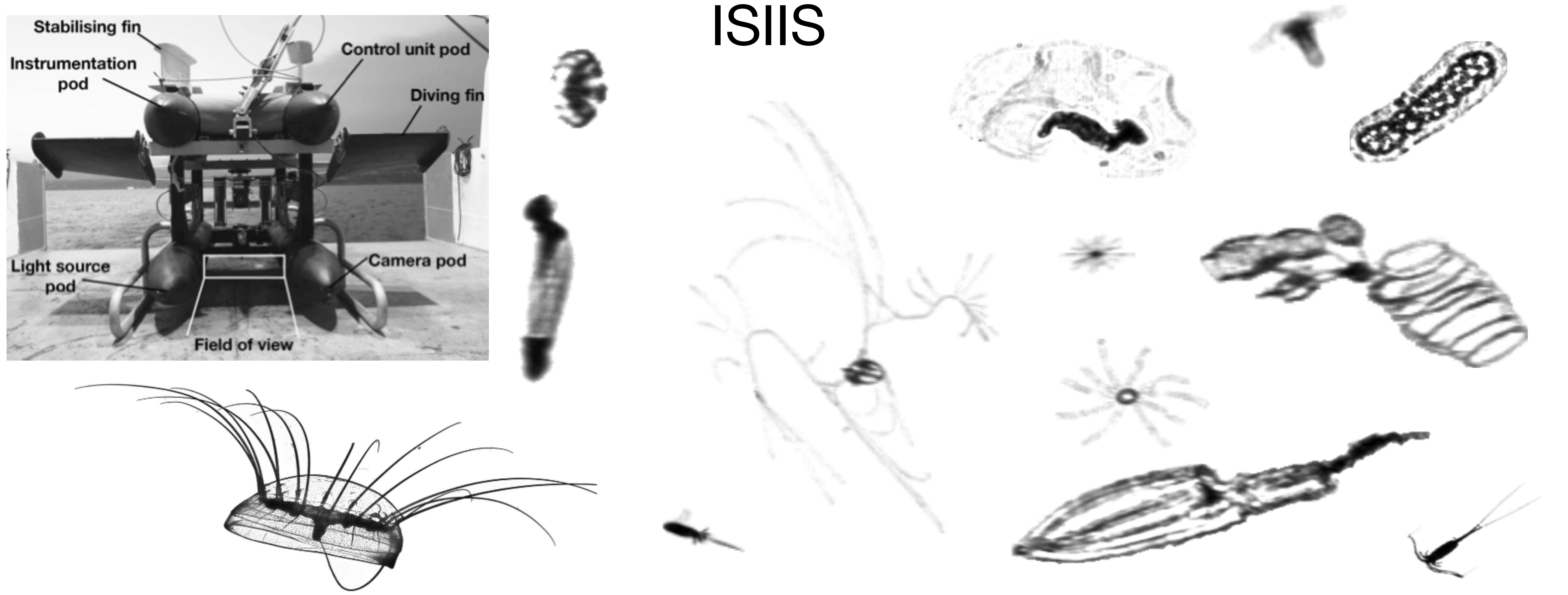
Material & methods

Datasets – imaging instruments

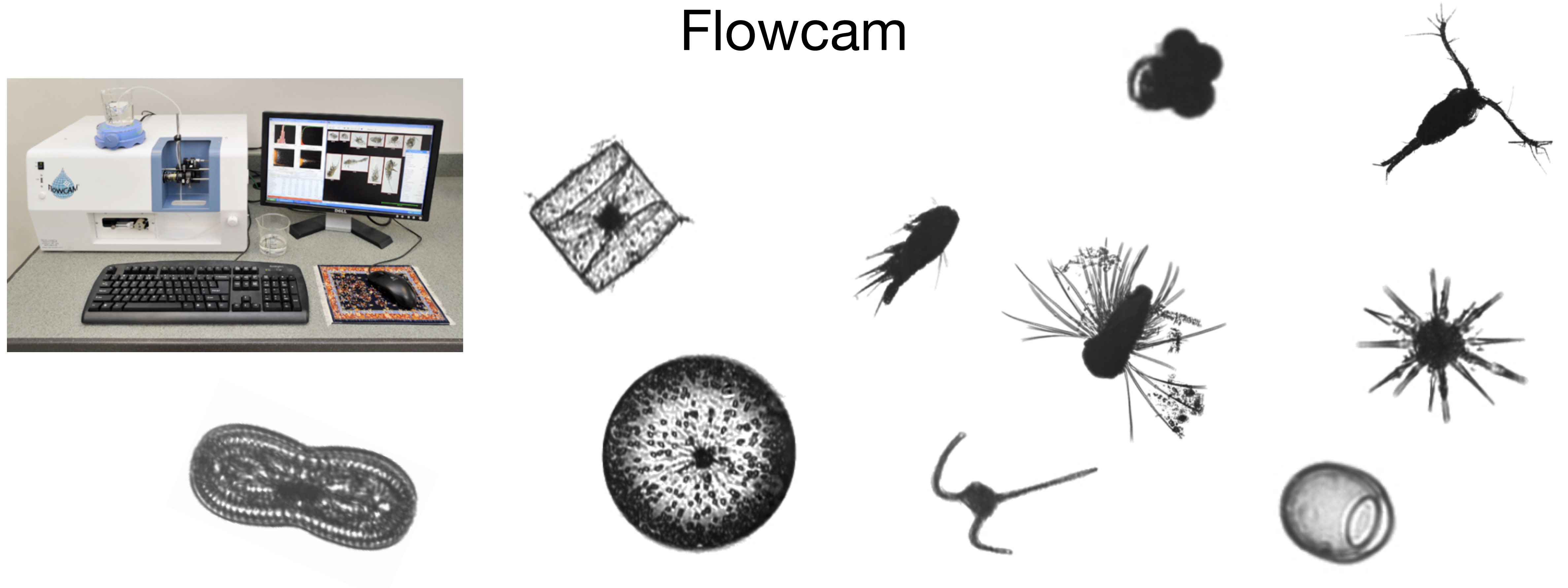
Zooscan



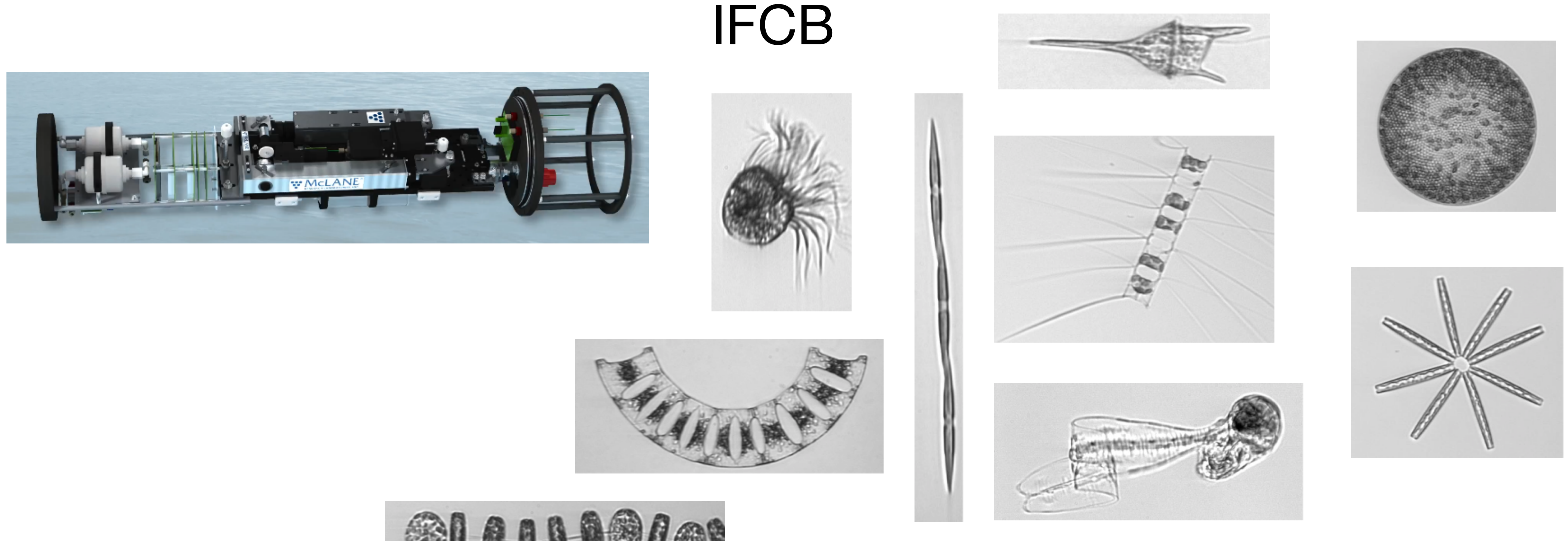
ISIIS


Stabilising fin
Instrumentation pod
Control unit pod
Diving fin
Light source pod
Camera pod
Field of view

Flowcam

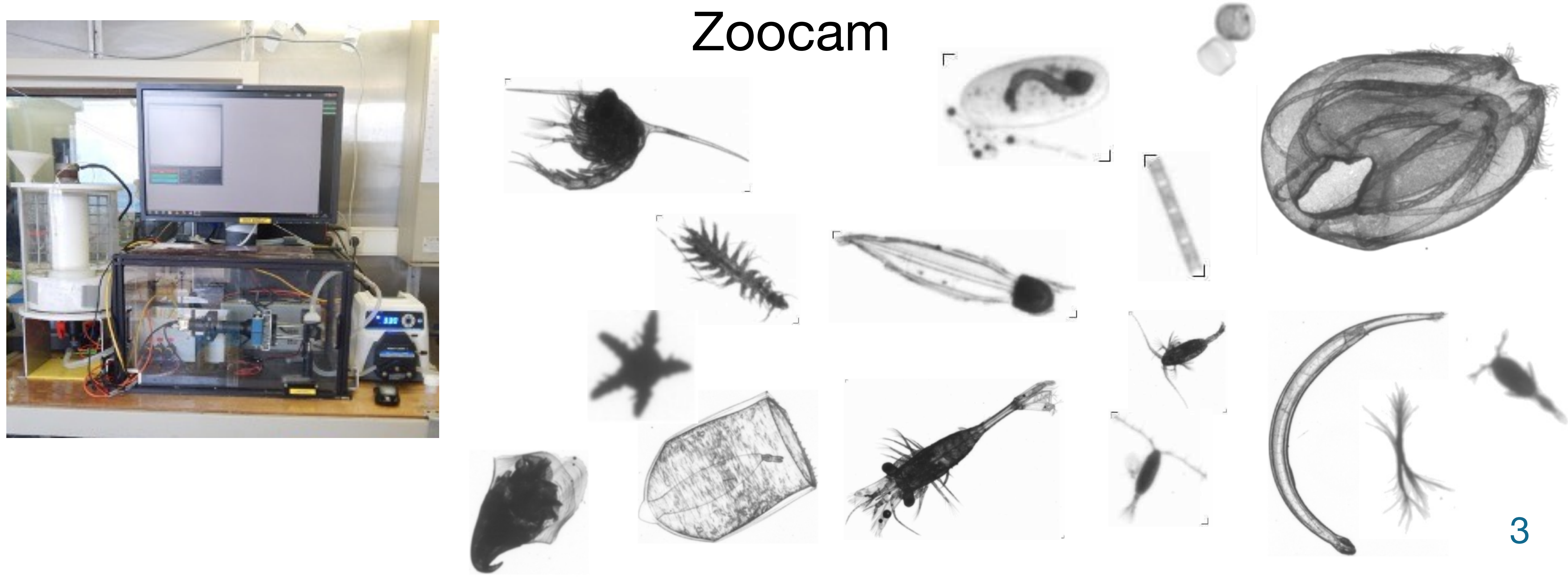


IFCB



https://whoigit.github.io/whoi-plankton/

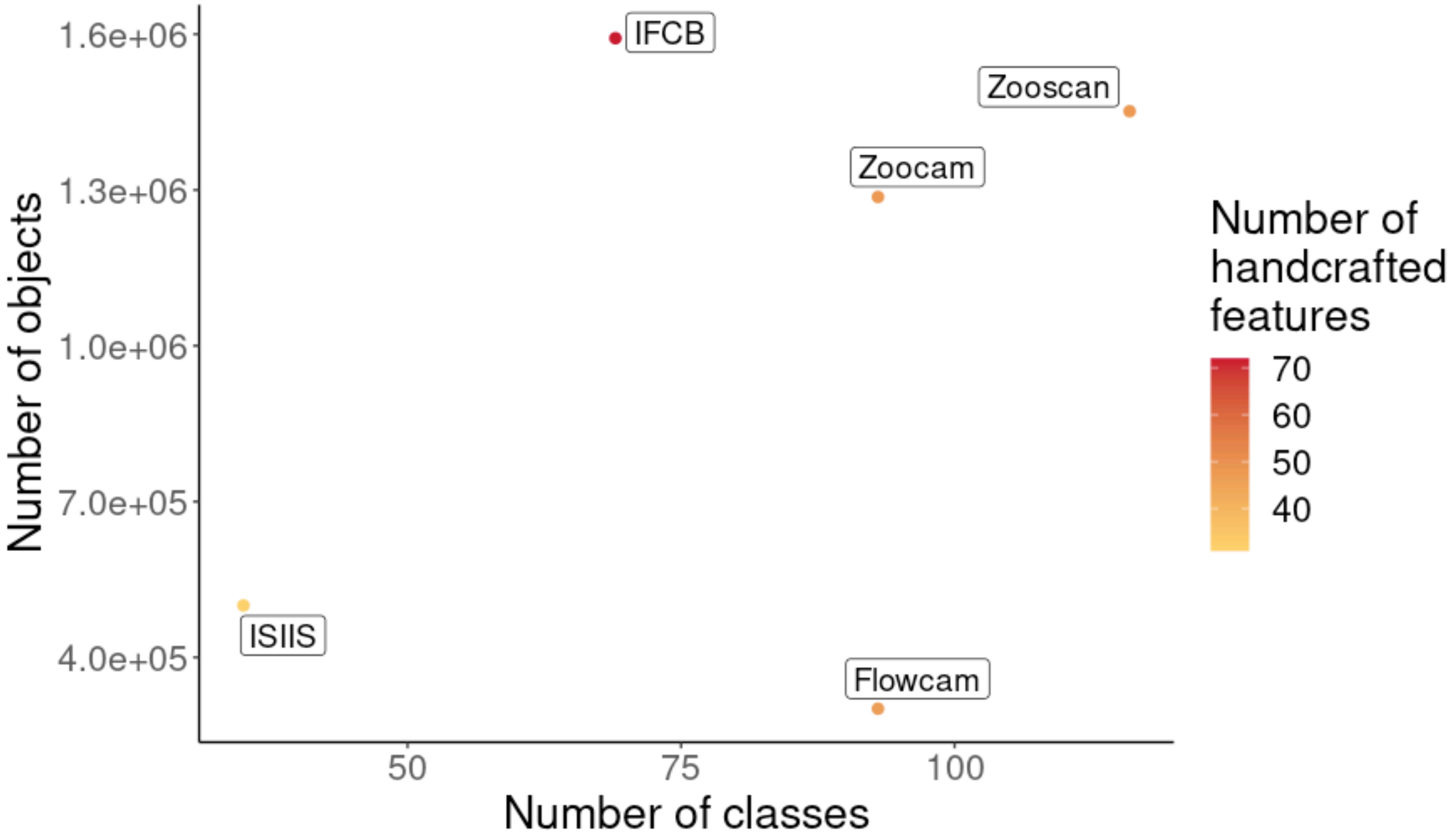
Zoocam



Material & methods

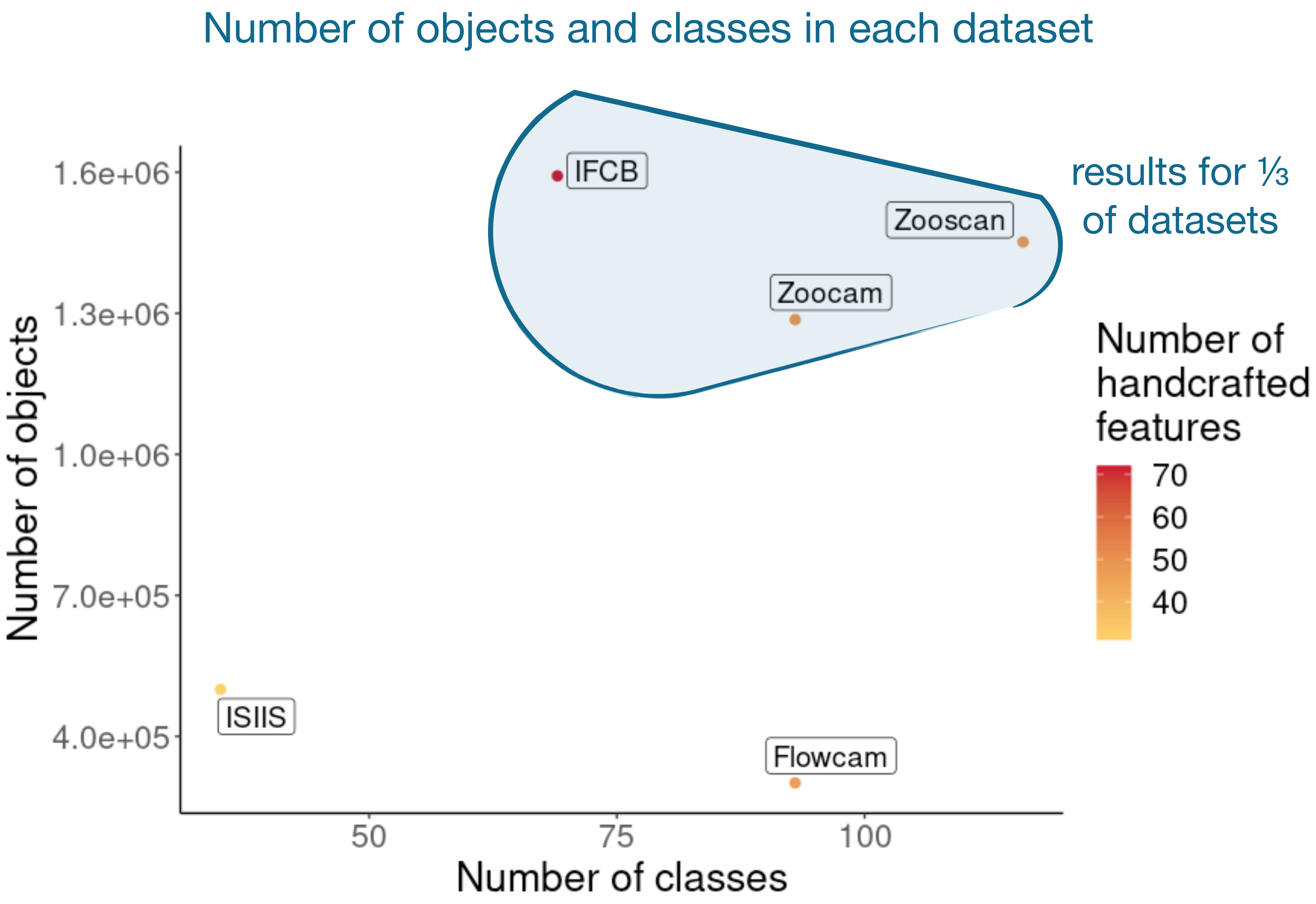
Datasets – composition

Number of objects and classes in each dataset



Material & methods

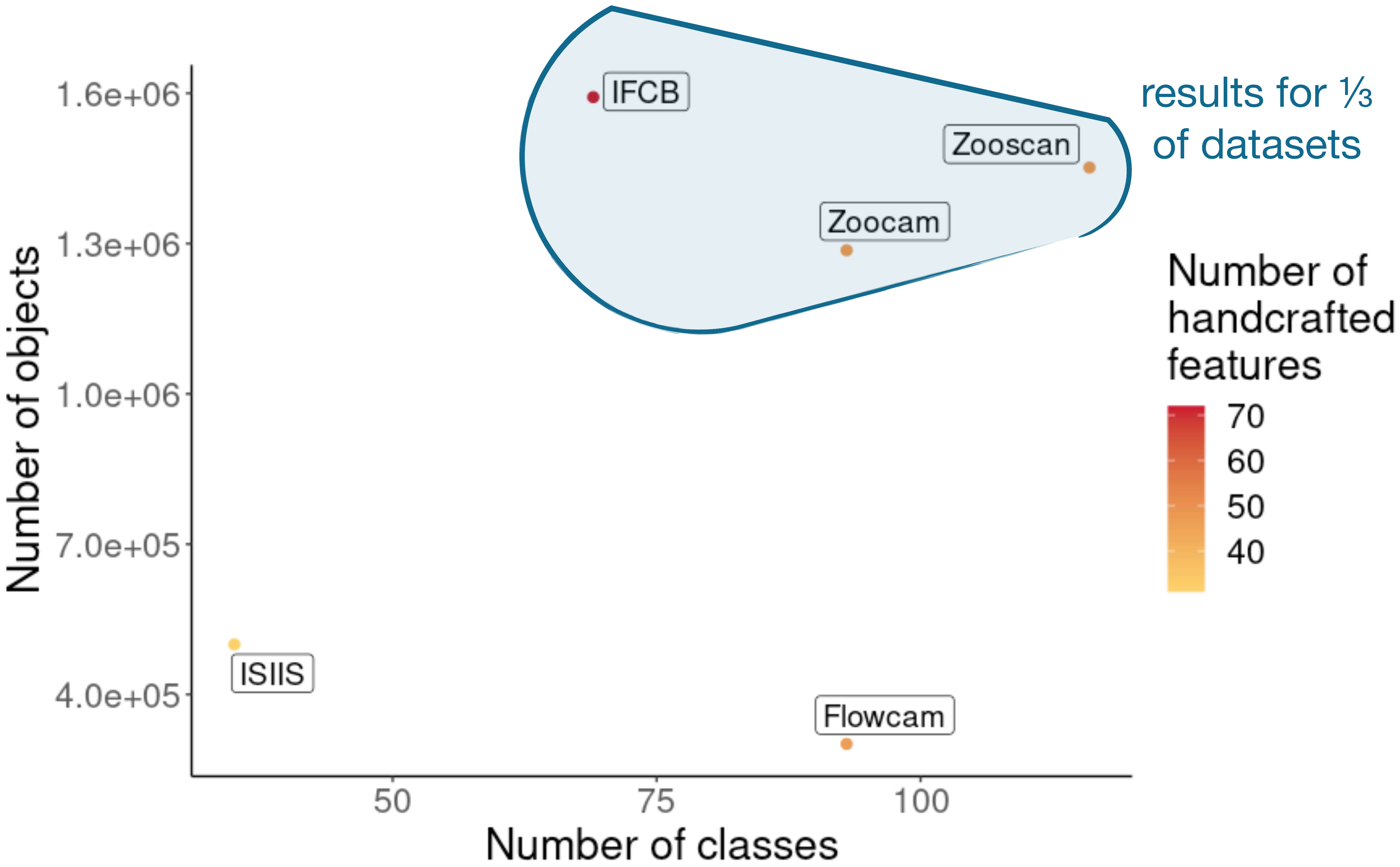
Datasets – composition



Material & methods

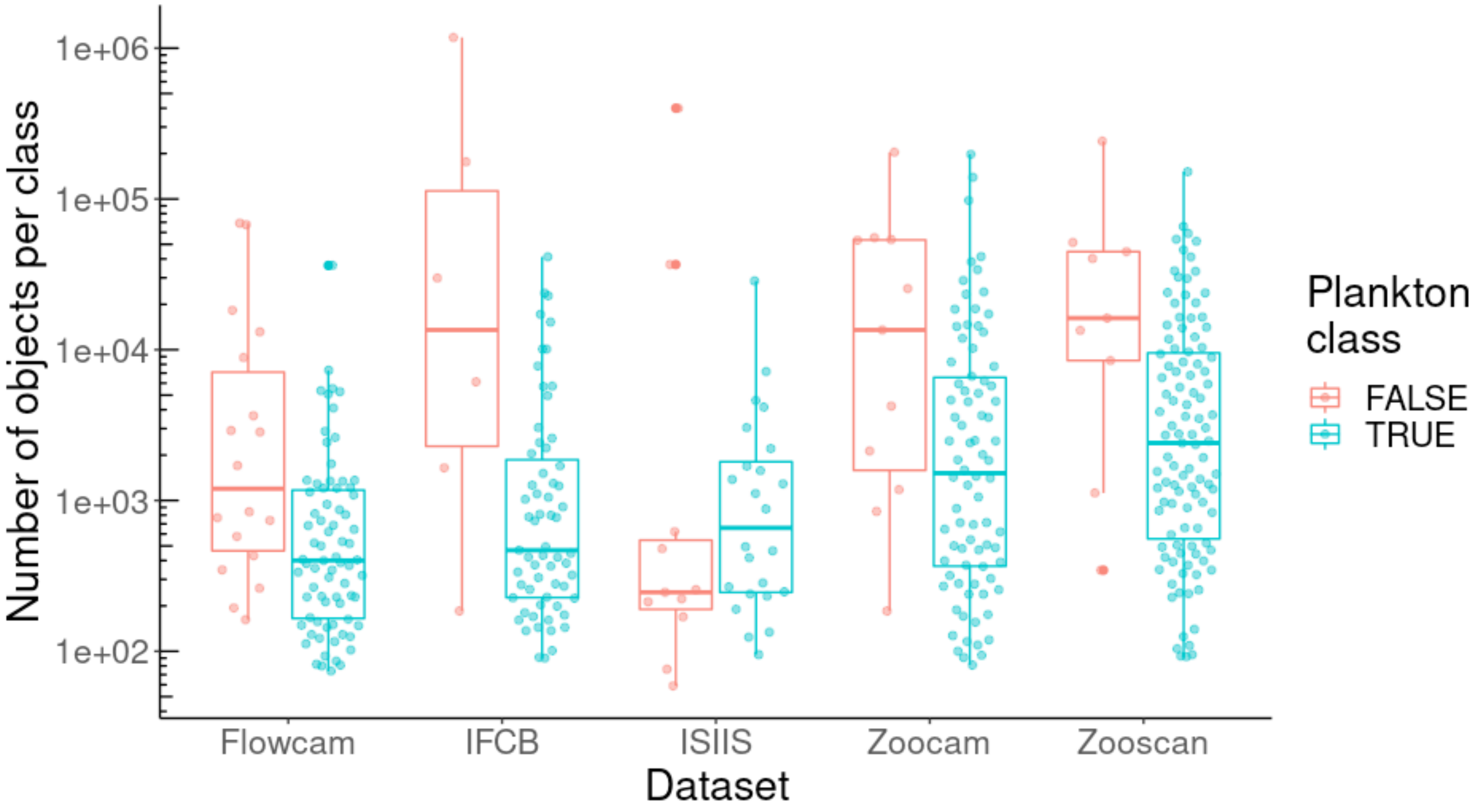
Datasets – composition

Number of objects and classes in each dataset



results for ⅓ of datasets

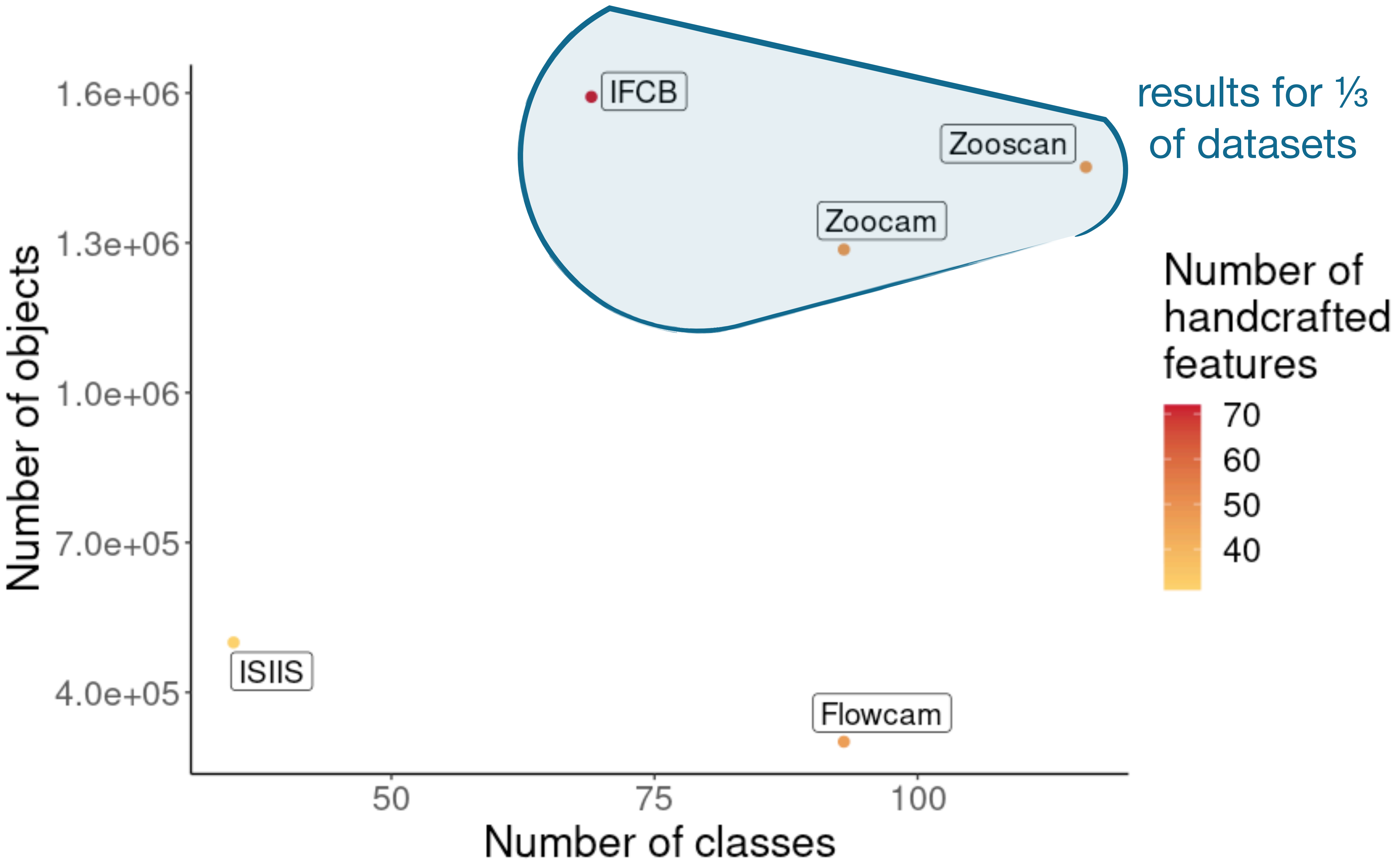
Distribution of objects per classes in each dataset



Material & methods

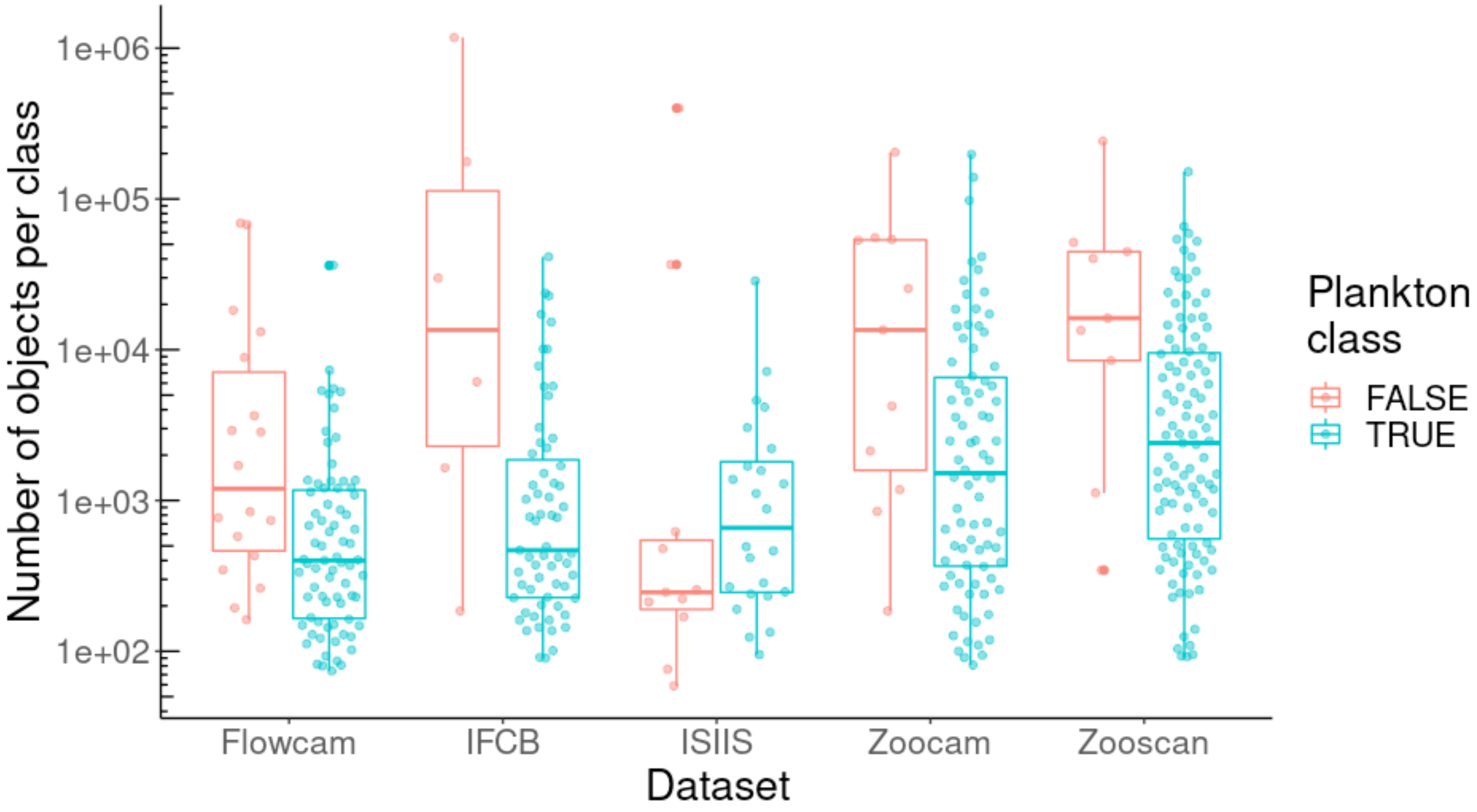
Datasets – composition

Number of objects and classes in each dataset



results for ⅓ of datasets

Distribution of objects per classes in each dataset

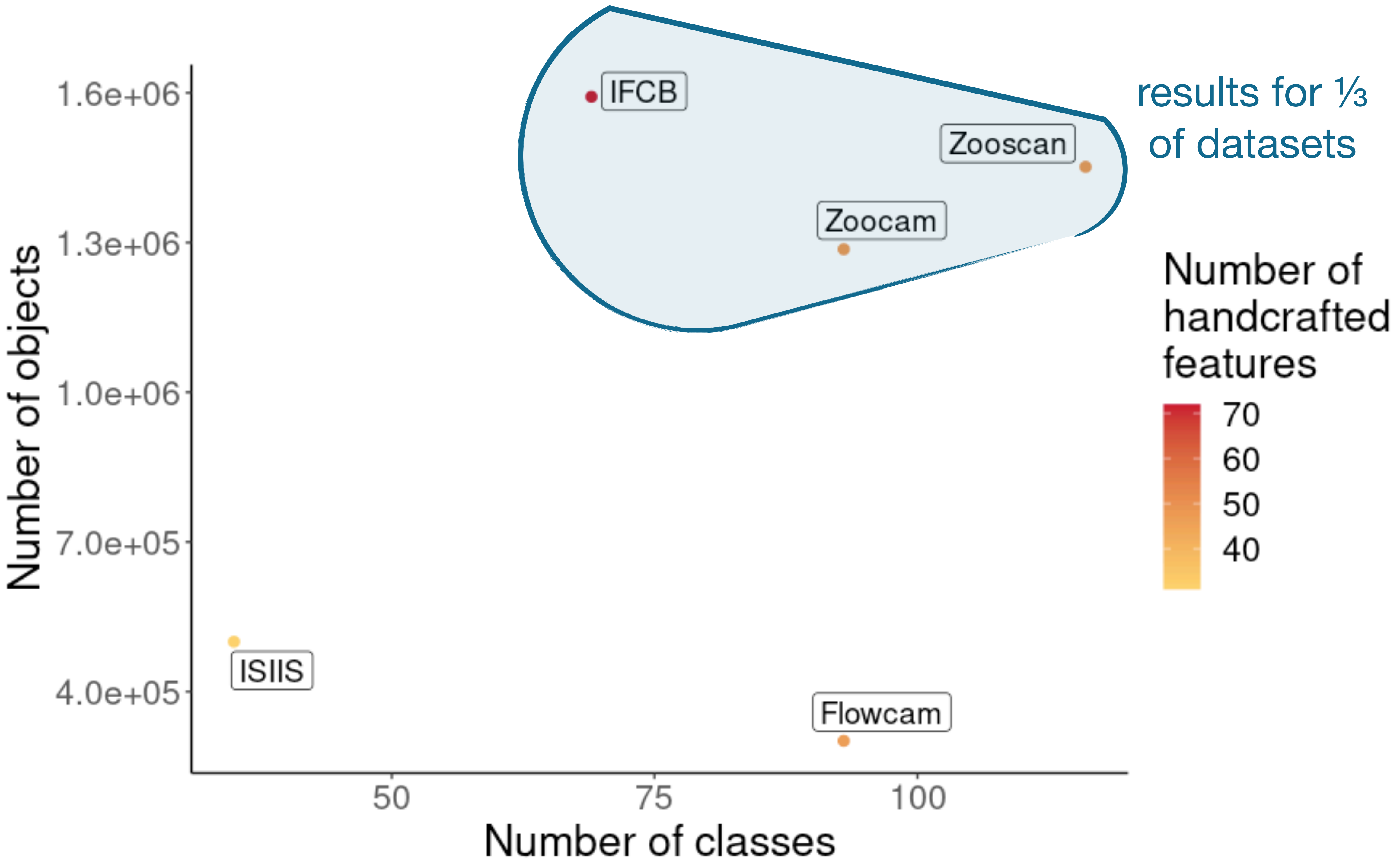


Strong unbalance

Material & methods

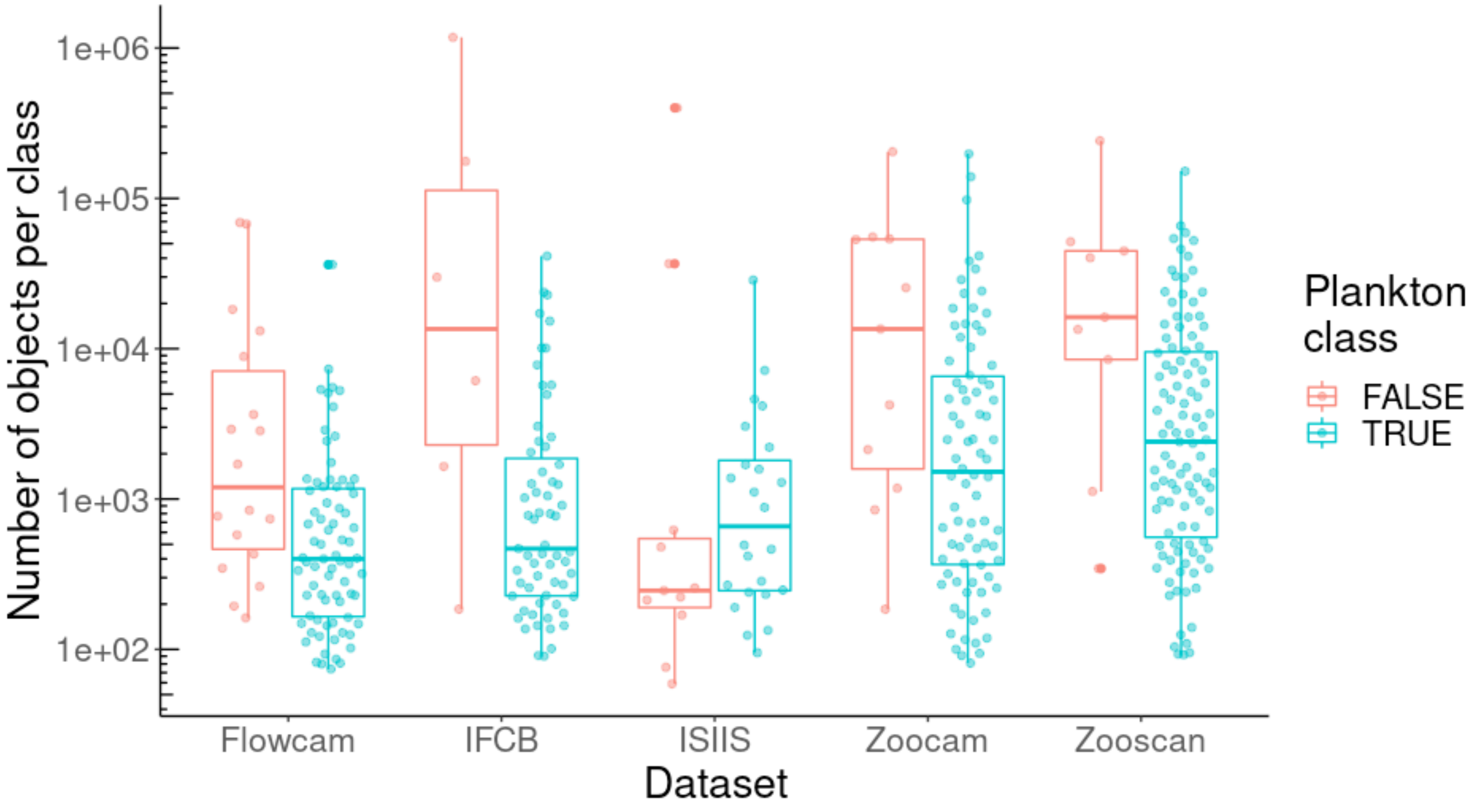
Datasets – composition

Number of objects and classes in each dataset



results for ⅓ of datasets

Distribution of objects per classes in each dataset



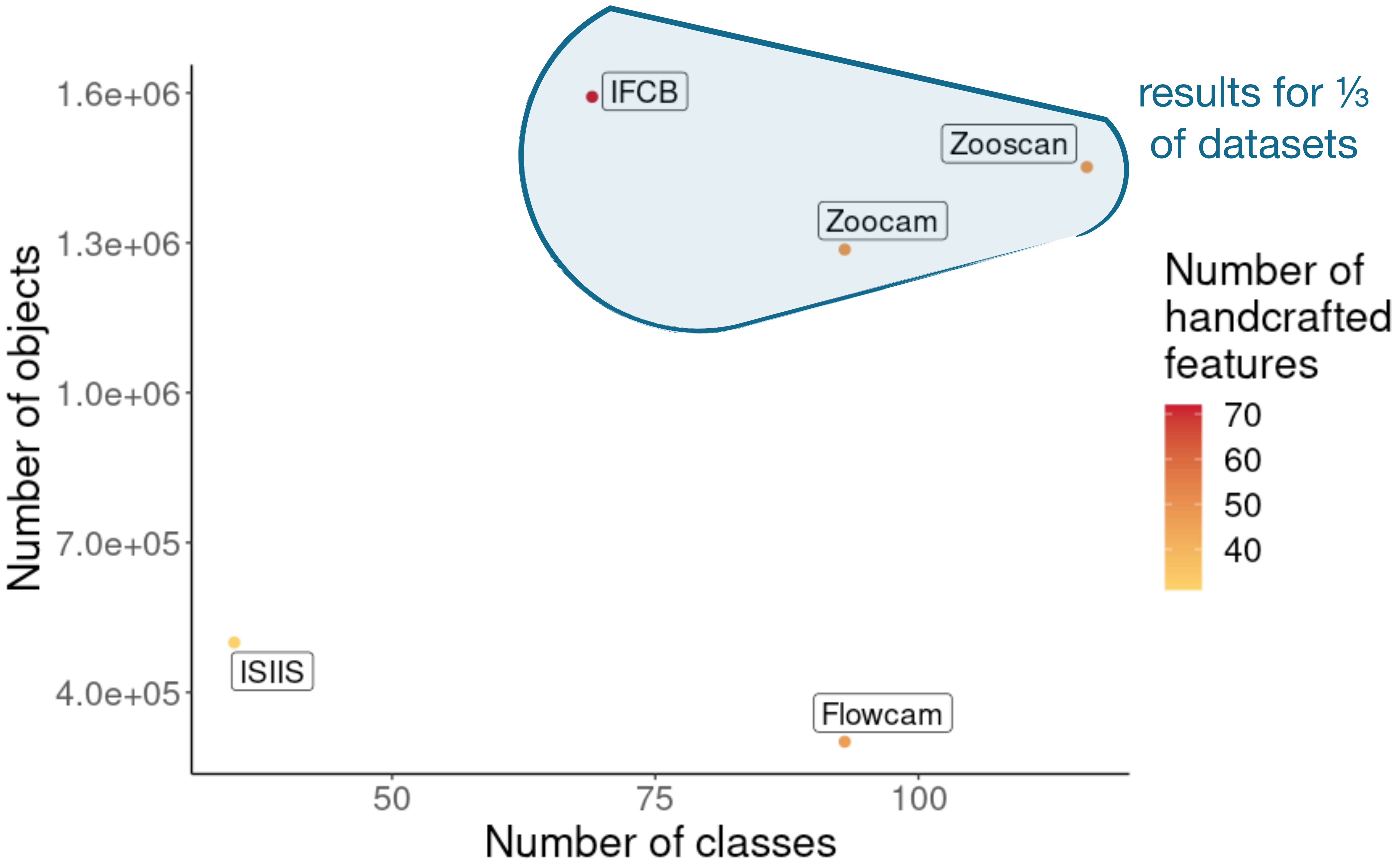
Strong unbalance

weight small classes

Material & methods

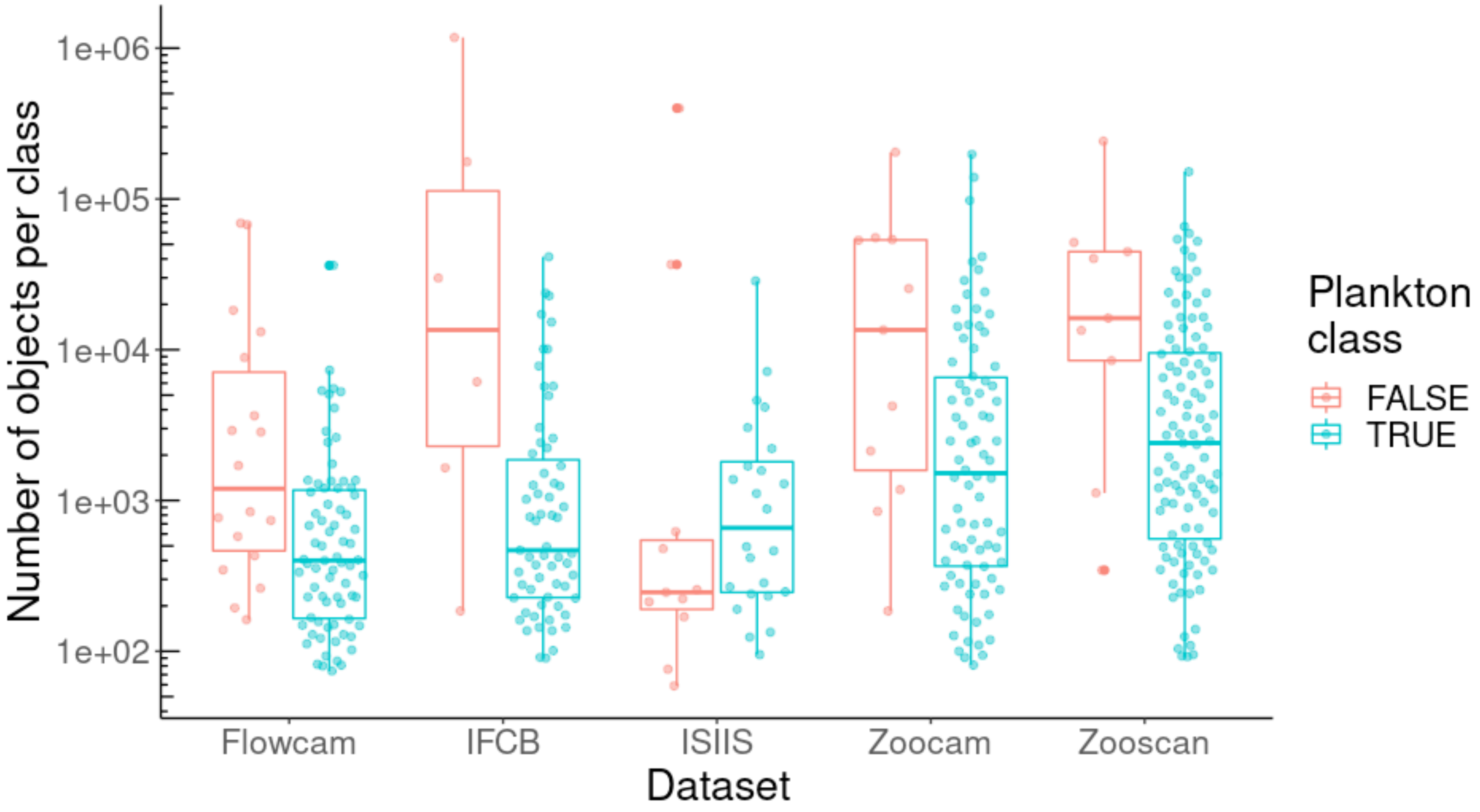
Datasets – composition

Number of objects and classes in each dataset



results for ⅓ of datasets

Distribution of objects per classes in each dataset



Strong unbalance

↓

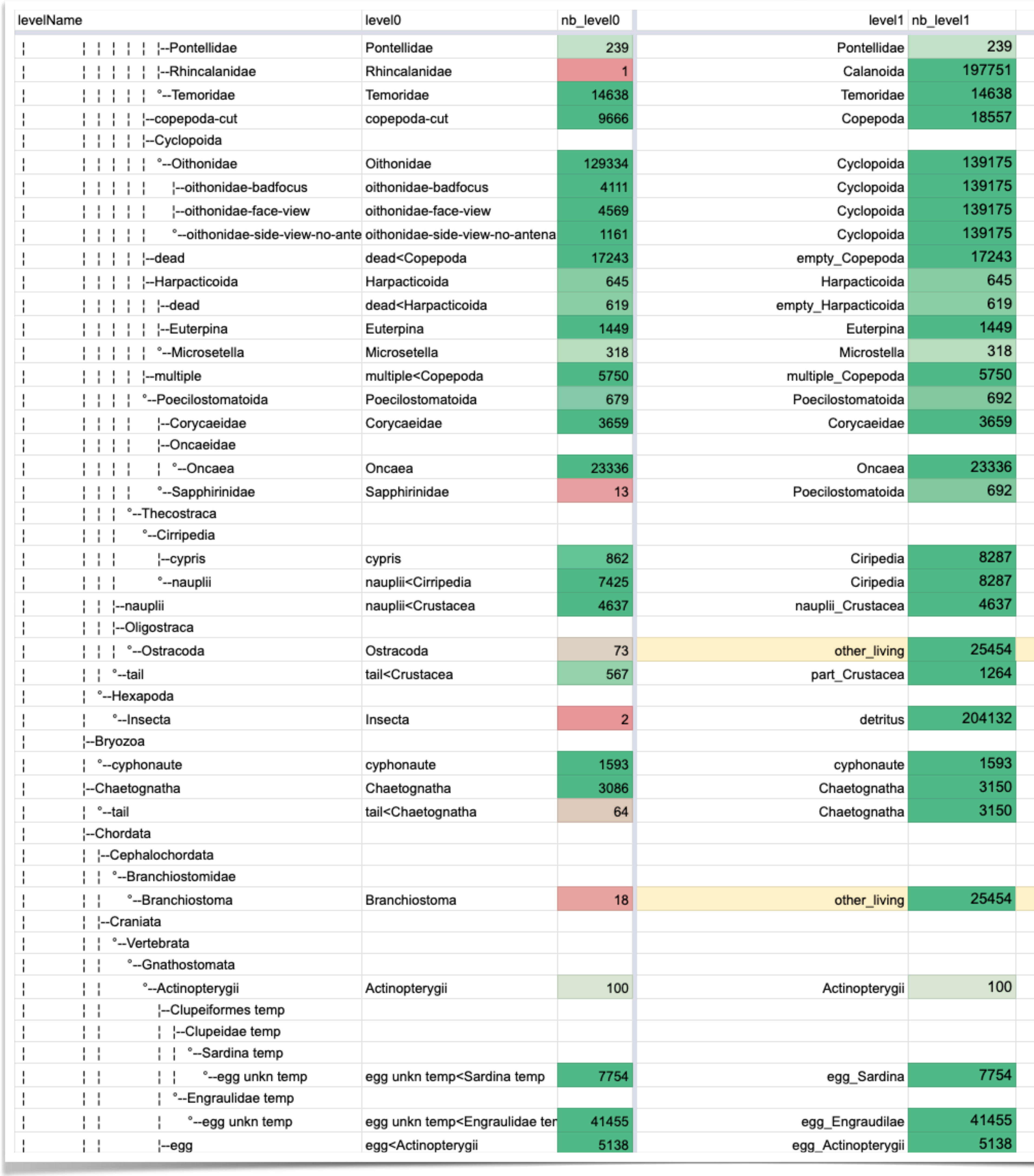
weight small classes

Class-stratified dataset split

70%	15%	15%
Training	Validation	Test

Material & methods

Datasets – processing

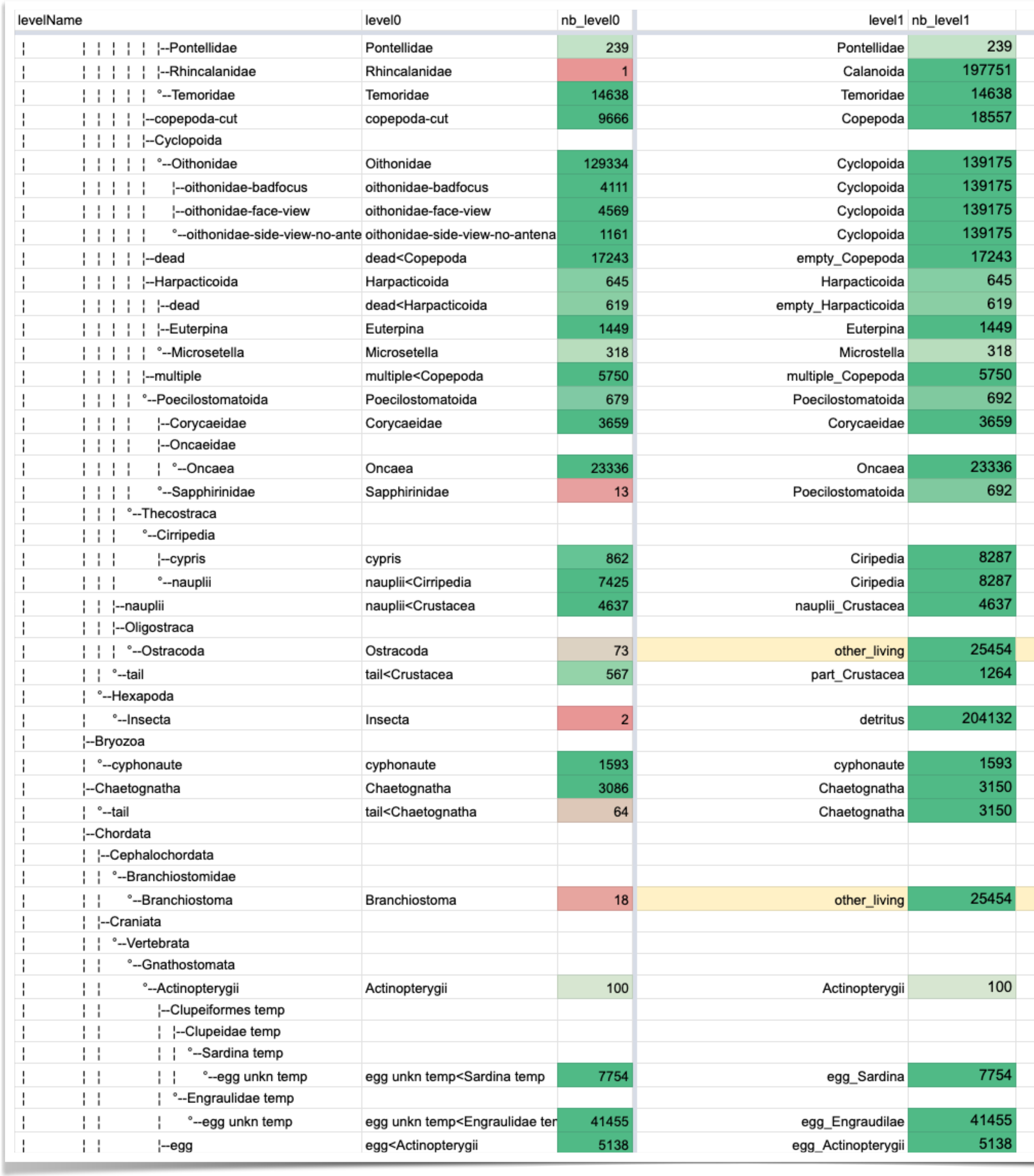


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

- include **every** object

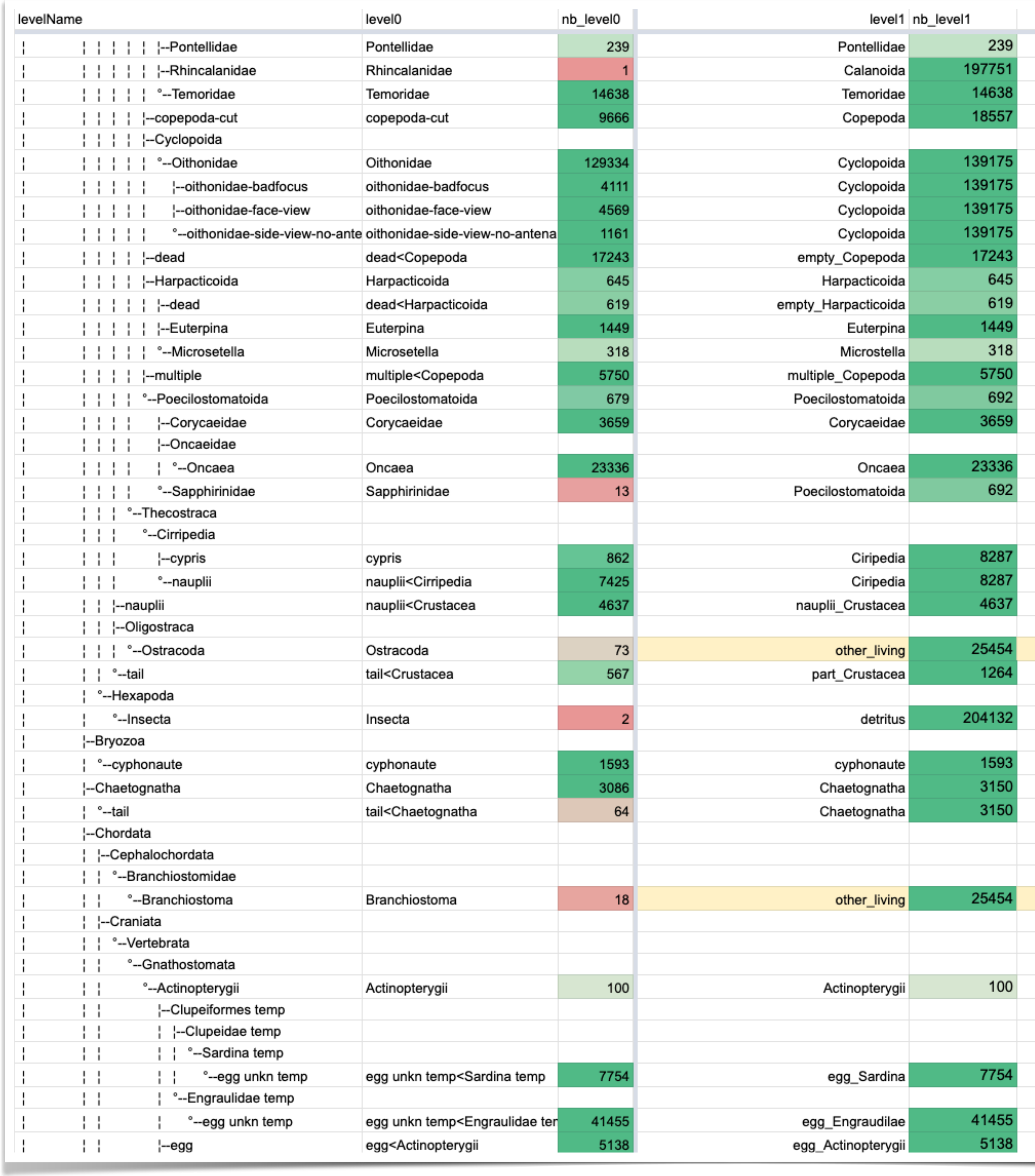


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

- include **every** object
- as **detailed as possible**… but small classes

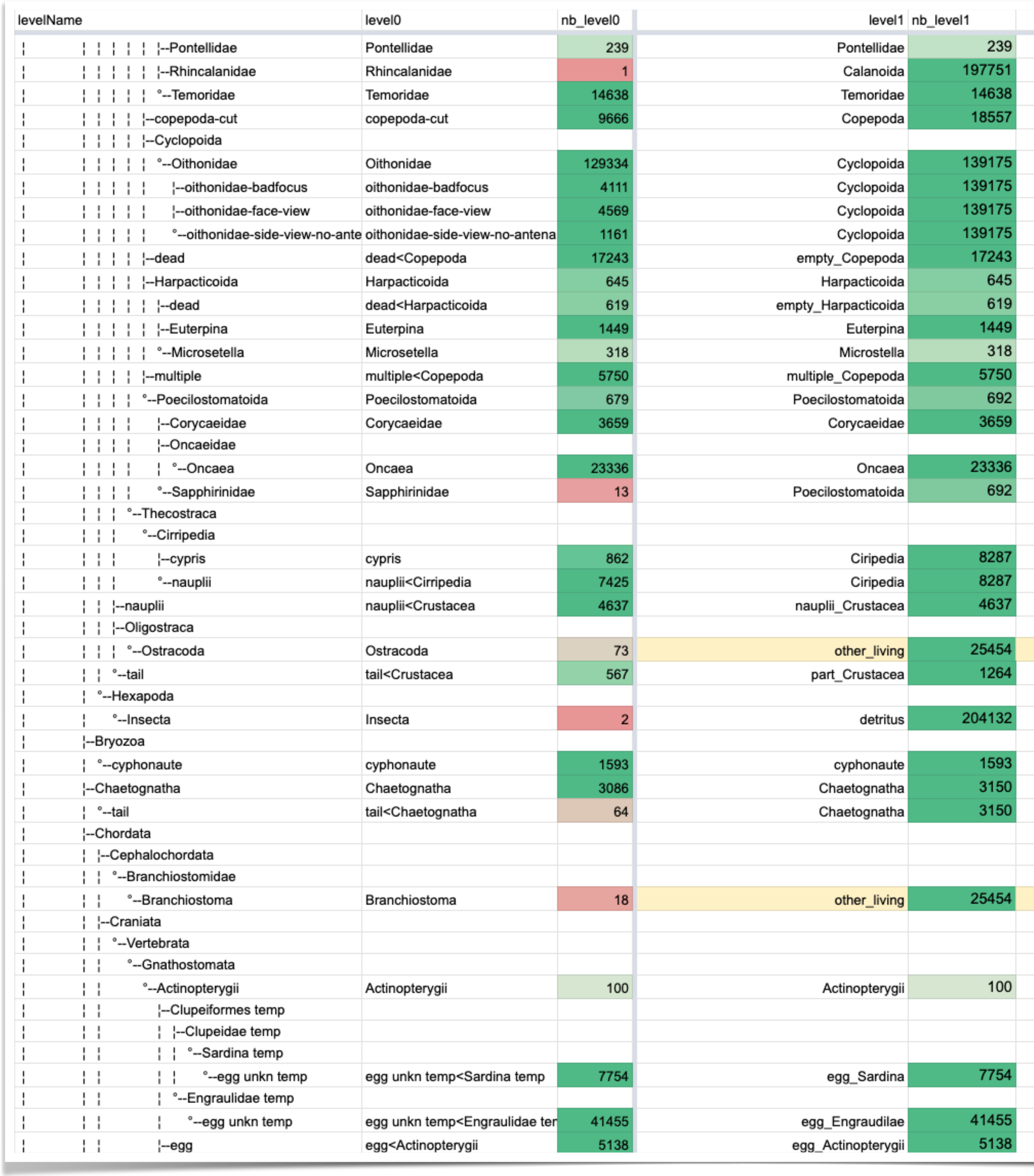


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

- include **every** object
- as **detailed as possible**… but small classes
  - if possible, merge with close relevant class

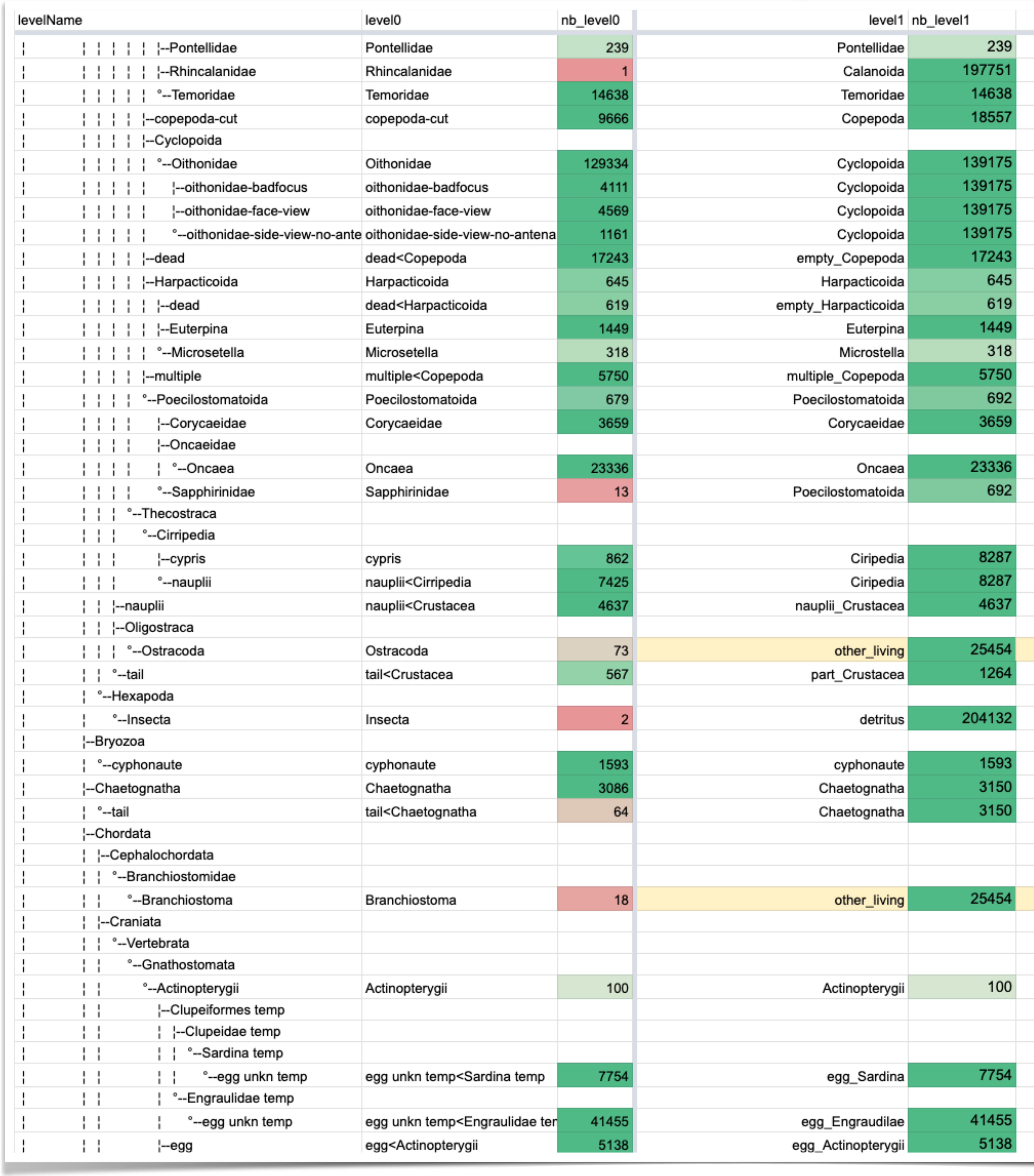


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

- include **every** object
- as **detailed as possible**… but small classes
    - if possible, merge with close relevant class
    - otherwise, merge with miscellaneous

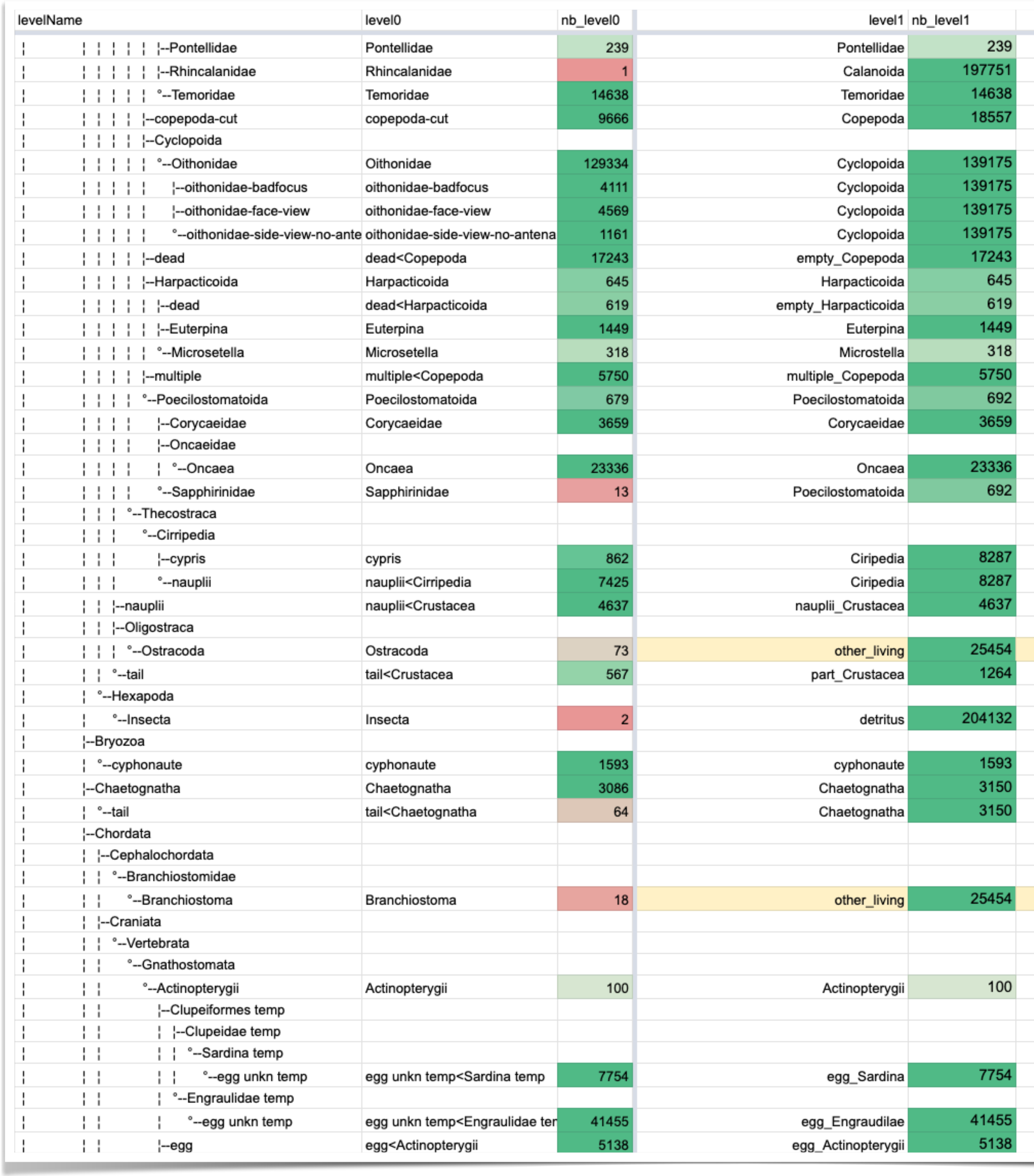


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

- include **every** object
- as **detailed as possible**… but small classes
    - if possible, merge with close relevant class
    - otherwise, merge with miscellaneous
- define **broader classes** corresponding to traditional approaches (e.g. Copepoda)

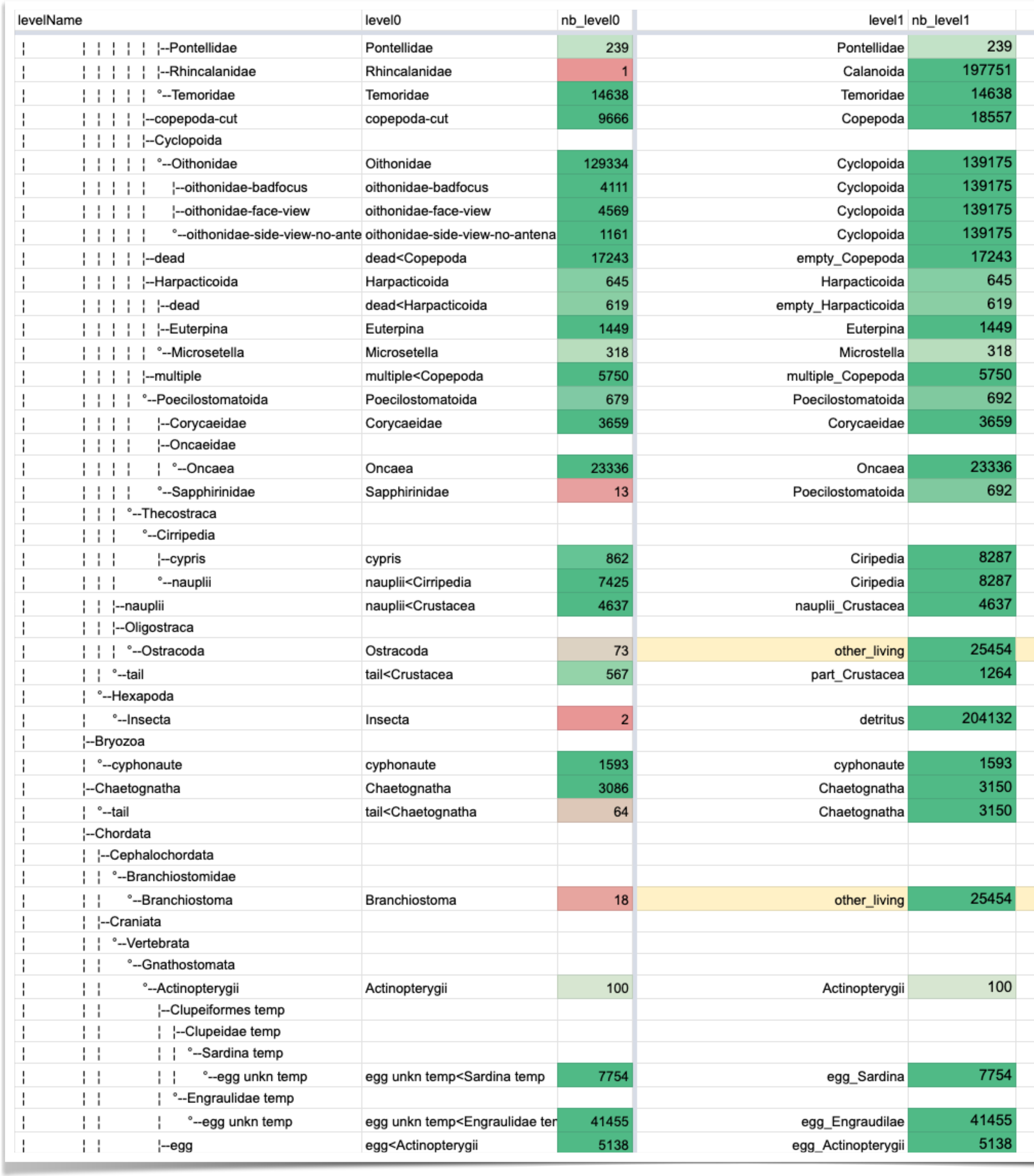


levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

Material & methods

Datasets – processing

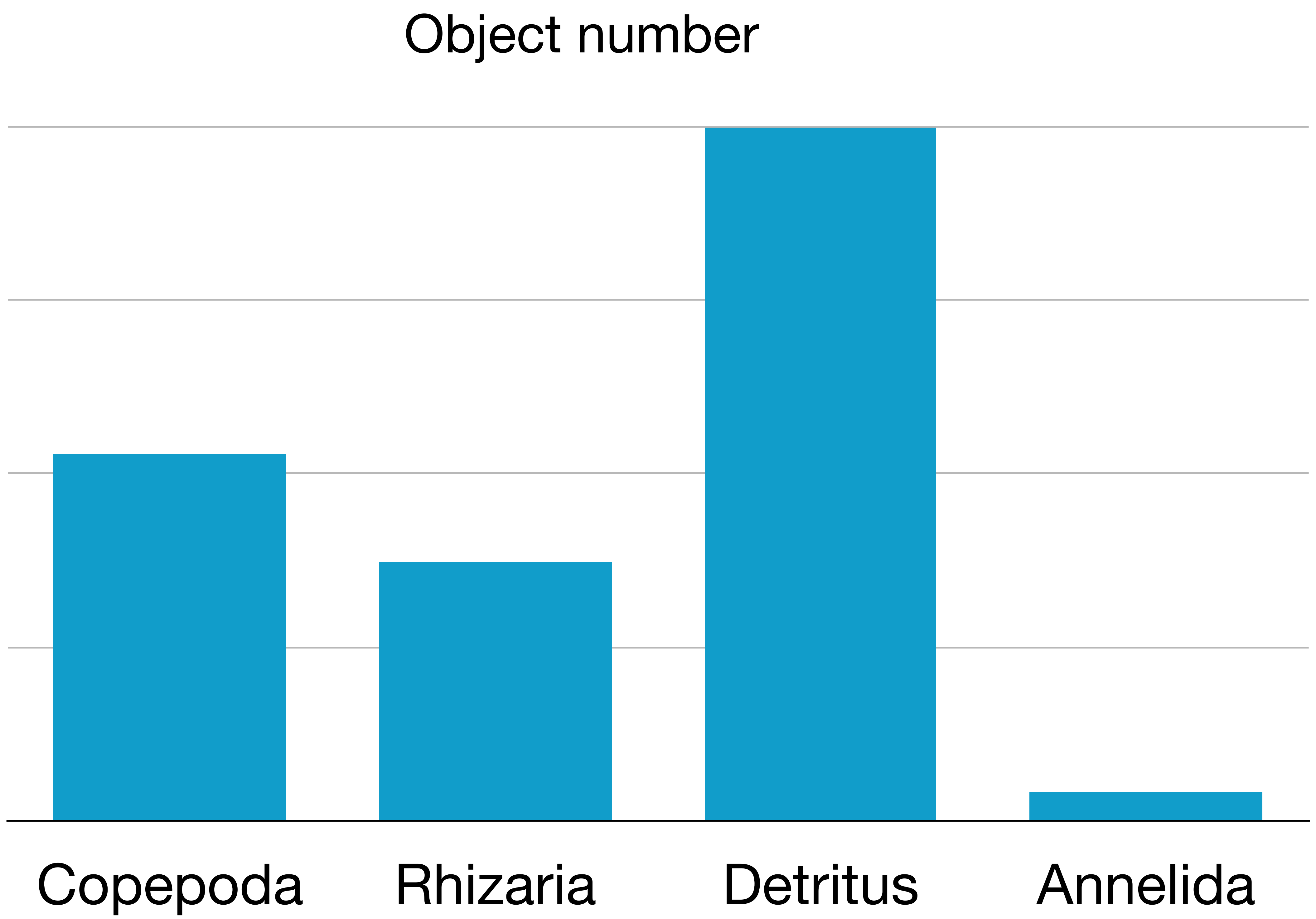
- include **every** object
- as **detailed as possible**… but small classes
  - if possible, merge with close relevant class
  - otherwise, merge with miscellaneous
- define **broader classes** corresponding to traditional approaches (e.g. Copepoda)
- categorise classes in **plankton classes** or not



levelName	level0	nb_level0	level1	nb_level1
¦ ¦ ¦ ¦ ¦ ¦ ¦--Pontellidae	Pontellidae	239	Pontellidae	239
¦ ¦ ¦ ¦ ¦ ¦ ¦--Rhincalanidae	Rhincalanidae	1	Calanoida	197751
¦ ¦ ¦ ¦ ¦ ¦ °--Temoridae	Temoridae	14638	Temoridae	14638
¦ ¦ ¦ ¦ ¦ ¦--copepoda-cut	copepoda-cut	9666	Copepoda	18557
¦ ¦ ¦ ¦ ¦ ¦--Cyclopoida				
¦ ¦ ¦ ¦ ¦ ¦ °--Oithonidae	Oithonidae	129334	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-badfocus	oithonidae-badfocus	4111	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ ¦--oithonidae-face-view	oithonidae-face-view	4569	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦ °--oithonidae-side-view-no-ante	oithonidae-side-view-no-antena	1161	Cyclopoida	139175
¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Copepoda	17243	empty_Copepoda	17243
¦ ¦ ¦ ¦ ¦ ¦--Harpacticoida	Harpacticoida	645	Harpacticoida	645
¦ ¦ ¦ ¦ ¦ ¦ ¦--dead	dead<Harpacticoida	619	empty_Harpacticoida	619
¦ ¦ ¦ ¦ ¦ ¦ ¦--Euterpina	Euterpina	1449	Euterpina	1449
¦ ¦ ¦ ¦ ¦ ¦ °--Microsetella	Microsetella	318	Microstella	318
¦ ¦ ¦ ¦ ¦ ¦--multiple	multiple<Copepoda	5750	multiple_Copepoda	5750
¦ ¦ ¦ ¦ ¦ °--Poecilostomatoida	Poecilostomatoida	679	Poecilostomatoida	692
¦ ¦ ¦ ¦ ¦ ¦--Corycaeidae	Corycaeidae	3659	Corycaeidae	3659
¦ ¦ ¦ ¦ ¦ ¦--Oncaeidae				
¦ ¦ ¦ ¦ ¦ ¦ °--Oncaea	Oncaea	23336	Oncaea	23336
¦ ¦ ¦ ¦ ¦ °--Sapphirinidae	Sapphirinidae	13	Poecilostomatoida	692
¦ ¦ ¦ ¦ °--Thecostraca				
¦ ¦ ¦ ¦ °--Cirripedia				
¦ ¦ ¦ ¦ ¦--cypris	cypris	862	Ciripedia	8287
¦ ¦ ¦ ¦ °--nauplii	nauplii<Cirripedia	7425	Ciripedia	8287
¦ ¦ ¦ ¦--nauplii	nauplii<Crustacea	4637	nauplii_Crustacea	4637
¦ ¦ ¦ ¦--Oligostraca				
¦ ¦ ¦ ¦ °--Ostracoda	Ostracoda	73	other_living	25454
¦ ¦ ¦ °--tail	tail<Crustacea	567	part_Crustacea	1264
¦ ¦ °--Hexapoda				
¦ ¦ °--Insecta	Insecta	2	detritus	204132
¦ ¦--Bryozoa				
¦ ¦ °--cyphonaute	cyphonaute	1593	cyphonaute	1593
¦ ¦--Chaetognatha	Chaetognatha	3086	Chaetognatha	3150
¦ ¦ °--tail	tail<Chaetognatha	64	Chaetognatha	3150
¦ ¦--Chordata				
¦ ¦ ¦--Cephalochordata				
¦ ¦ ¦ °--Branchiostomidae				
¦ ¦ ¦ °--Branchiostoma	Branchiostoma	18	other_living	25454
¦ ¦ ¦--Craniata				
¦ ¦ ¦ °--Vertebrata				
¦ ¦ ¦ °--Gnathostomata				
¦ ¦ ¦ °--Actinopterygii	Actinopterygii	100	Actinopterygii	100
¦ ¦ ¦ ¦--Clupeiformes temp				
¦ ¦ ¦ ¦ ¦--Clupeidae temp				
¦ ¦ ¦ ¦ ¦ °--Sardina temp				
¦ ¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Sardina temp	7754	egg_Sardina	7754
¦ ¦ ¦ ¦ °--Engraulidae temp				
¦ ¦ ¦ ¦ °--egg unkn temp	egg unkn temp<Engraulidae ter	41455	egg_Engraudilae	41455
¦ ¦ ¦ ¦--egg	egg<Actinopterygii	5138	egg_Actinopterygii	5138

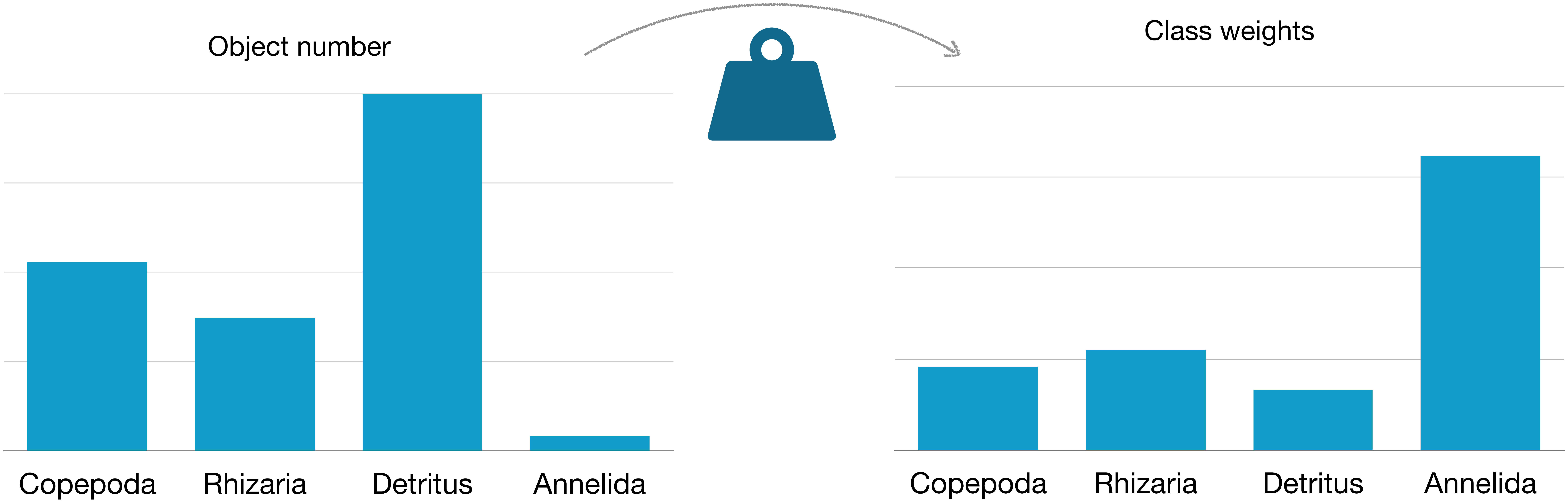
Material & methods

Models – class weights



Material & methods

Models – class weights



Material & methods

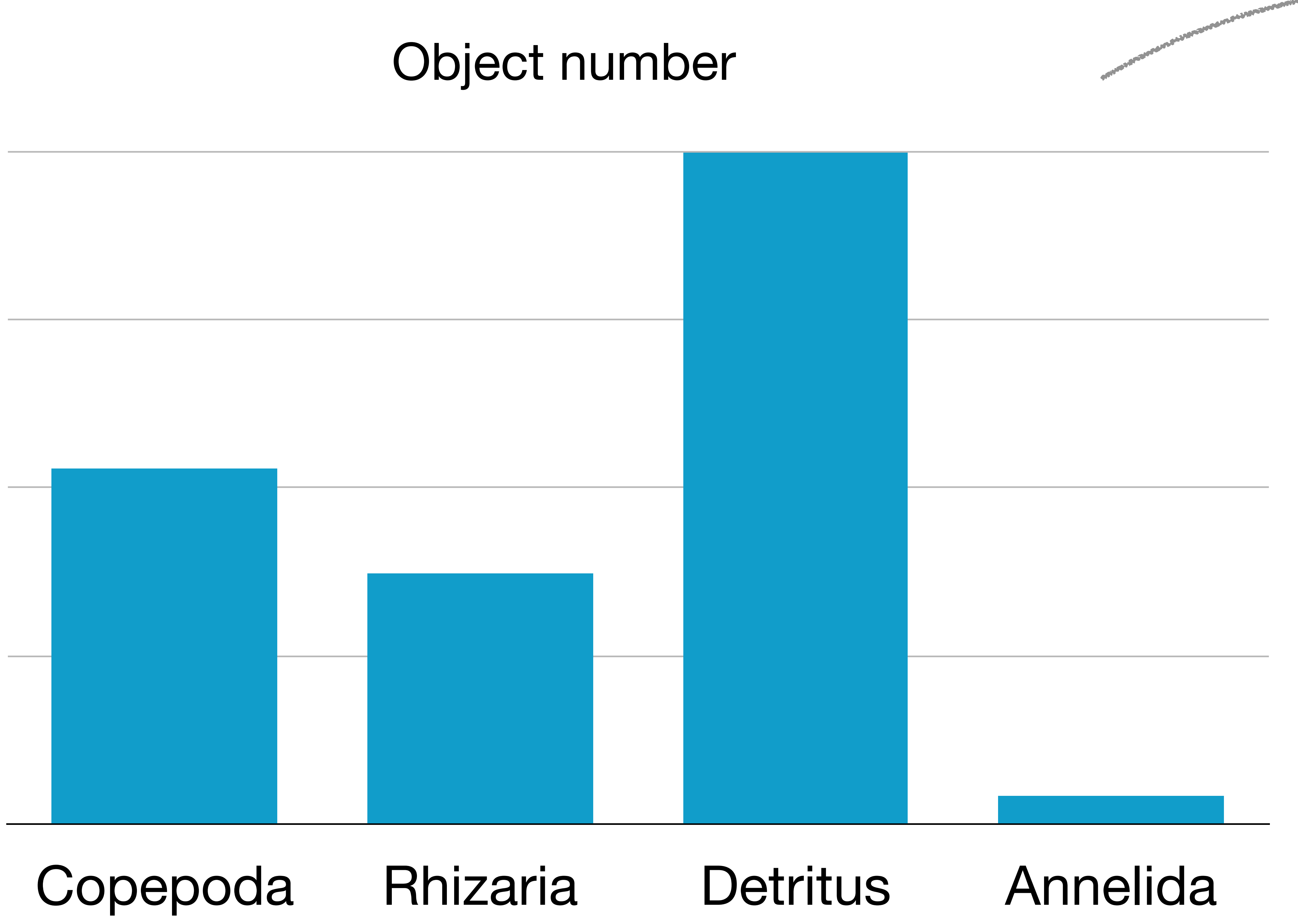
Models – class weights

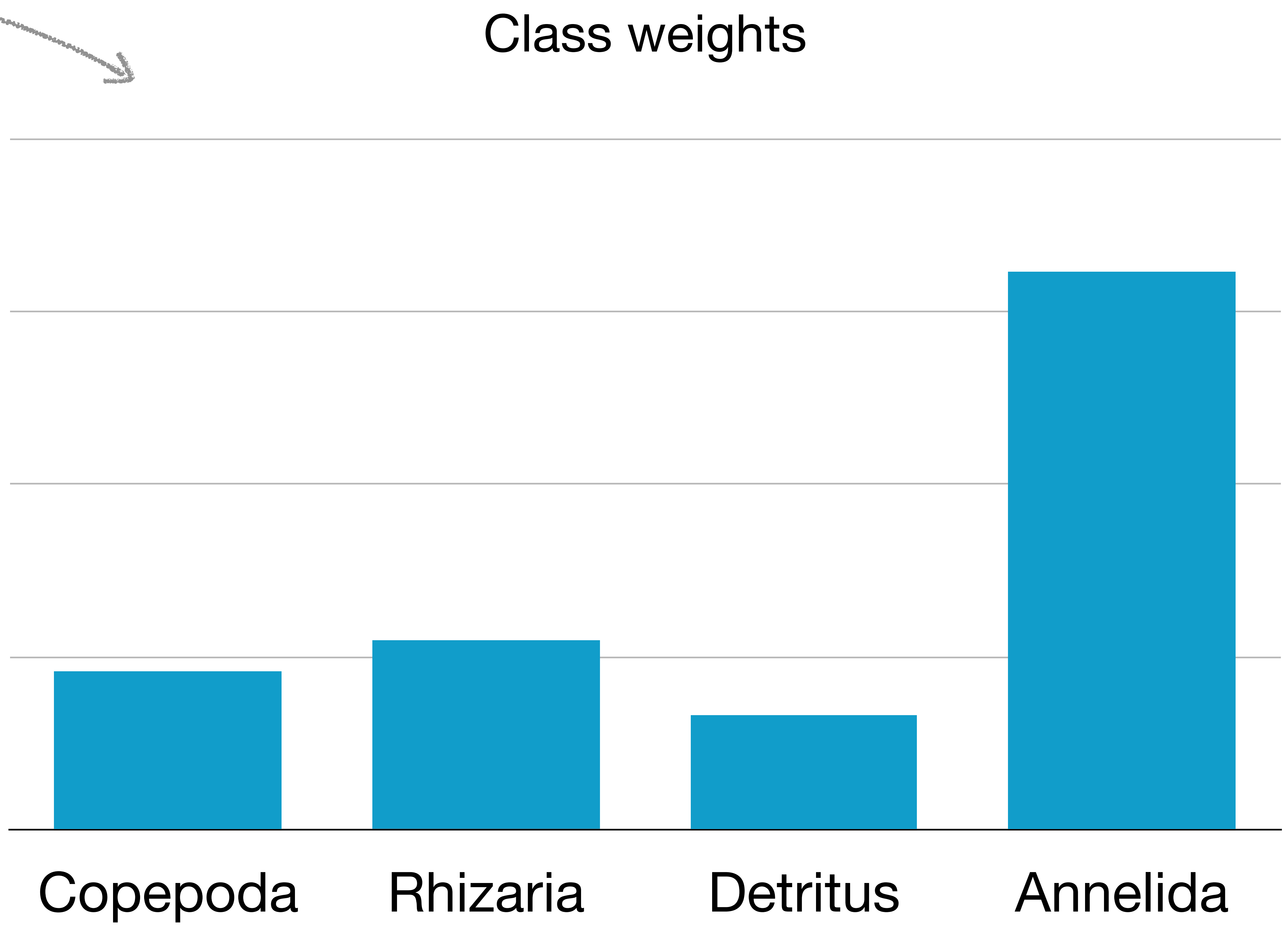
Weights for class *i*

Number of objects in largest class

$$W_i = \sqrt{\frac{c_{max}}{c_i}}$$

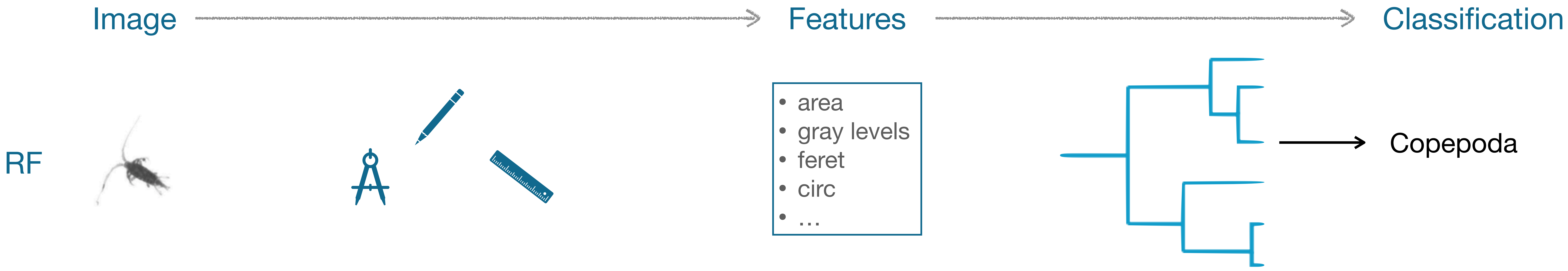
Number of objects in class *i*


Object number


Class weights

Material & methods

Models



Image

Features

Classification

RF

- area
- gray levels
- feret
- circ
- …

Copepoda

Material & methods

Models

Image → Features → Classification

RF

- area
- gray levels
- feret
- circ
- …

→ Copepoda

Gridsearch for hyperparameters

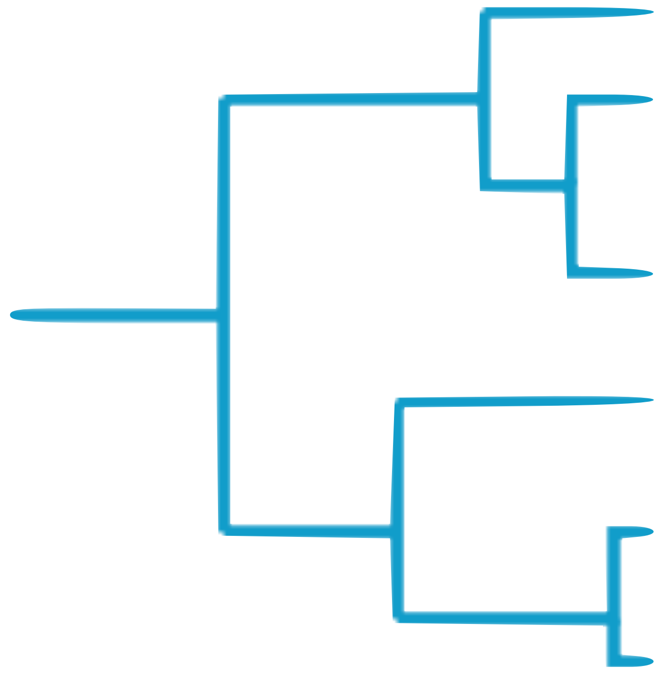
Material & methods

Models

Image → Features → Classification

RF

- area
- gray levels
- feret
- circ
- …

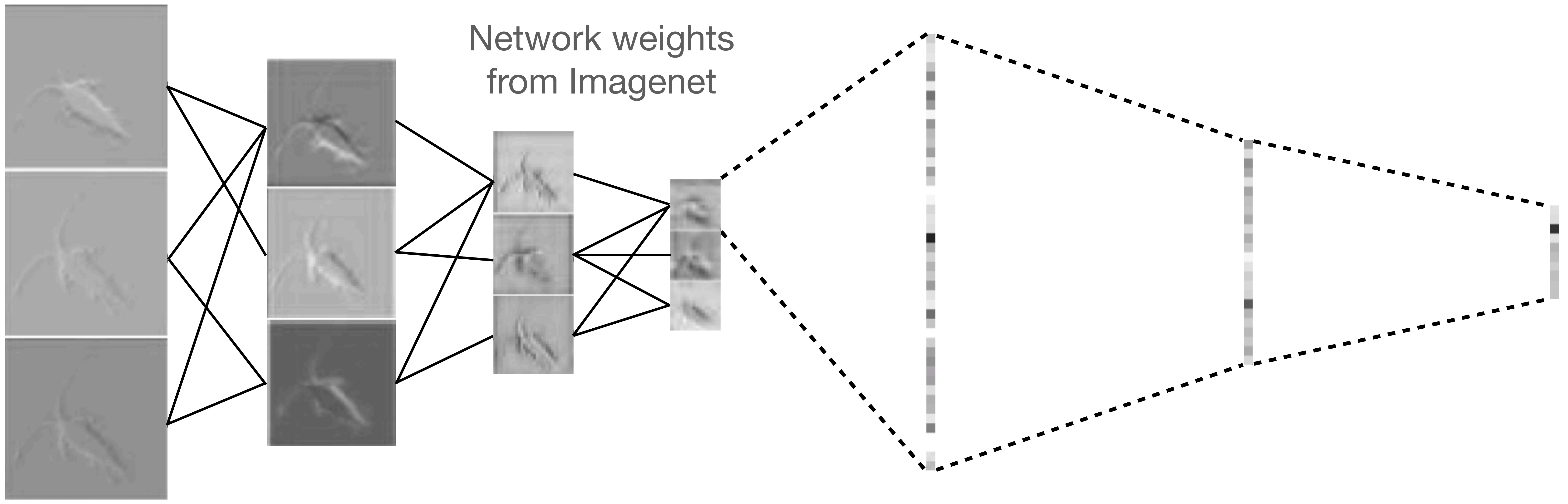


→ Copepoda

Gridsearch for hyperparameters

CNN

→


Network weights from Imagenet
Conv.
Pool.
…
Flatten
Fully connected layers & dropout
Classif.

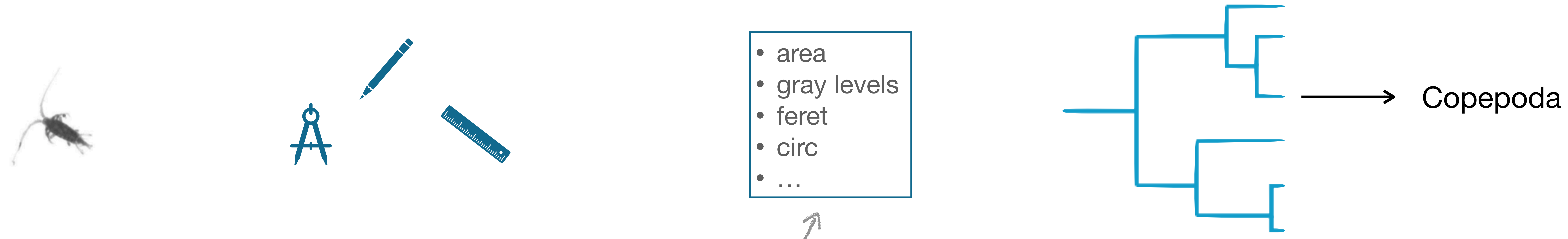
→ Copepoda

Material & methods

Models

Image → Features → Classification

RF



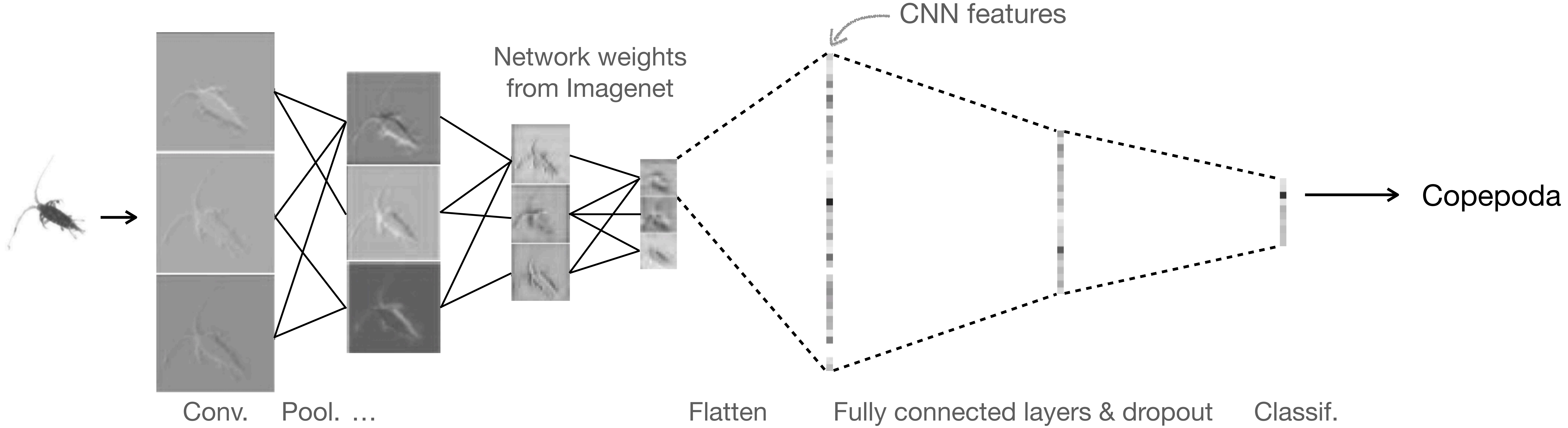
- area
- gray levels
- feret
- circ
- …

→ Copepoda

handcrafted features

Gridsearch for hyperparameters

CNN



CNN features

Network weights from Imagenet

→ Copepoda

Conv.
Pool.
…
Flatten
Fully connected layers & dropout
Classif.

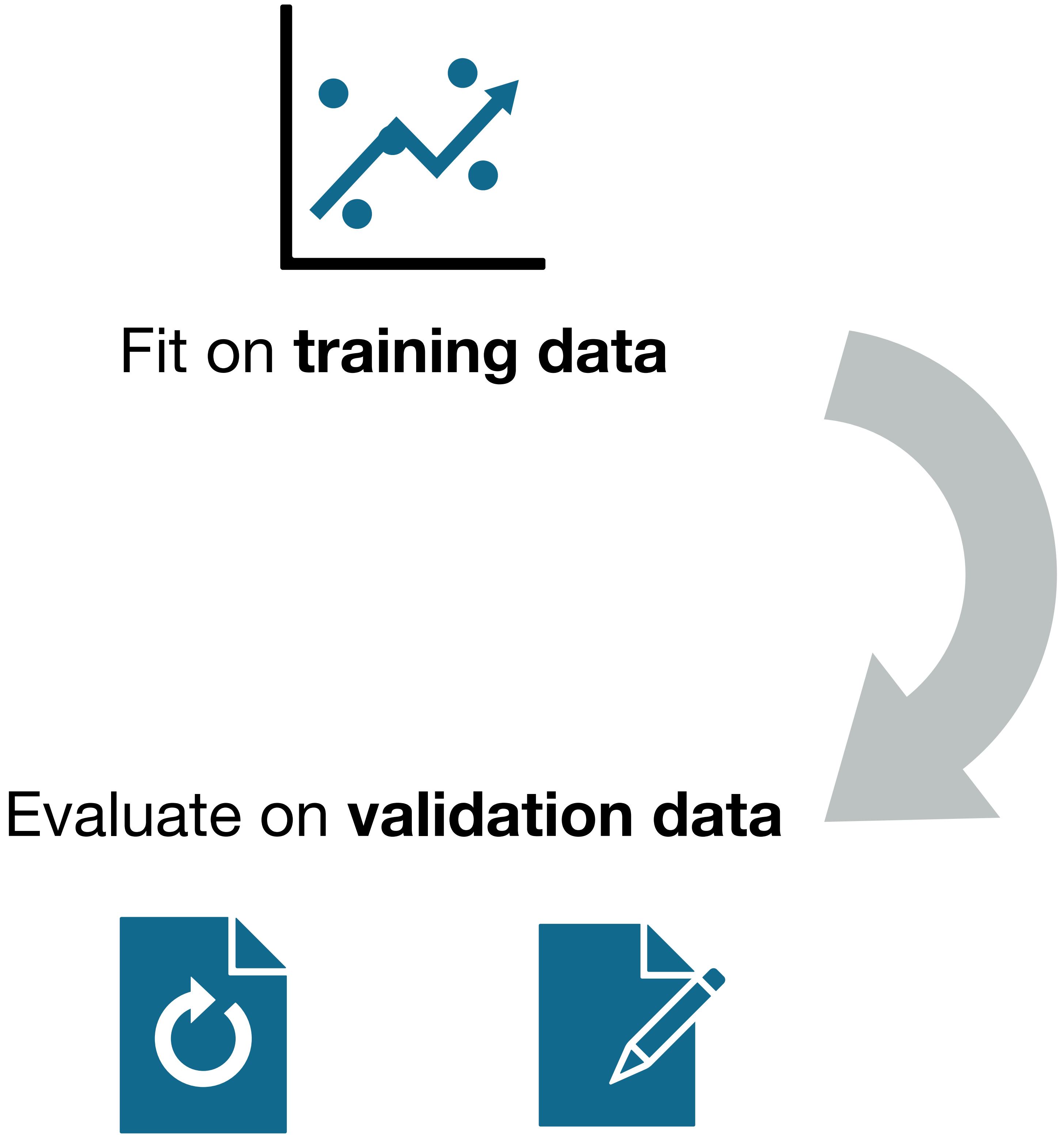
Material & methods

Models – training procedure

Fit on **training data**

Material & methods

Models – training procedure

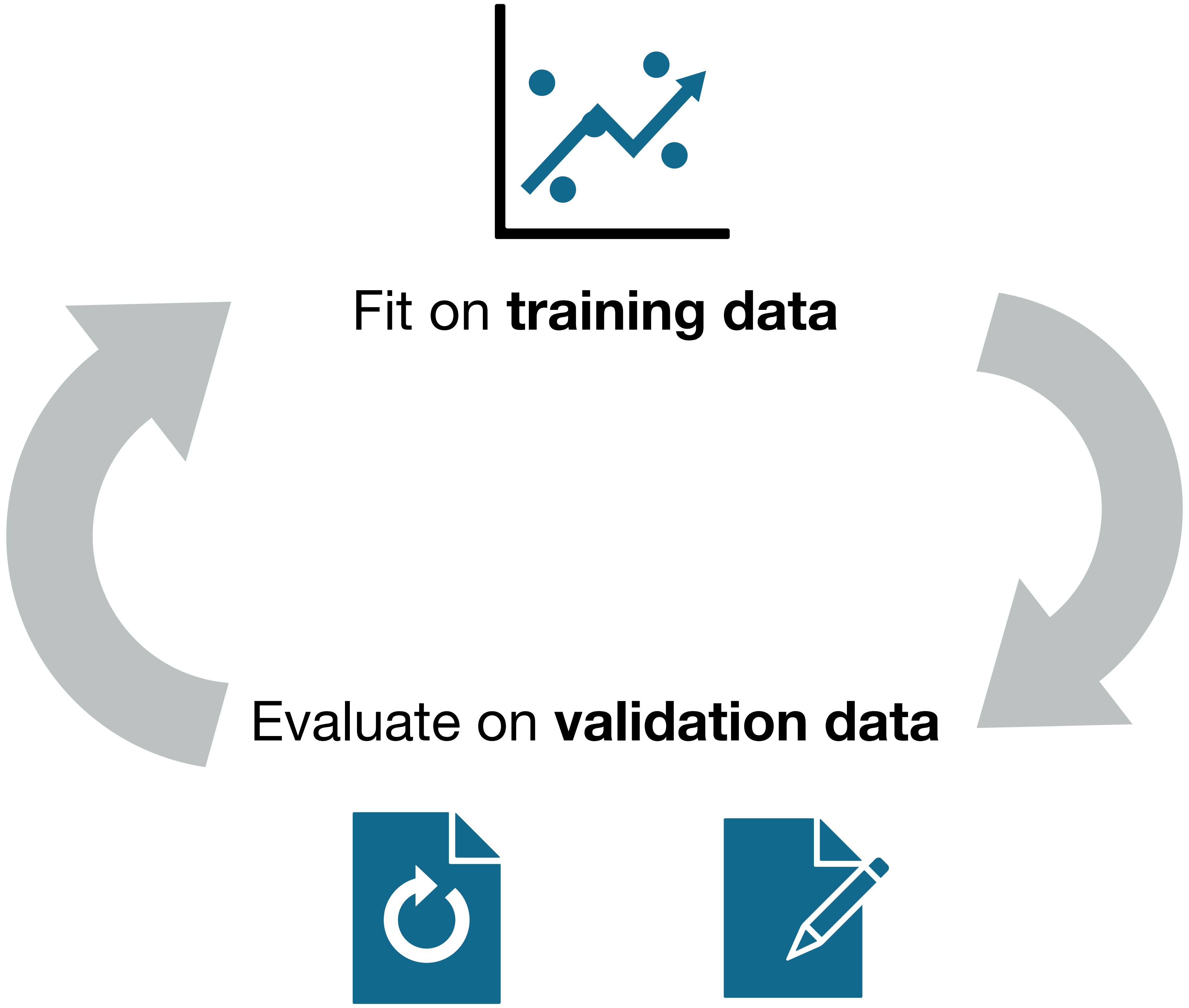


Fit on **training data**

Evaluate on **validation data**

Material & methods

Models – training procedure

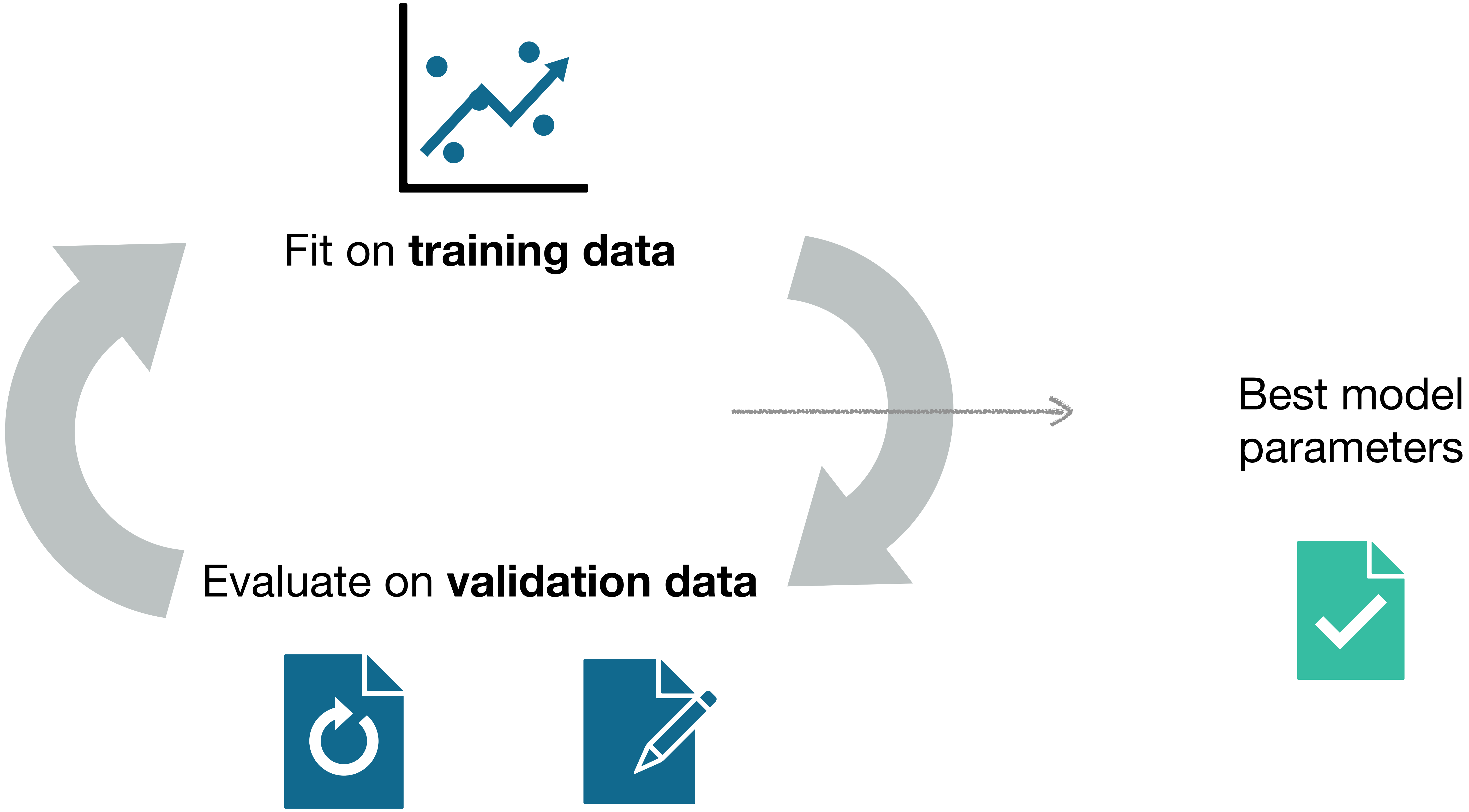


Fit on **training data**

Evaluate on **validation data**

Material & methods

Models – training procedure



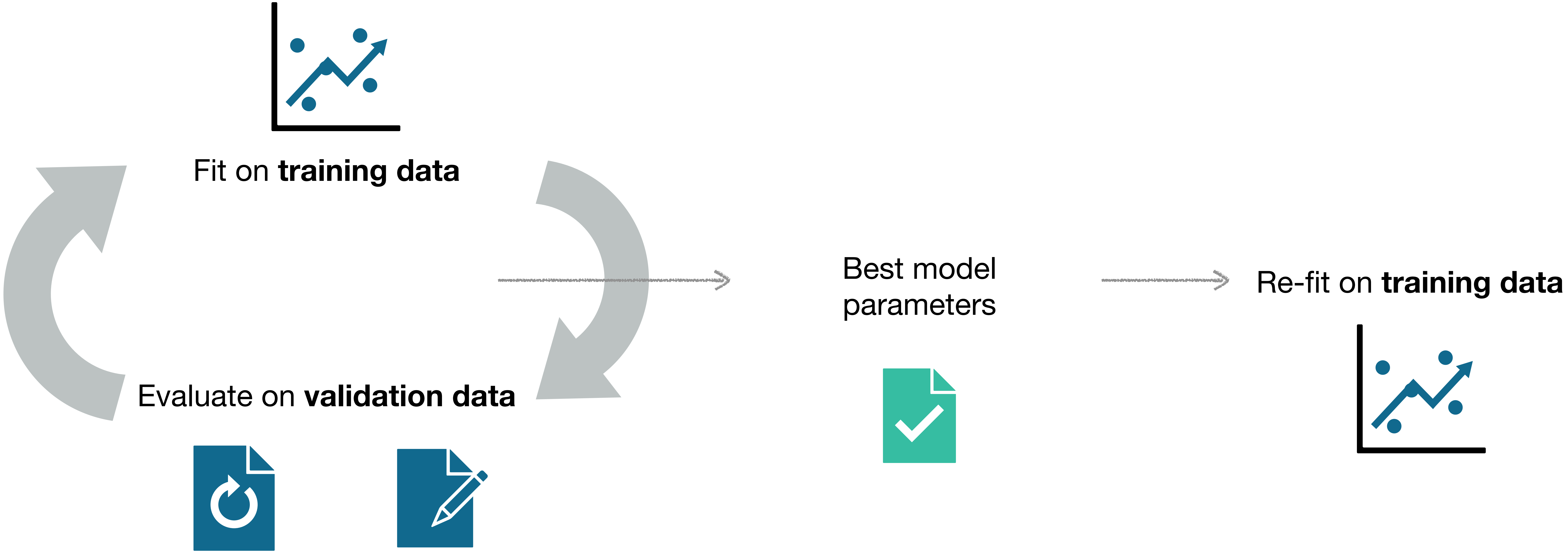
Fit on **training data**

Evaluate on **validation data**

Best model parameters

Material & methods

Models – training procedure



Fit on **training data**

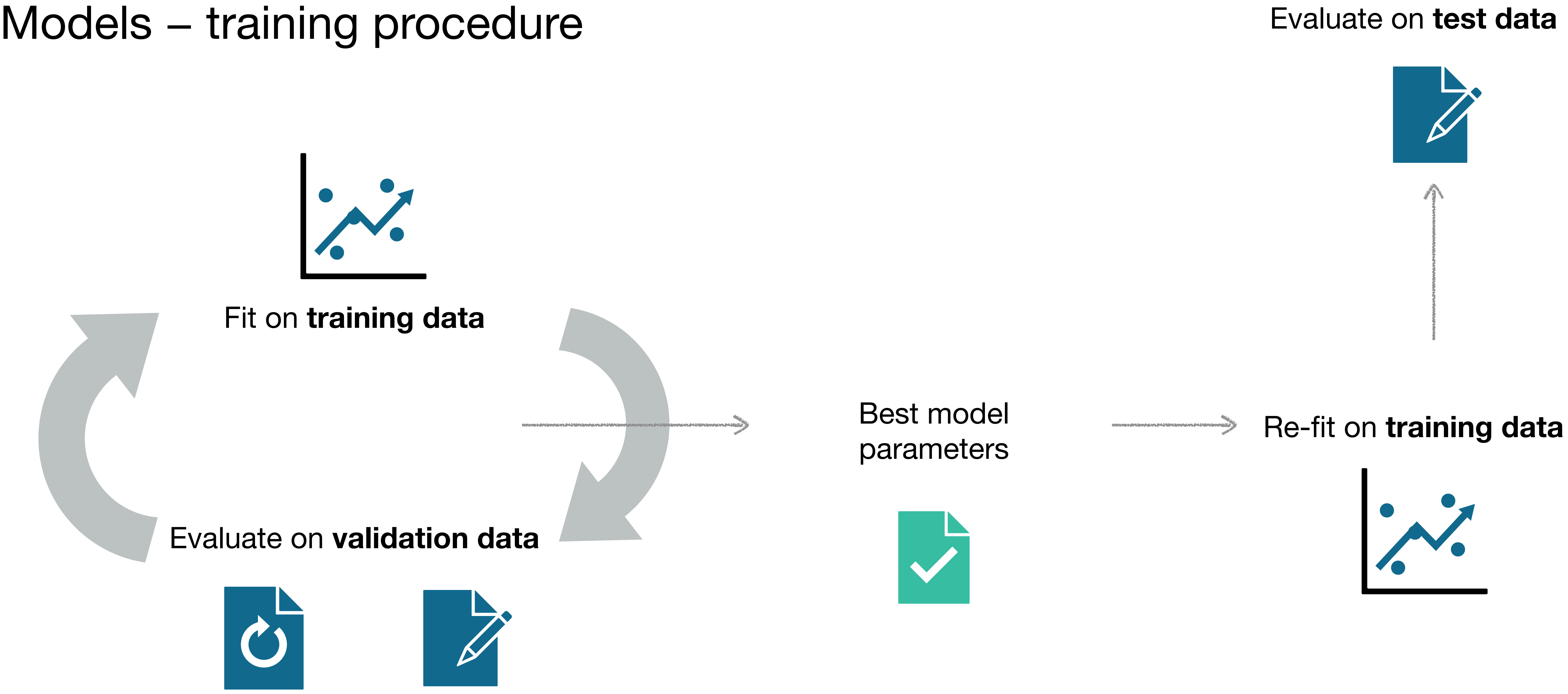
Evaluate on **validation data**

Best model parameters

Re-fit on **training data**

Material & methods

Models – training procedure



Fit on **training data**

Evaluate on **validation data**

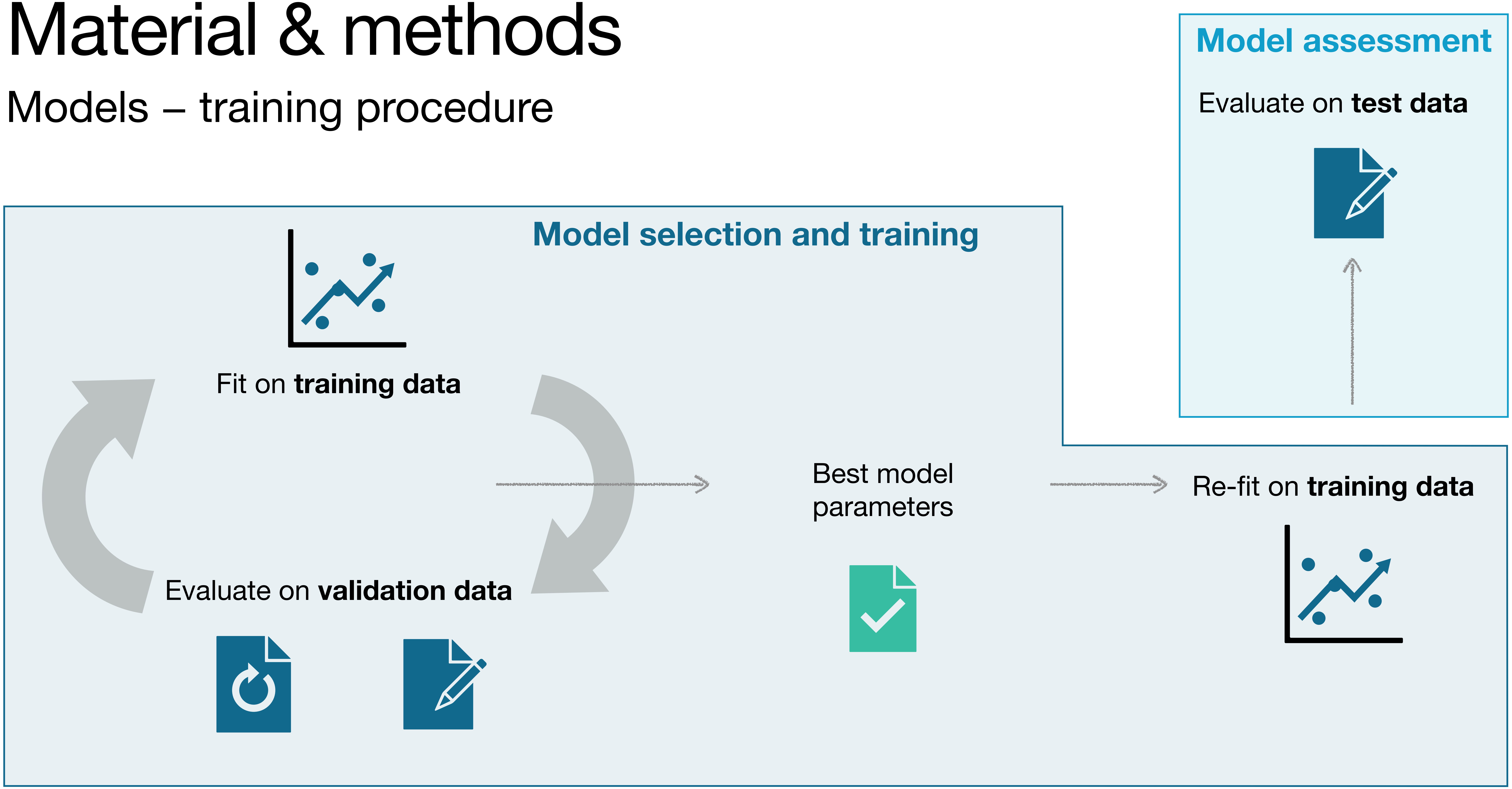
Best model parameters

Re-fit on **training data**

Evaluate on **test data**

Material & methods

Models – training procedure



Model selection and training

Fit on **training data**

Evaluate on **validation data**

Best model parameters

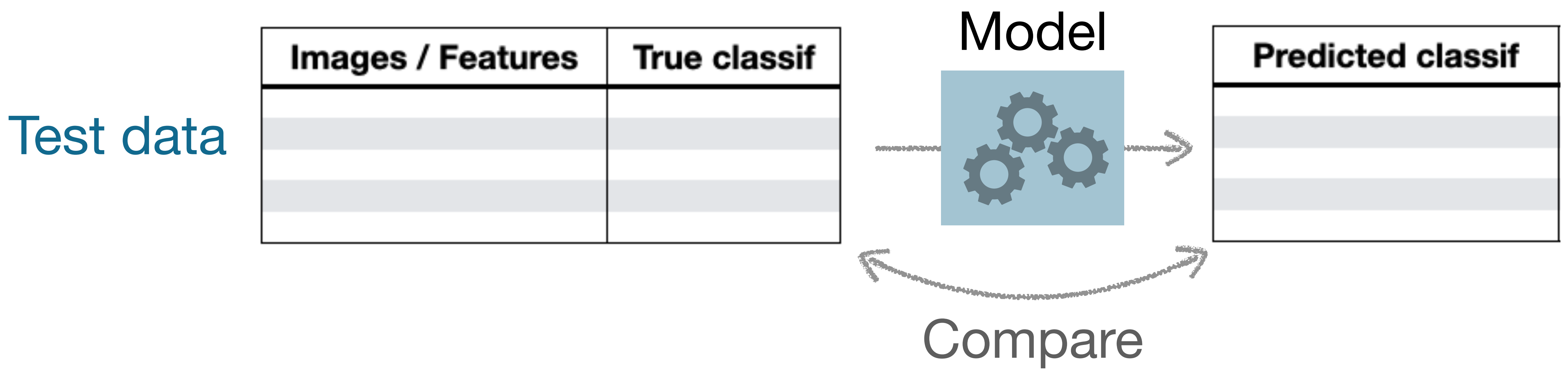
Re-fit on **training data**

Model assessment

Evaluate on **test data**

Material & methods

Model evaluation



Test data

Images / Features	True classif

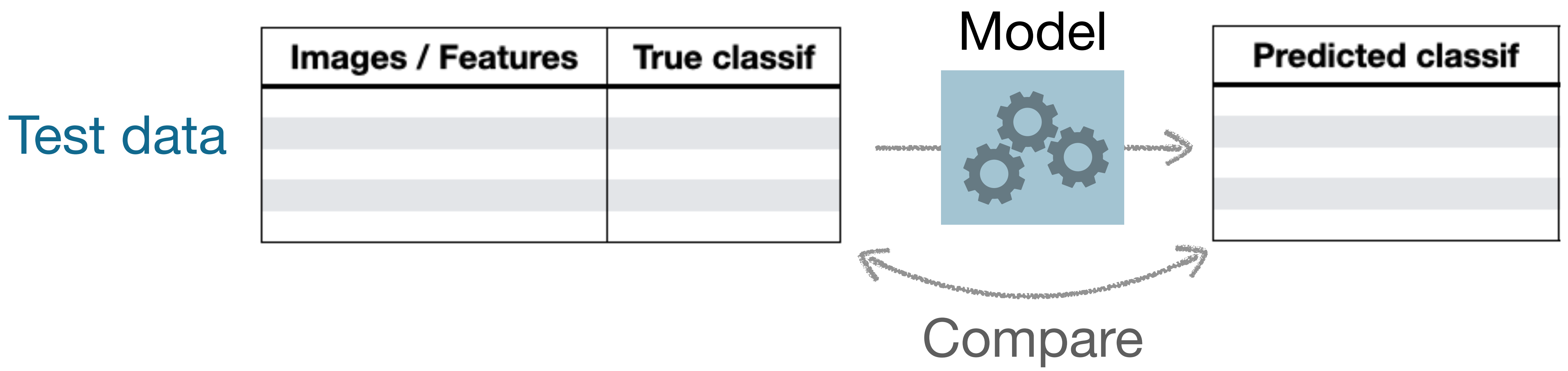
Model

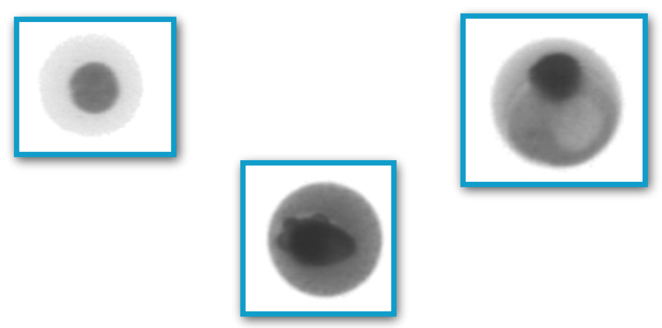
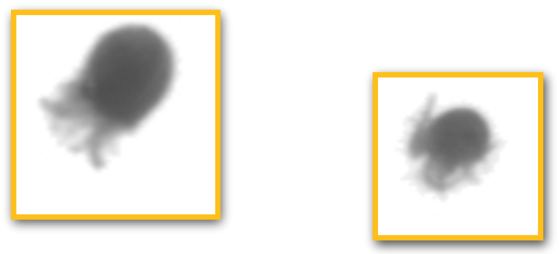
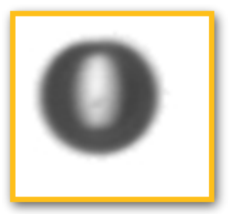
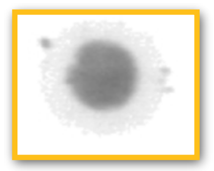
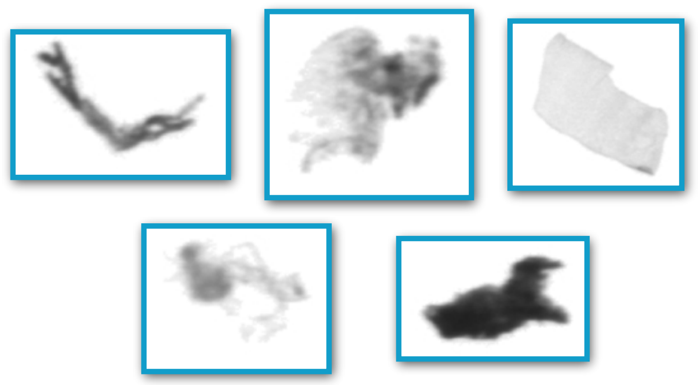
Predicted classif

Compare

Material & methods

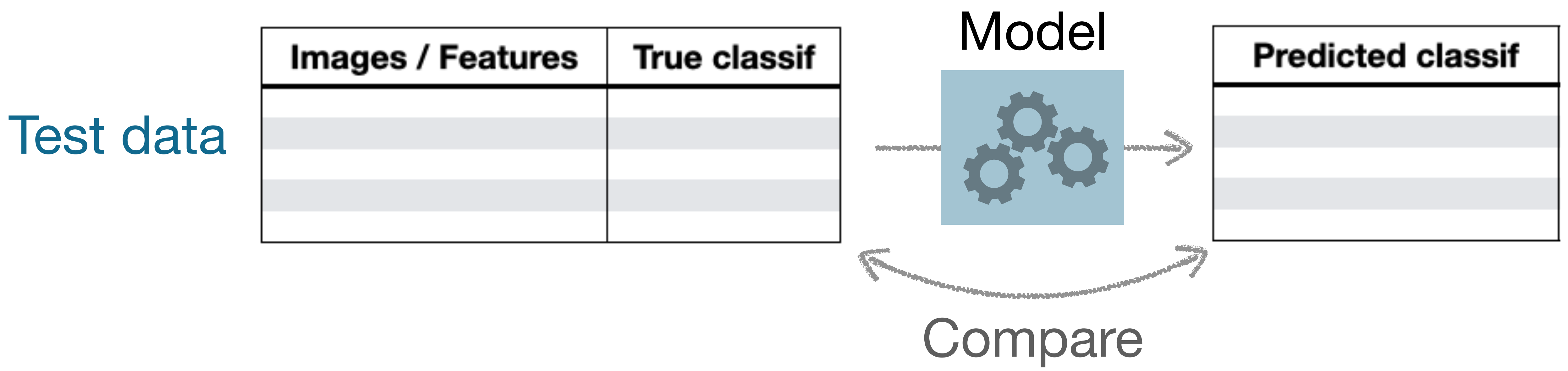
Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

		Truth		
		Egg	**Copepoda**	**Detritus**
Prediction	**Egg**			
	Copepoda			
	Detritus			

Material & methods

Model evaluation



Test data

Images / Features	True classif

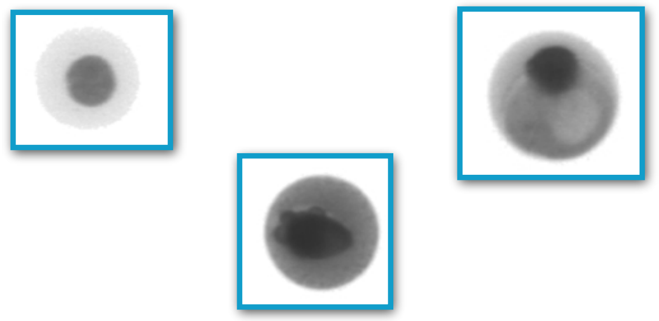
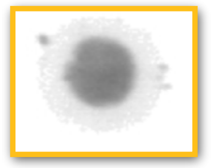
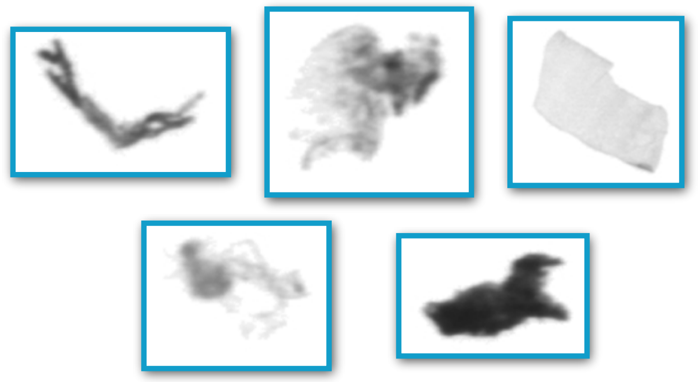
Model

Predicted classif

Compare

Truth

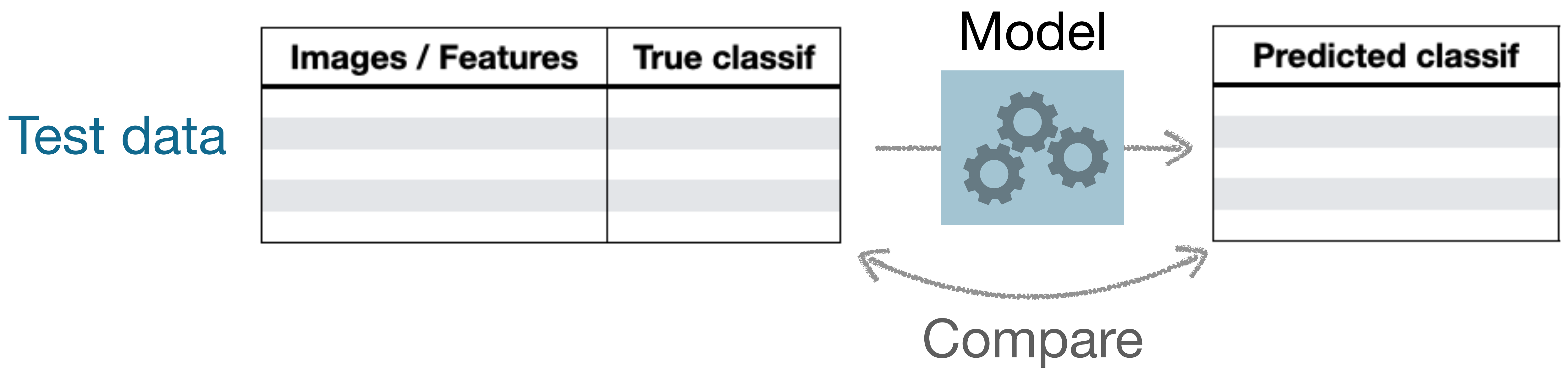
Prediction

	Egg	**Copepoda**	**Detritus**
Egg			
Copepoda			
Detritus			

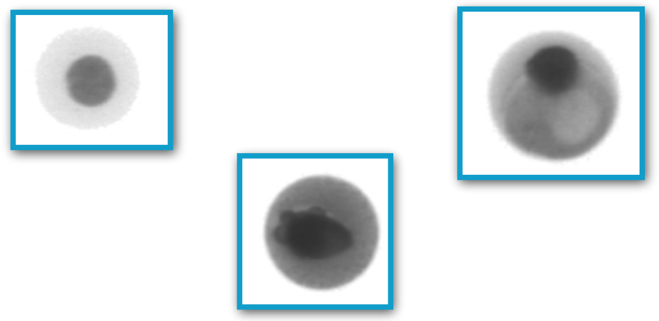
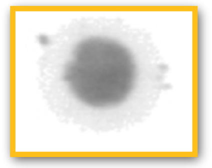
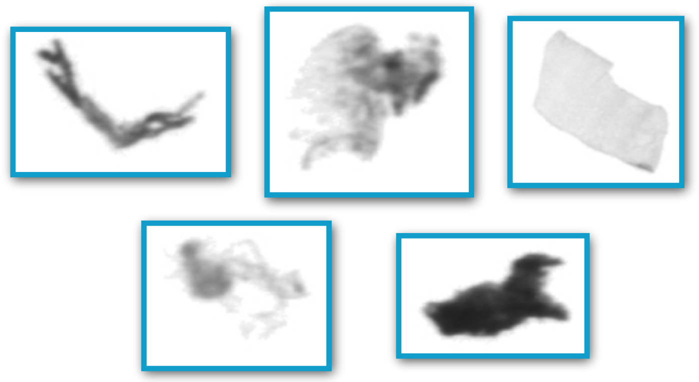
Accuracy

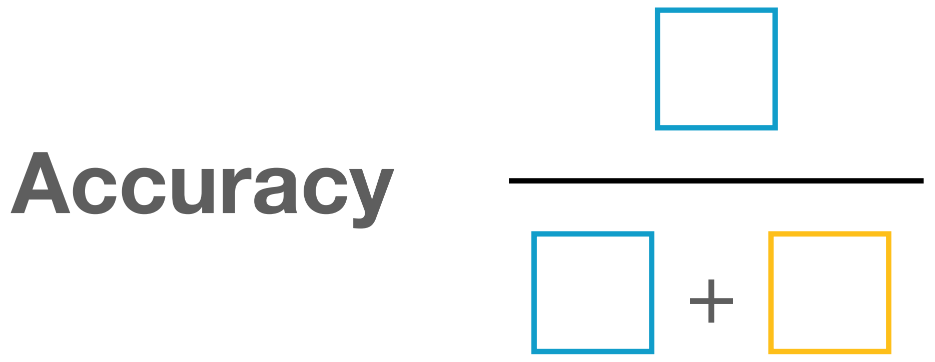
Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

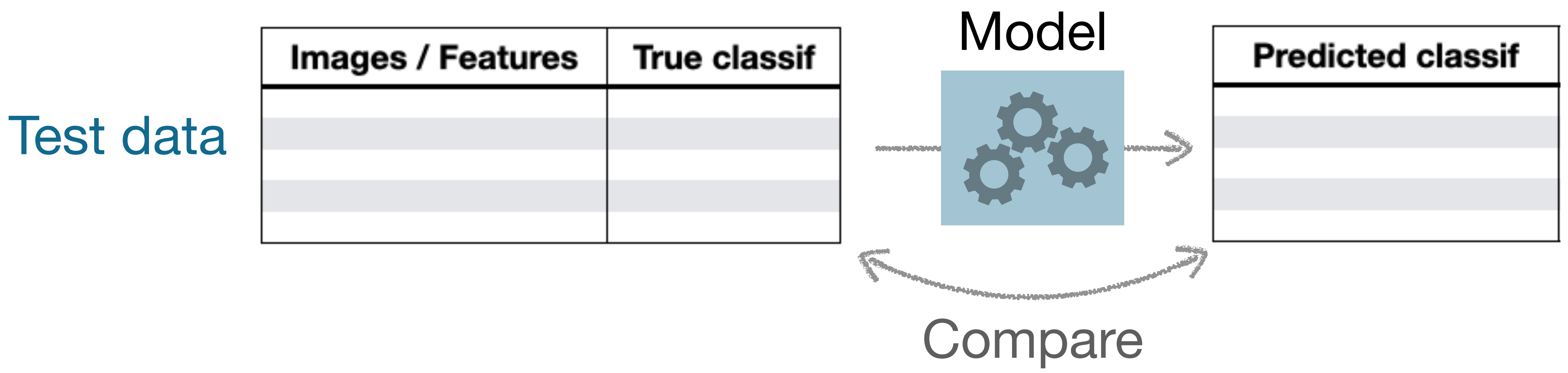
Truth

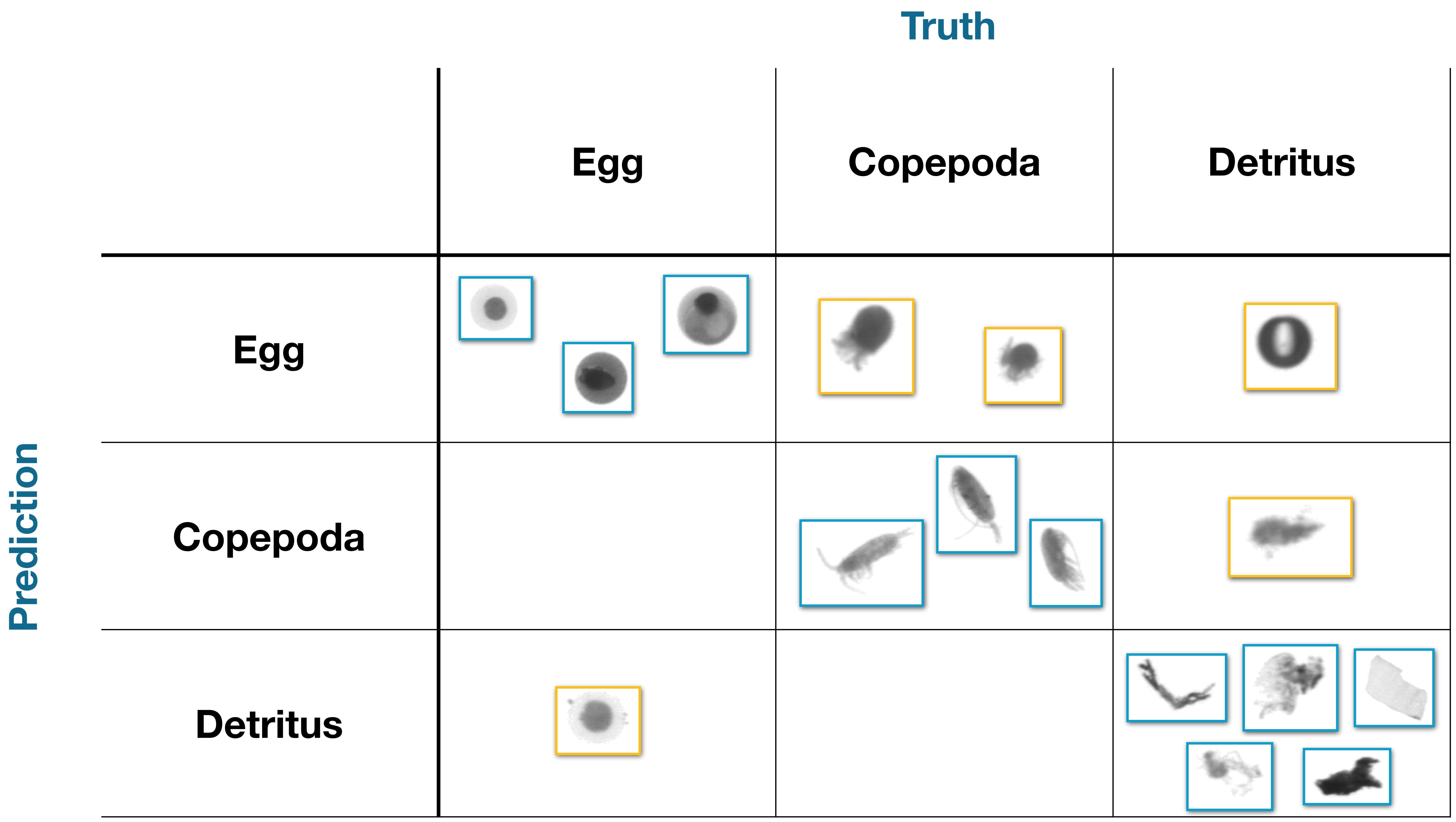
Prediction	**Egg**	**Copepoda**	**Detritus**
Egg			
Copepoda			
Detritus			



Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

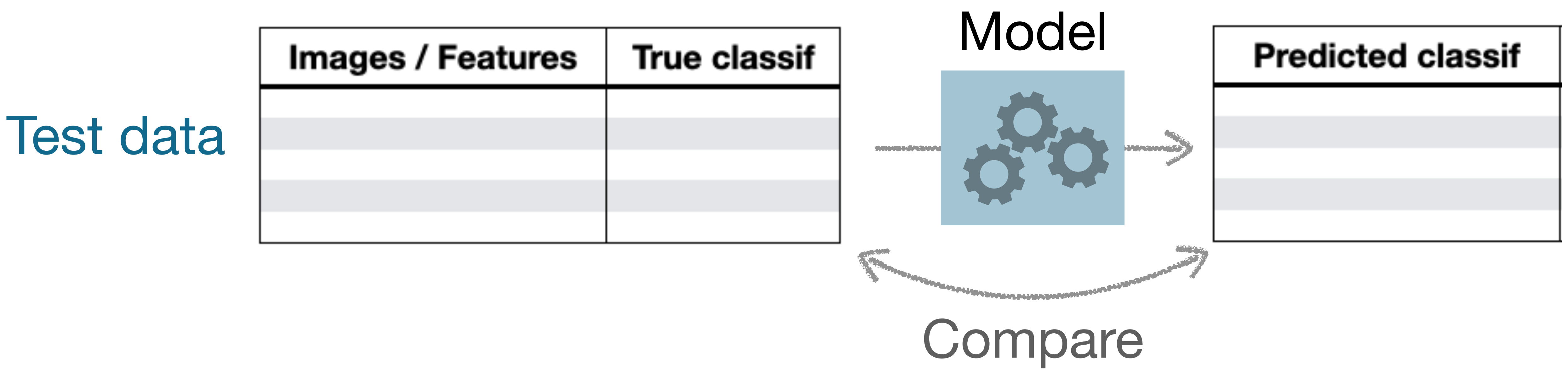

Truth
Prediction
Egg
Copepoda
Detritus
Egg
Copepoda
Detritus

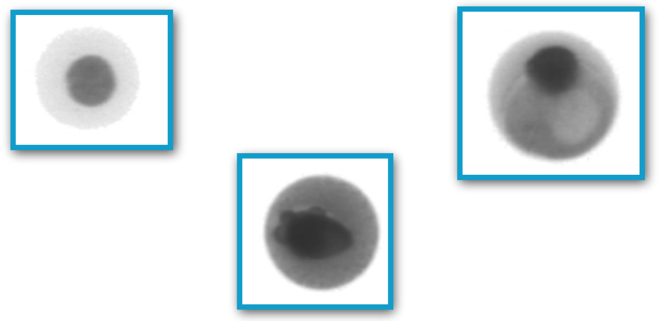
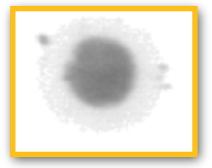
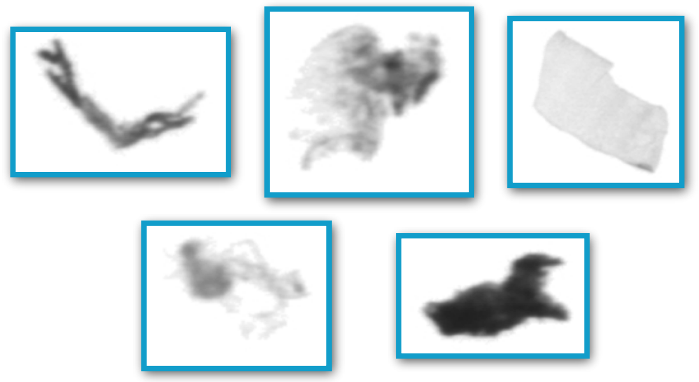
Accuracy $\frac{\square}{\square + \square}$

Balanced accuracy

Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

		Truth		
		Egg	**Copepoda**	**Detritus**
Prediction	**Egg**			
	Copepoda			
	Detritus			

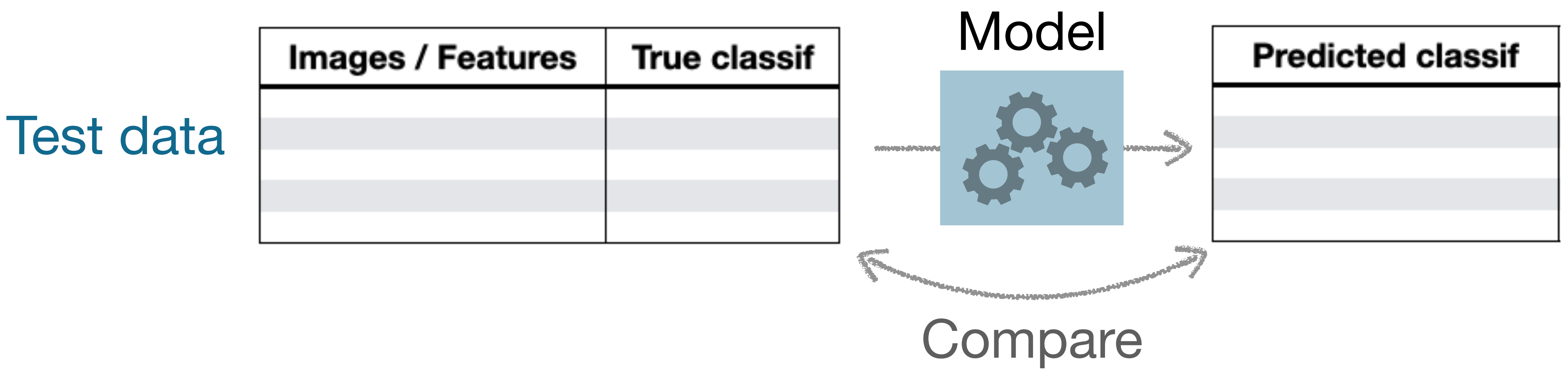
Accuracy $\frac{\color{blue}\square}{\color{blue}\square + \color{orange}\square}$

Balanced accuracy

Weighted plankton precision

Material & methods

Model evaluation

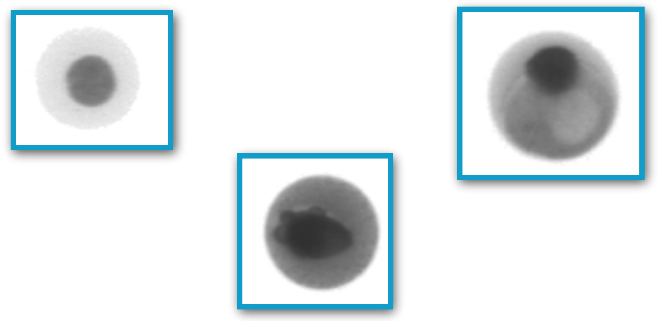
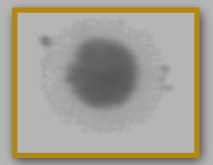
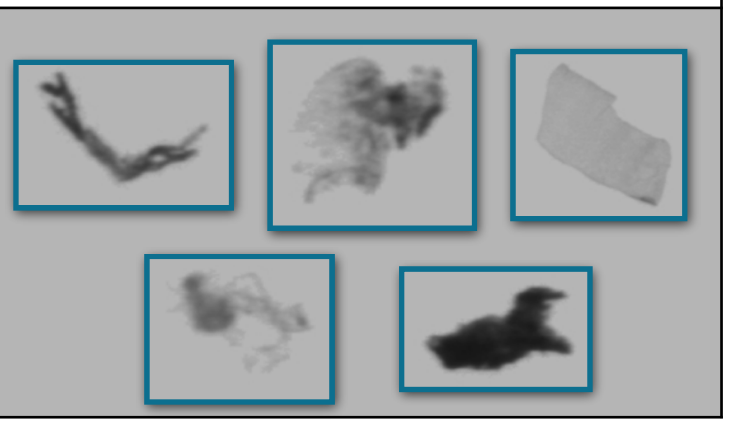

Test data

Images / Features	True classif

Model

Predicted classif

Compare

		Truth			
		Egg	**Copepoda**	**Detritus**	
Prediction	**Egg**				3/6
	Copepoda				3/4
	Detritus				

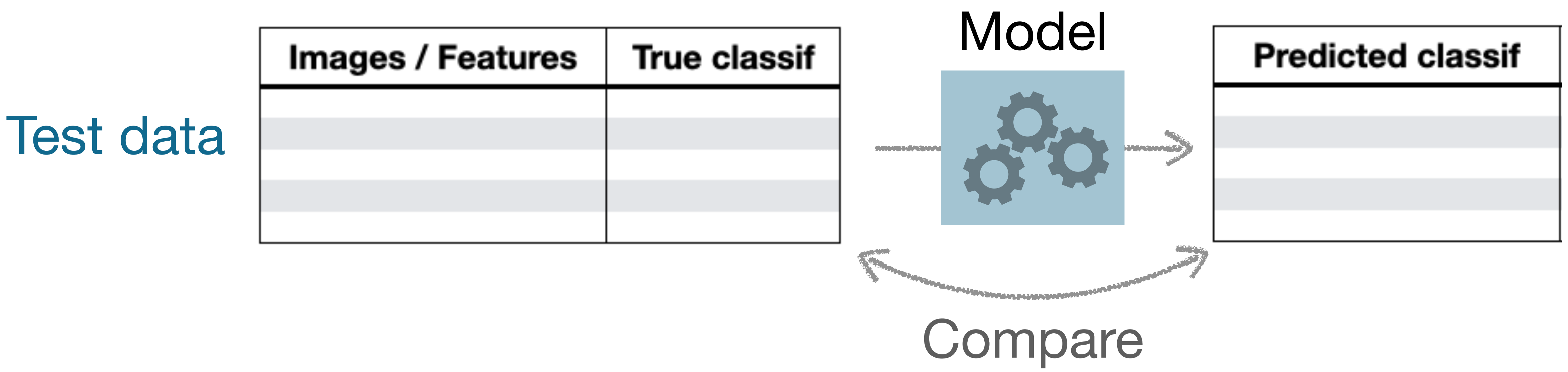
Accuracy $\frac{\square}{\square + \square}$

Balanced accuracy

Weighted plankton precision

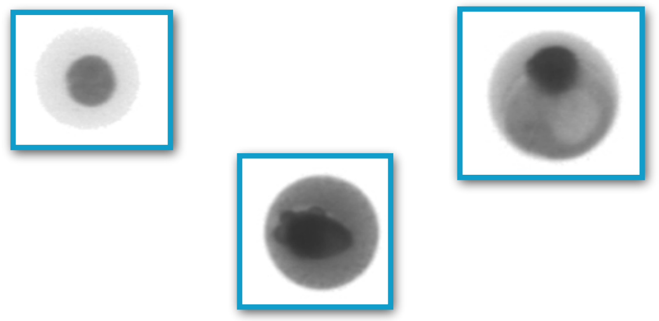
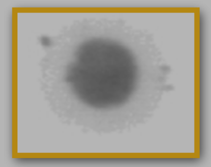
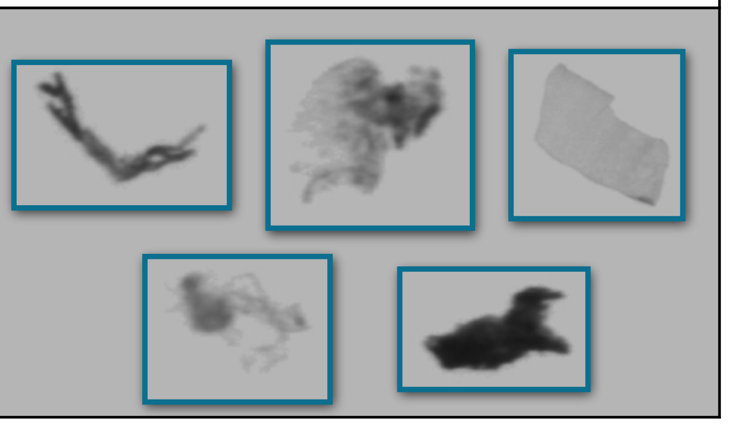
Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

Truth

Prediction

	Egg	**Copepoda**	**Detritus**	
Egg				3/6
Copepoda				3/4
Detritus				

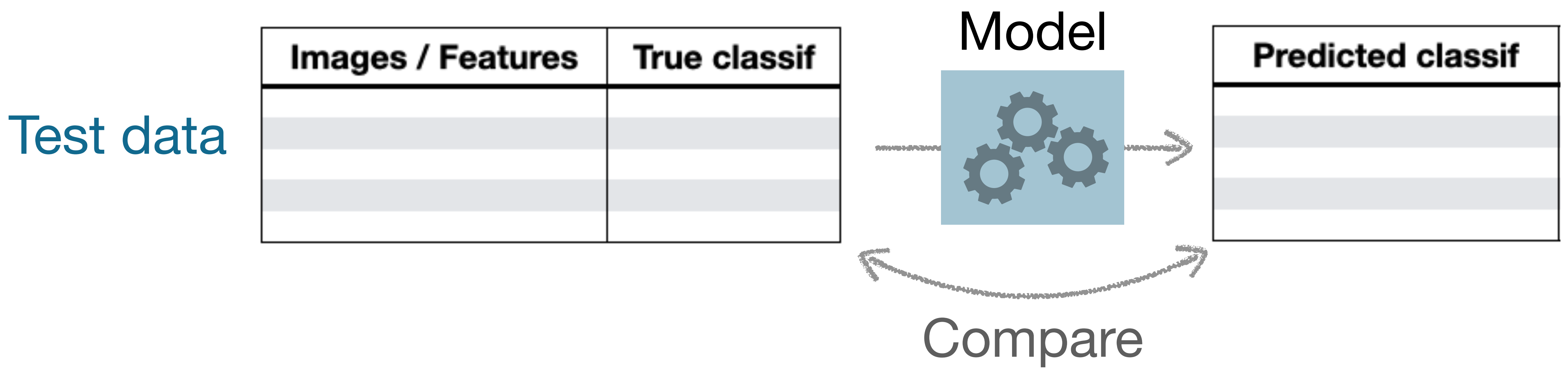
Accuracy $\frac{\square}{\square + \square}$

Balanced accuracy

Weighted plankton precision 60%

Material & methods

Model evaluation



Test data

Images / Features	True classif

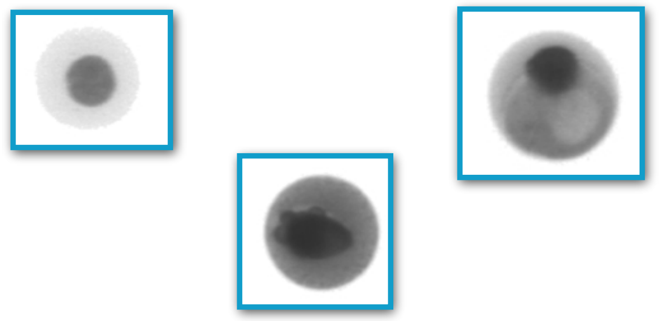
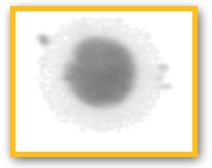
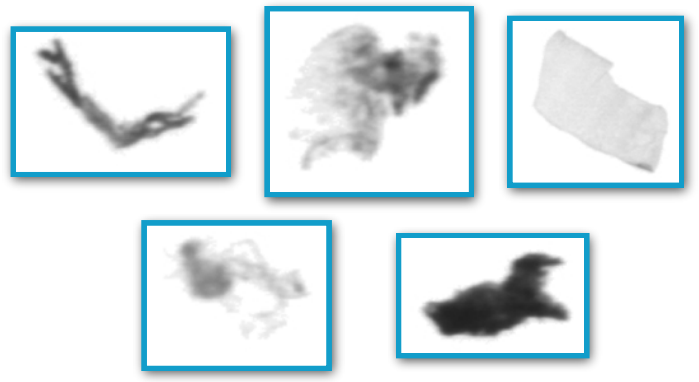
Model

Predicted classif

Compare

Truth

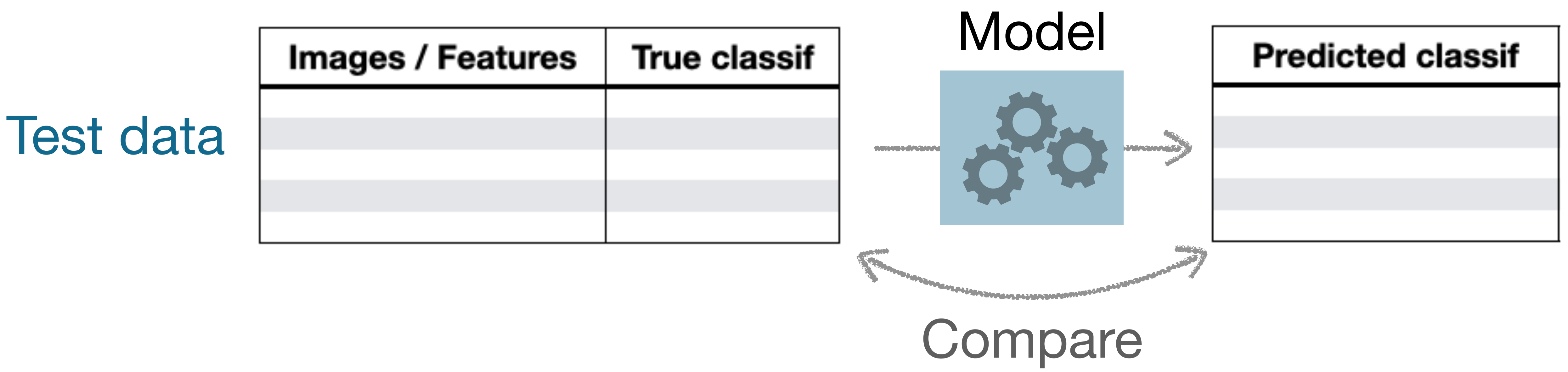
Prediction

	Egg	**Copepoda**	**Detritus**
Egg			
Copepoda			
Detritus			

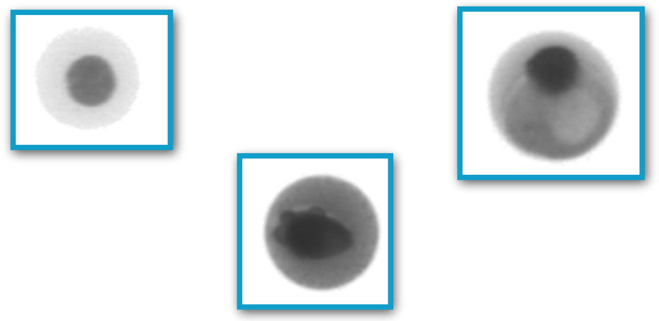
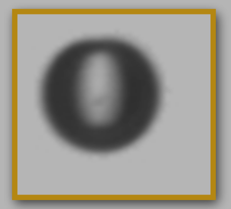
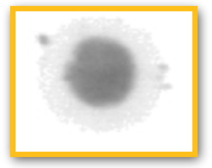
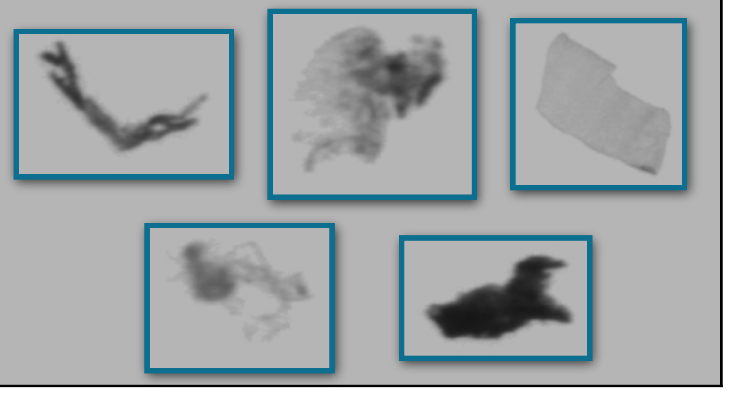
Accuracy	🟦 / (🟦 + 🟨)
Balanced accuracy	
Weighted plankton precision	60%
Weighted plankton recall	

Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

Truth

Prediction	**Egg**	**Copepoda**	**Detritus**
Egg			
Copepoda			
Detritus			
	3/4	3/5	

Accuracy $\frac{\square}{\square + \square}$

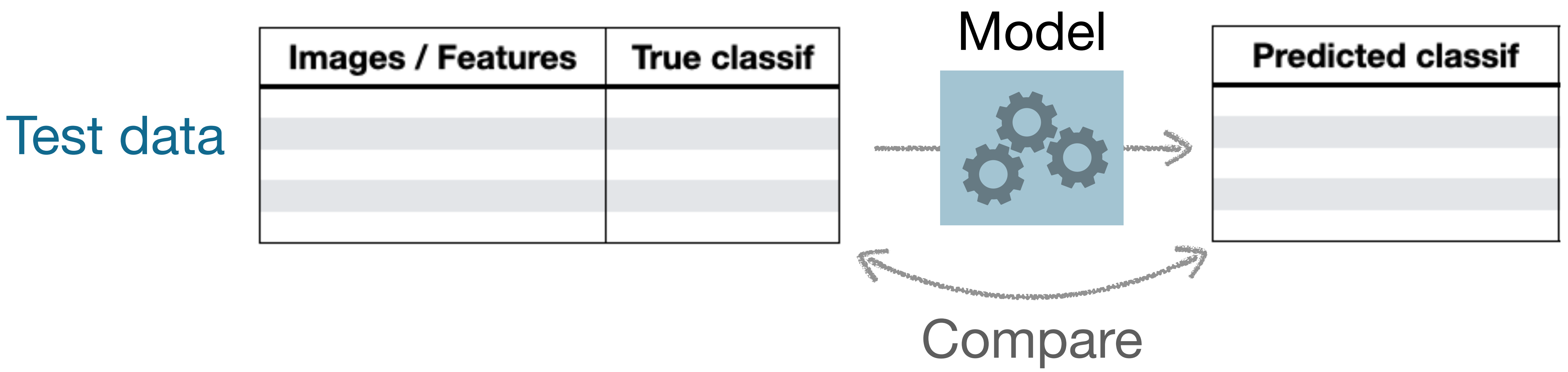
Balanced accuracy

Weighted plankton precision 60%

Weighted plankton recall

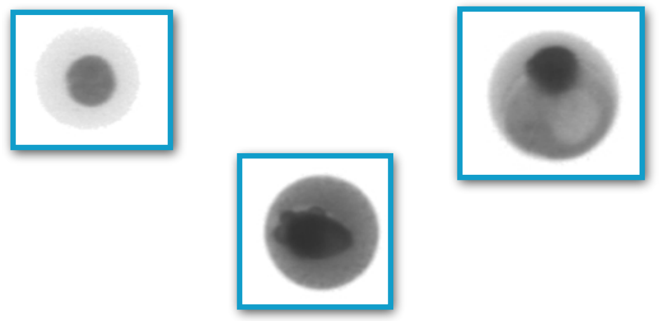
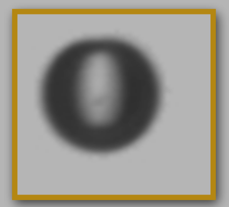
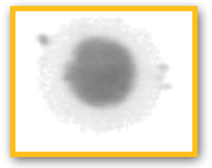
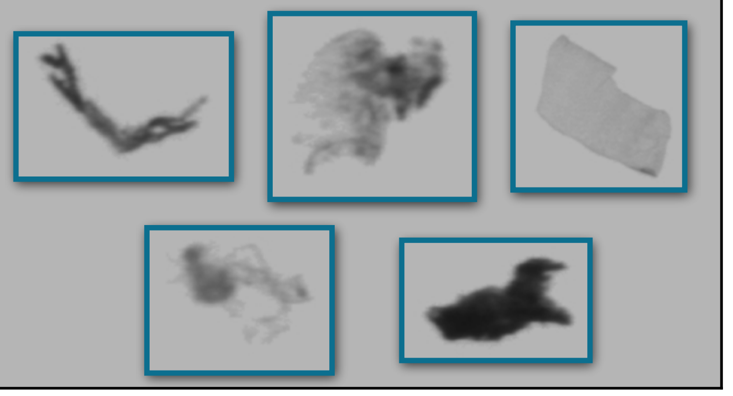
Material & methods

Model evaluation


Test data
Images / Features
True classif
Model
Predicted classif
Compare

Truth

Prediction

	Egg	**Copepoda**	**Detritus**
Egg			
Copepoda			
Detritus			
	3/4	3/5	

Accuracy $\frac{\text{🟦}}{\text{🟦} + \text{🟨}}$

Balanced accuracy

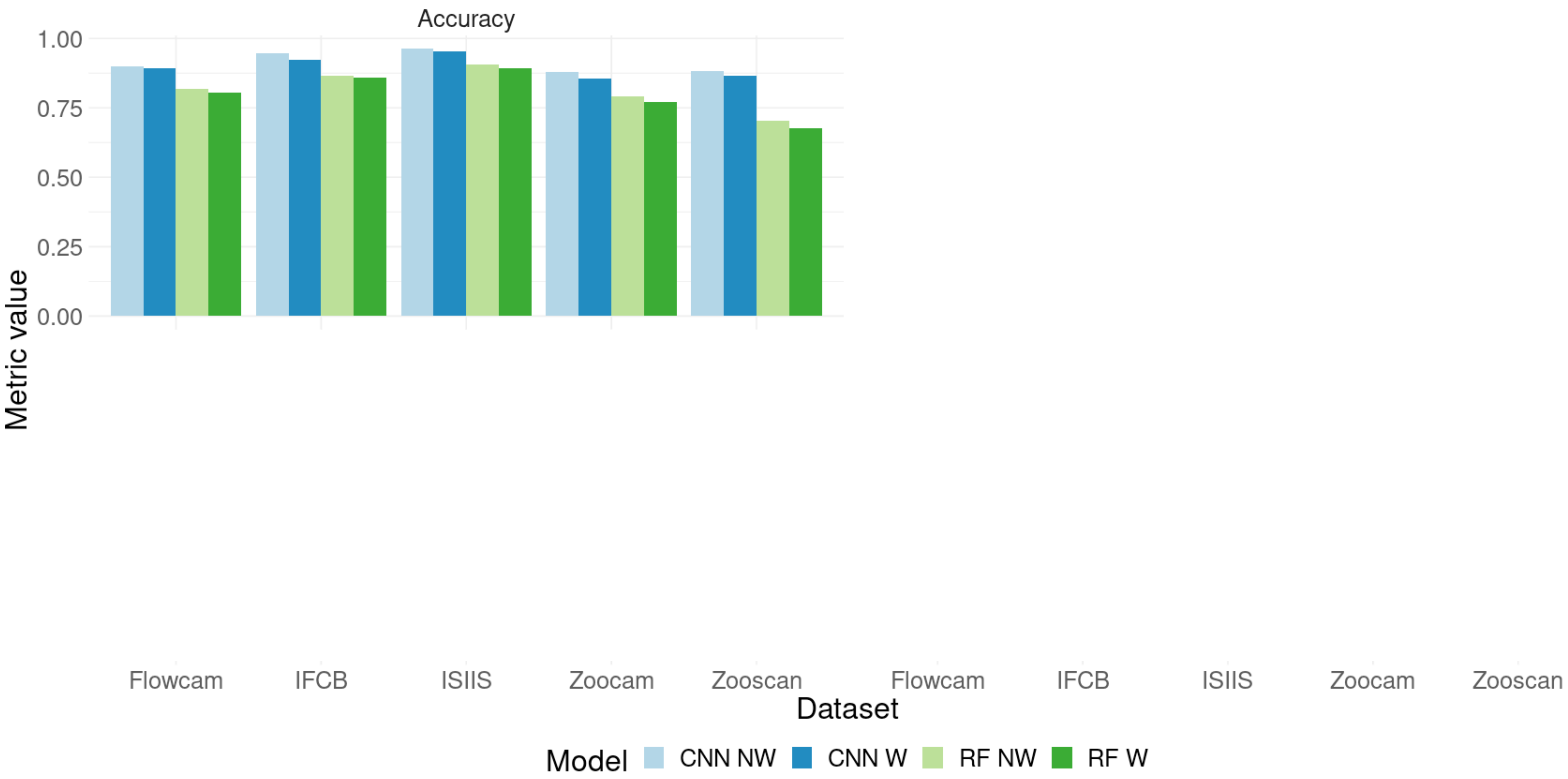
Weighted plankton precision 60%

Weighted plankton recall 67%

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Results

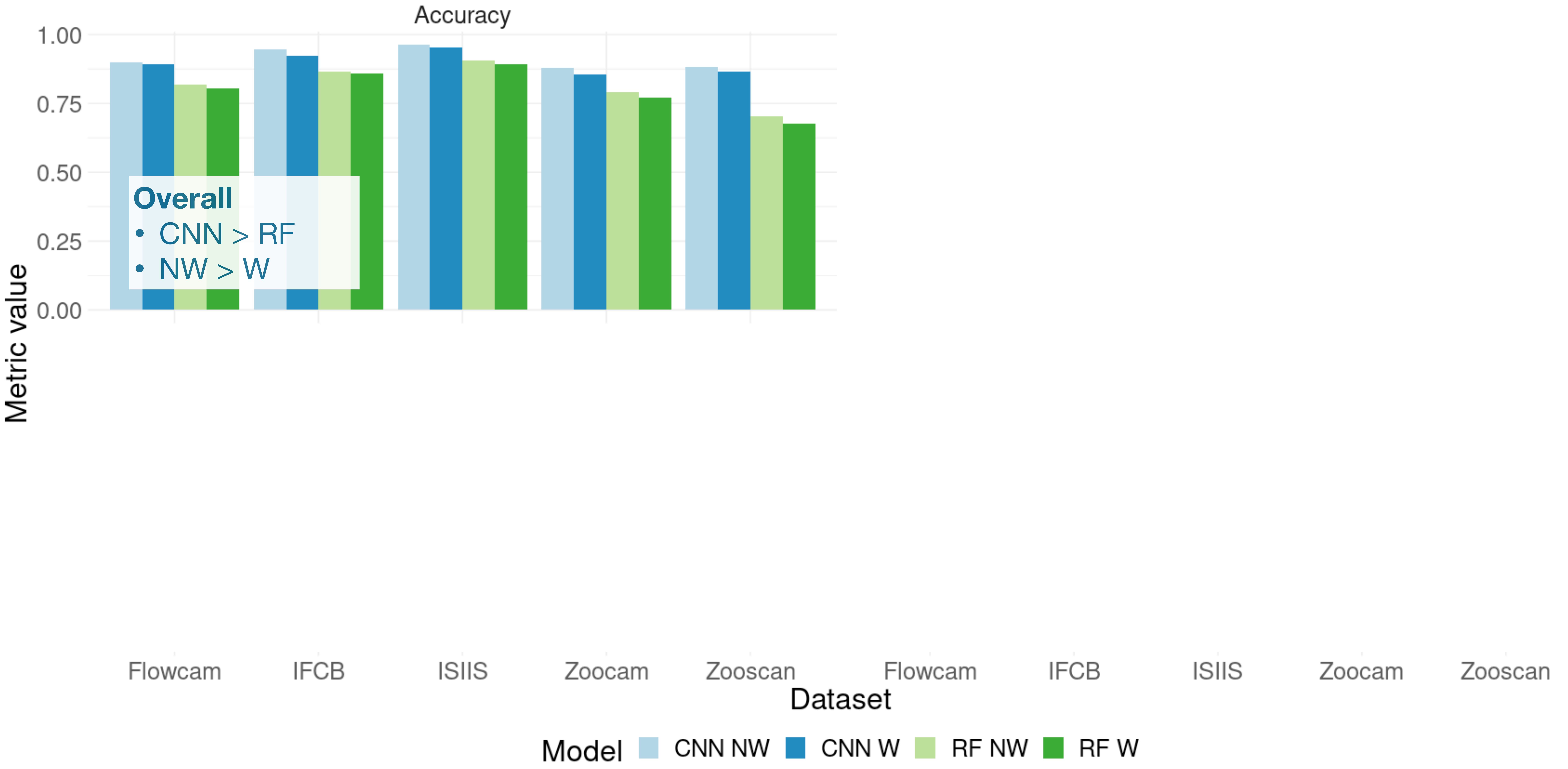
Model performances on detailed classes



CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Results

Model performances on detailed classes

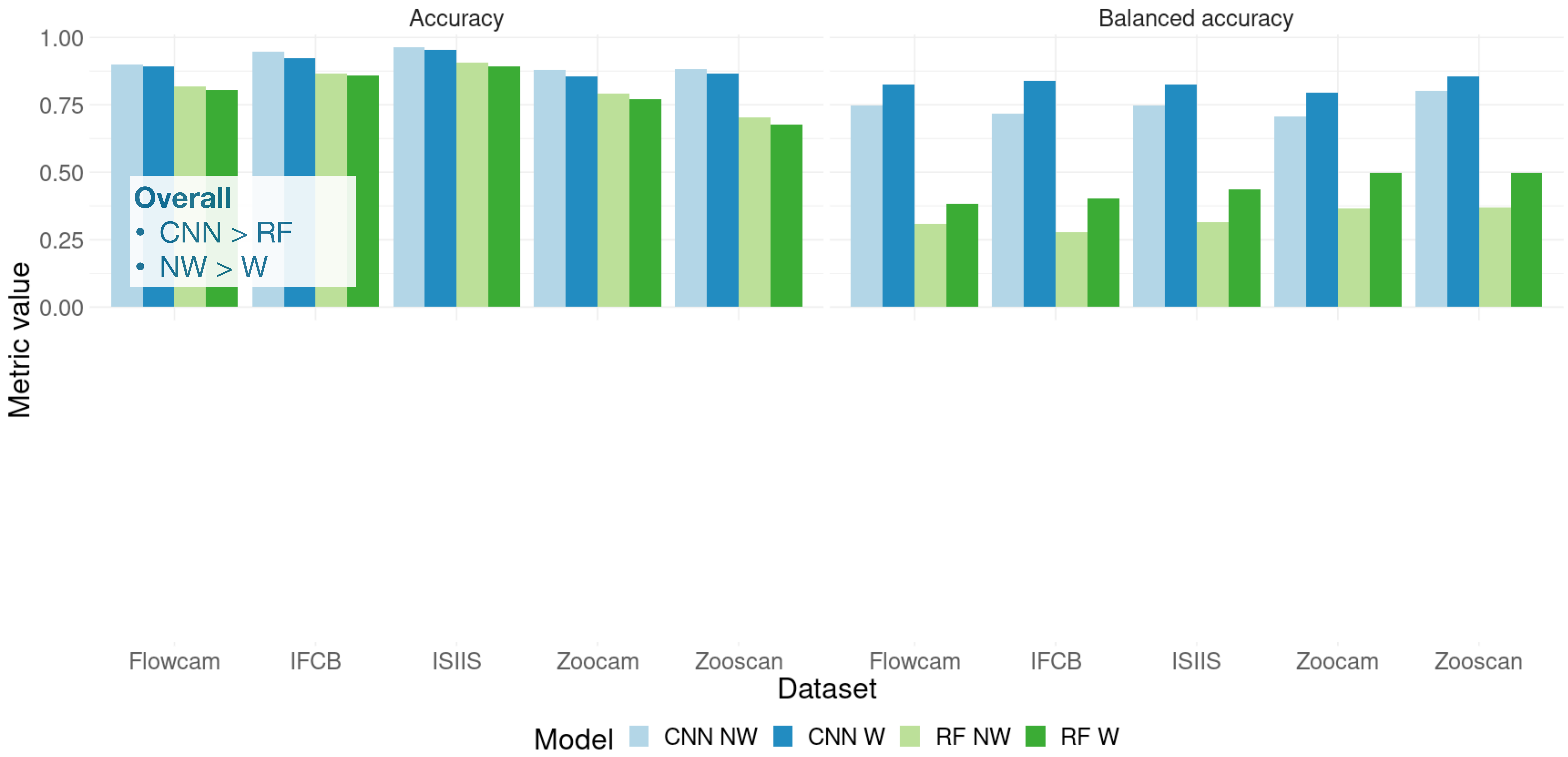


Overall
- CNN > RF
- NW > W

Results

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Model performances on detailed classes

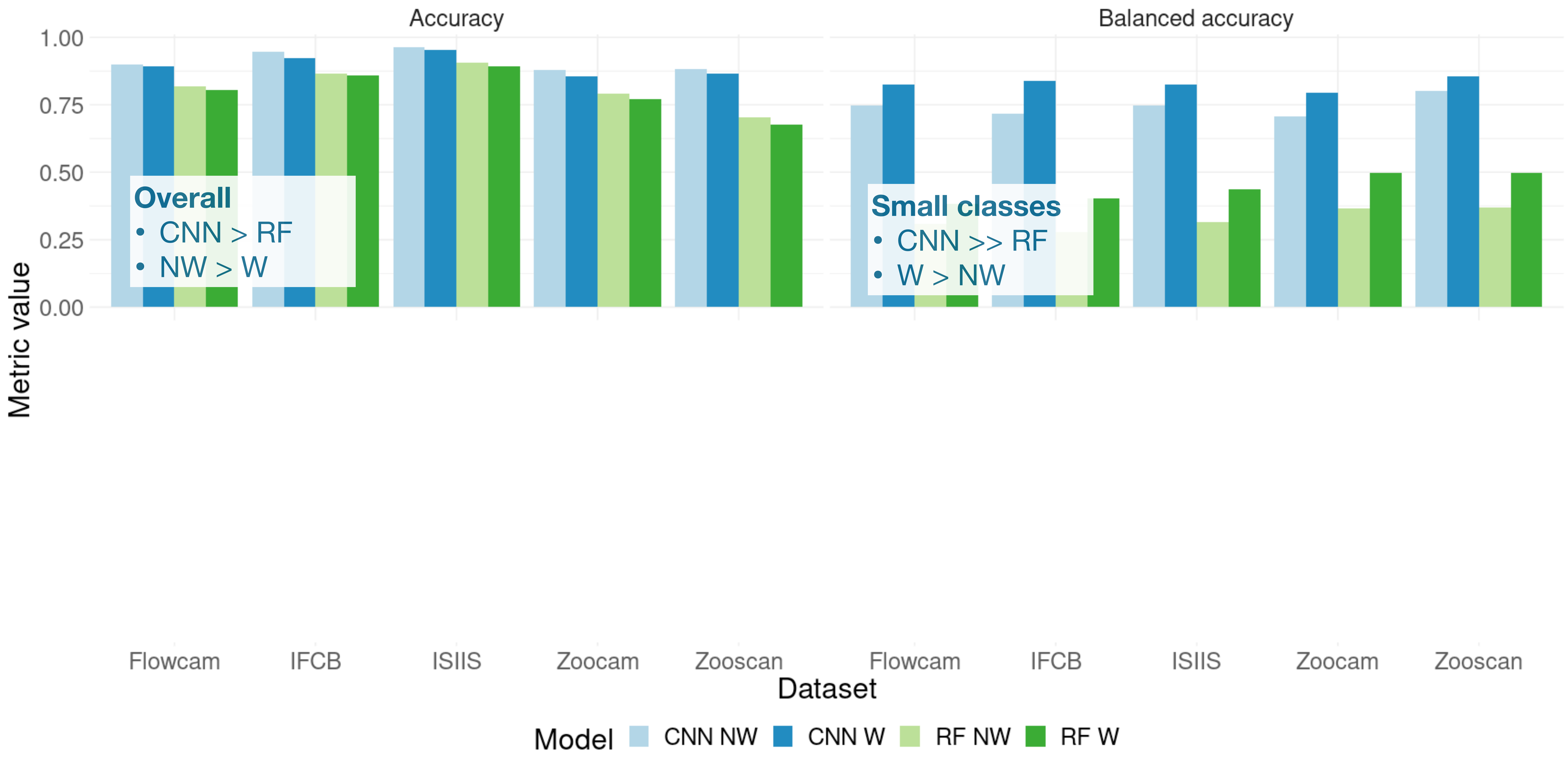


Overall
- CNN > RF
- NW > W

Results

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Model performances on detailed classes



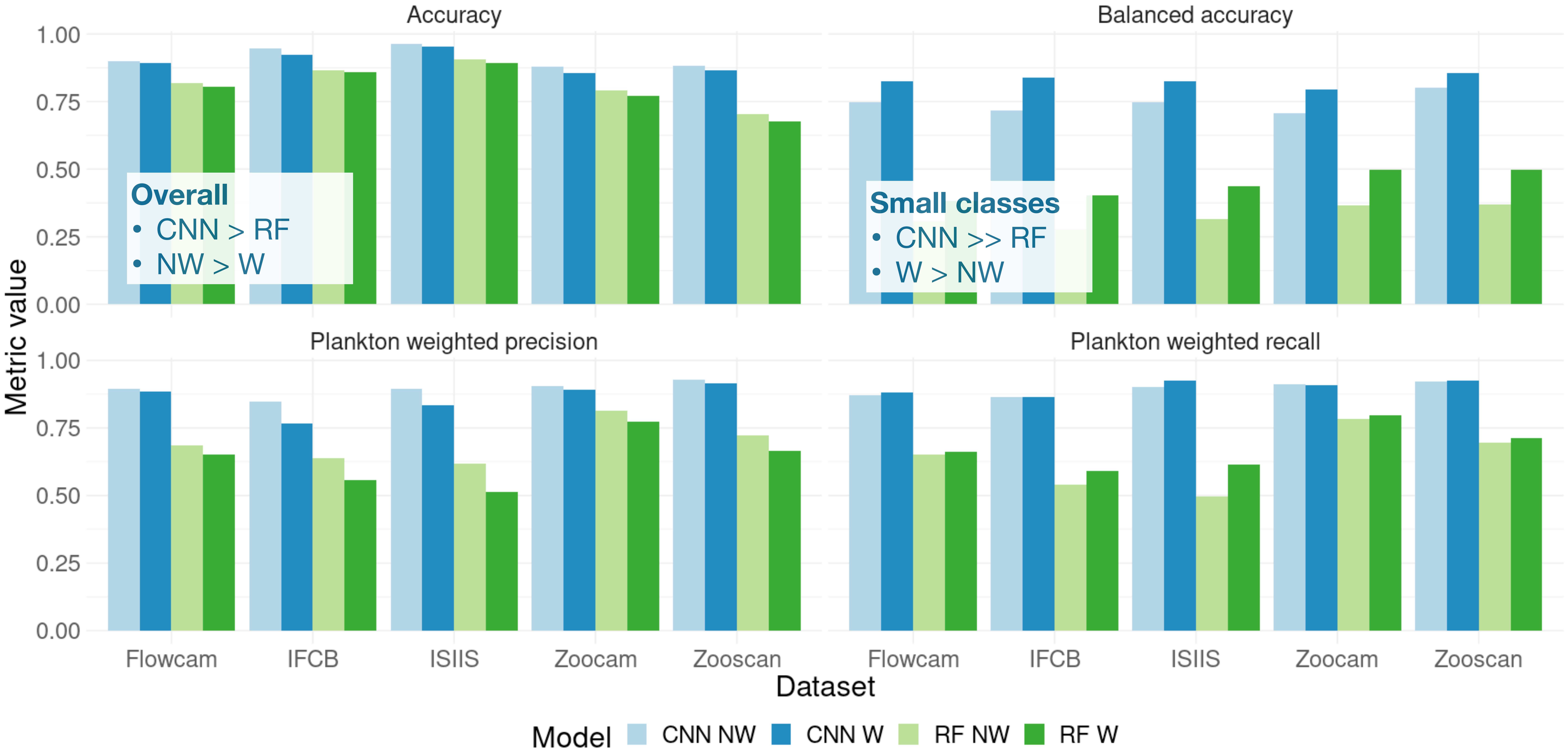
Overall
- CNN > RF
- NW > W

Small classes
- CNN >> RF
- W > NW

Results

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Model performances on detailed classes



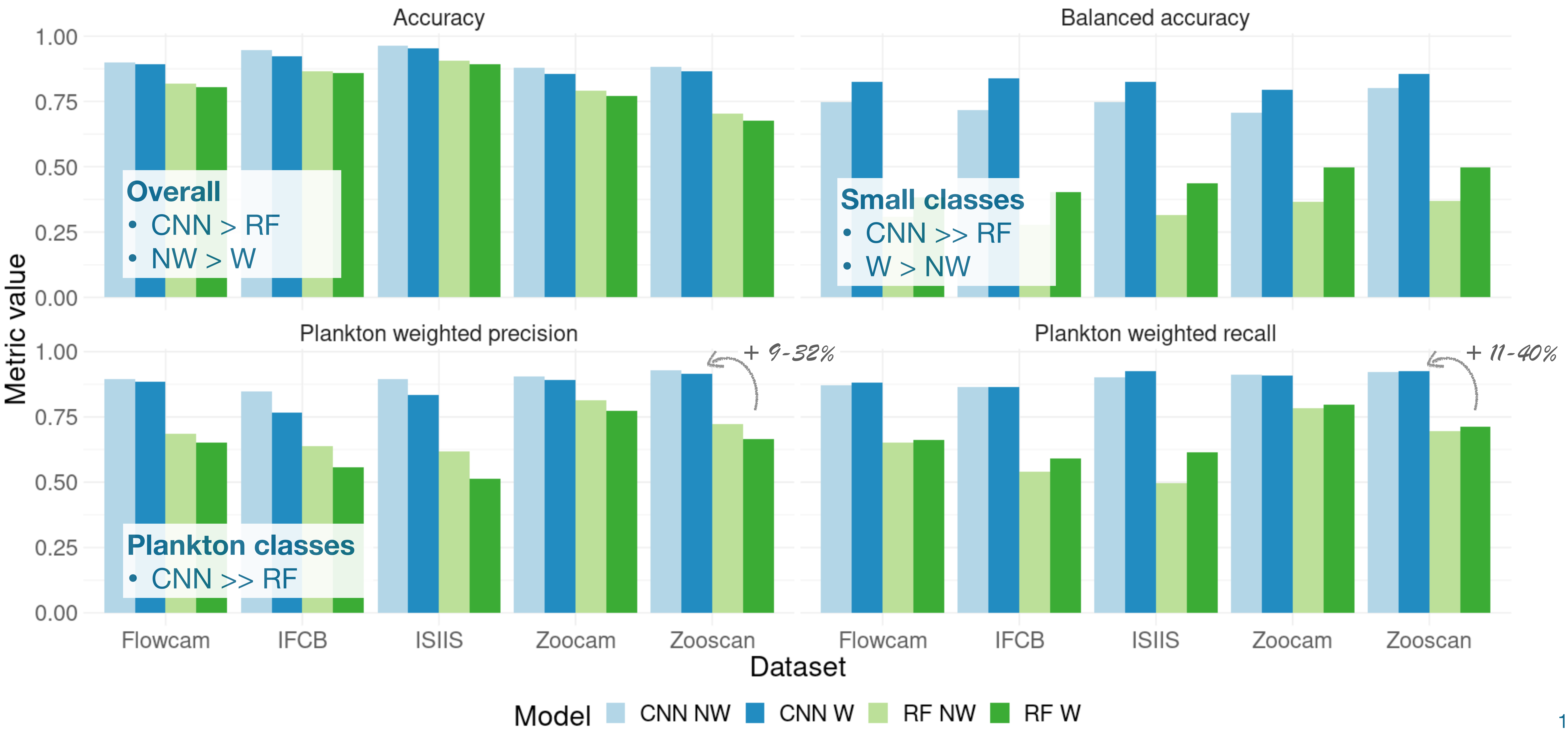
Overall
- CNN > RF
- NW > W

Small classes
- CNN >> RF
- W > NW

Results

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Model performances on detailed classes



Overall
- CNN > RF
- NW > W

Small classes
- CNN >> RF
- W > NW

Plankton classes
- CNN >> RF

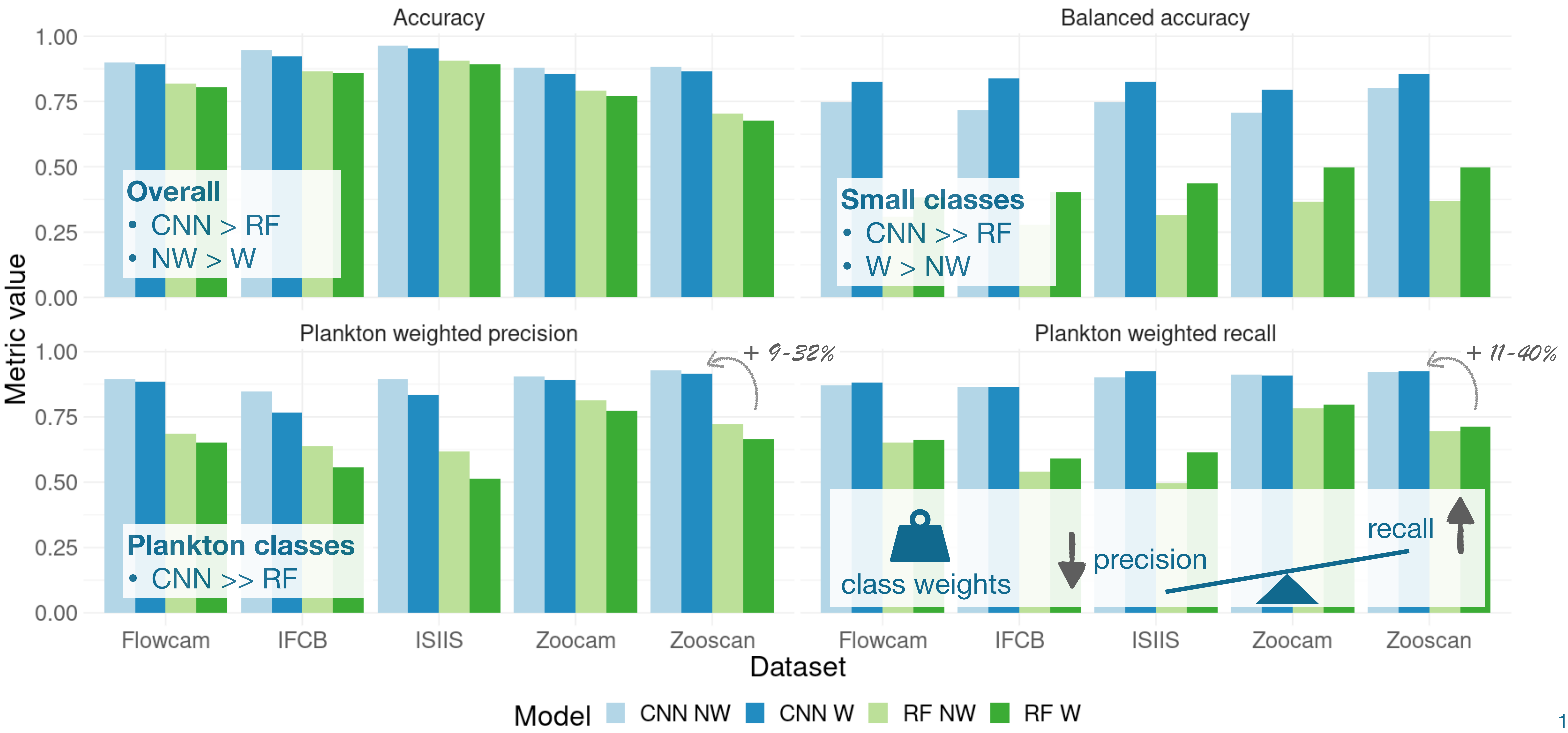
+ 9-32%

+ 11-40%

Results

CNN = convolutional neural network
RF = random forest
W = weighted
NW = non weighted

Model performances on detailed classes



Overall
- CNN > RF
- NW > W

Small classes
- CNN >> RF
- W > NW

Plankton classes
- CNN >> RF

+ 9-32%

+ 11-40%

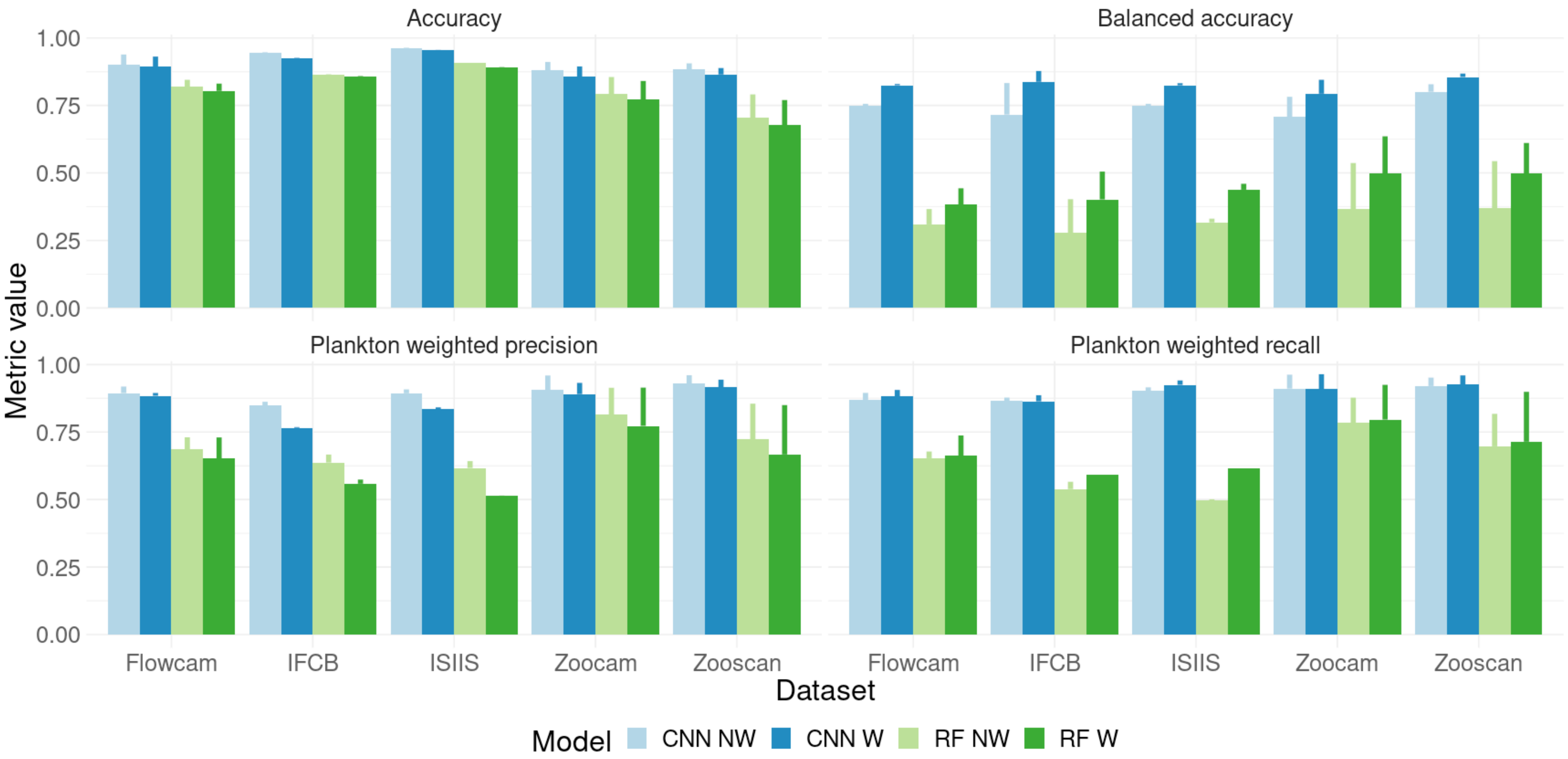
class weights

precision

recall

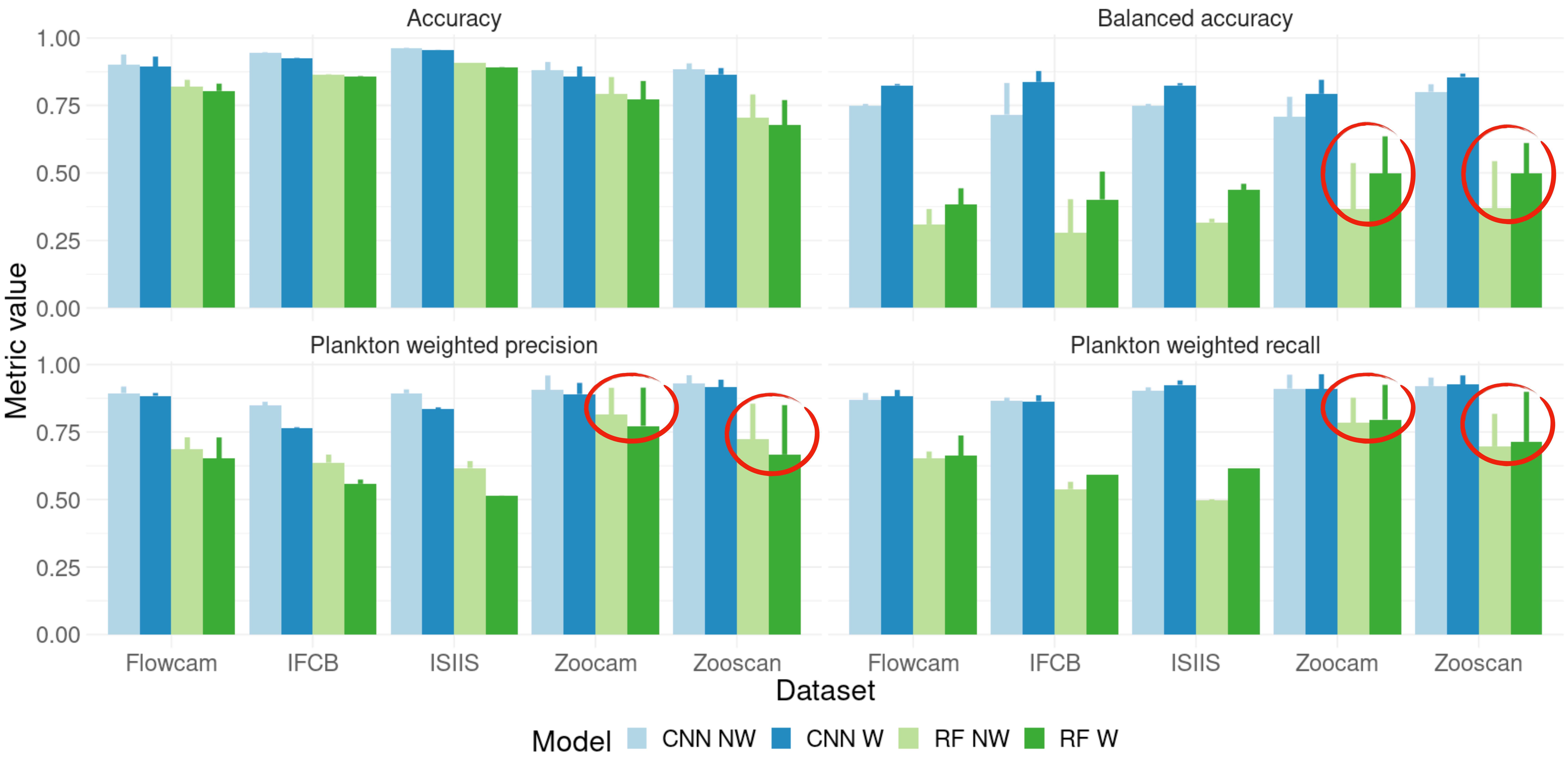
Results

Model performances on detailed and broader classes



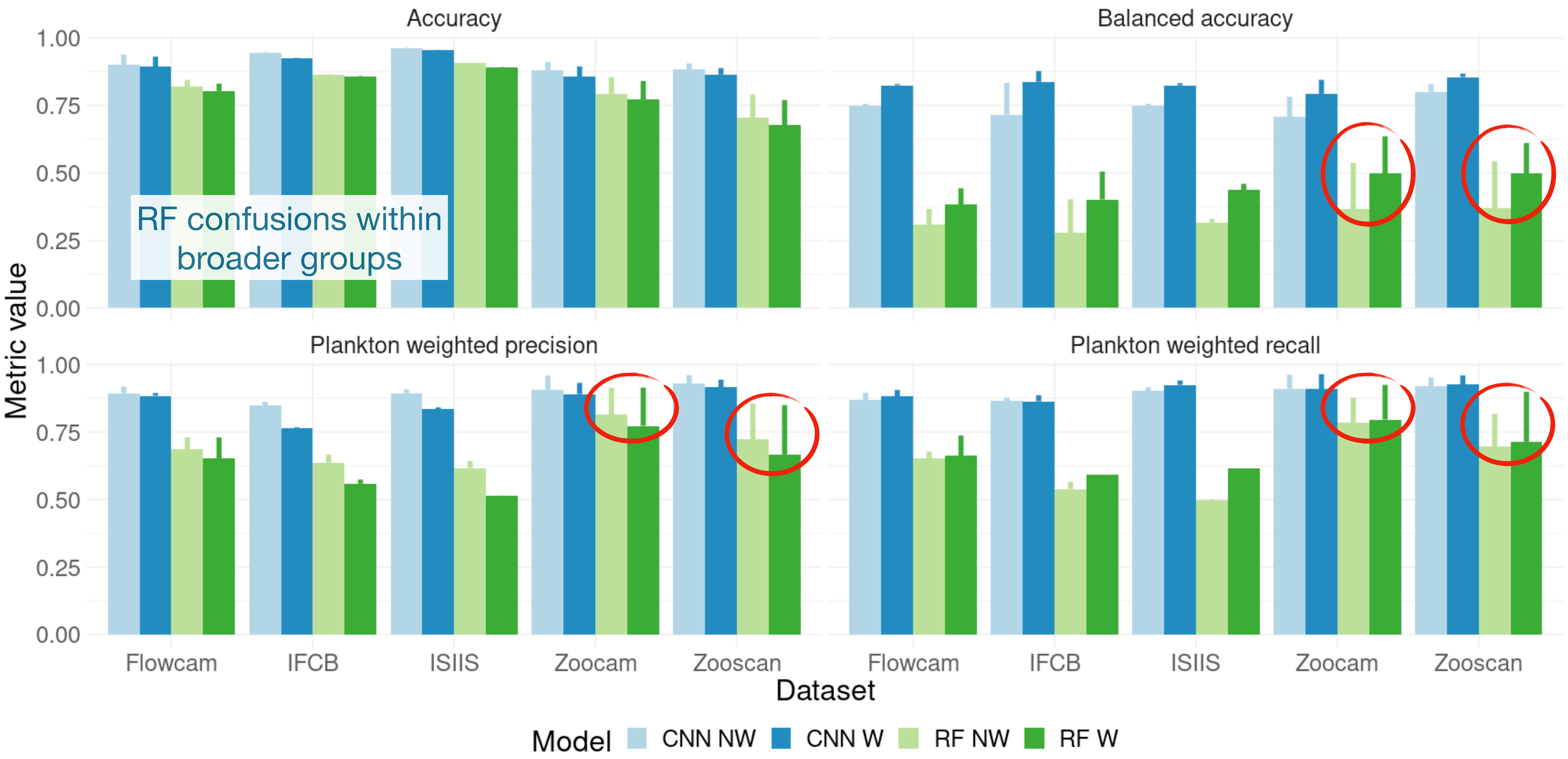
Results

Model performances on detailed and broader classes



Results

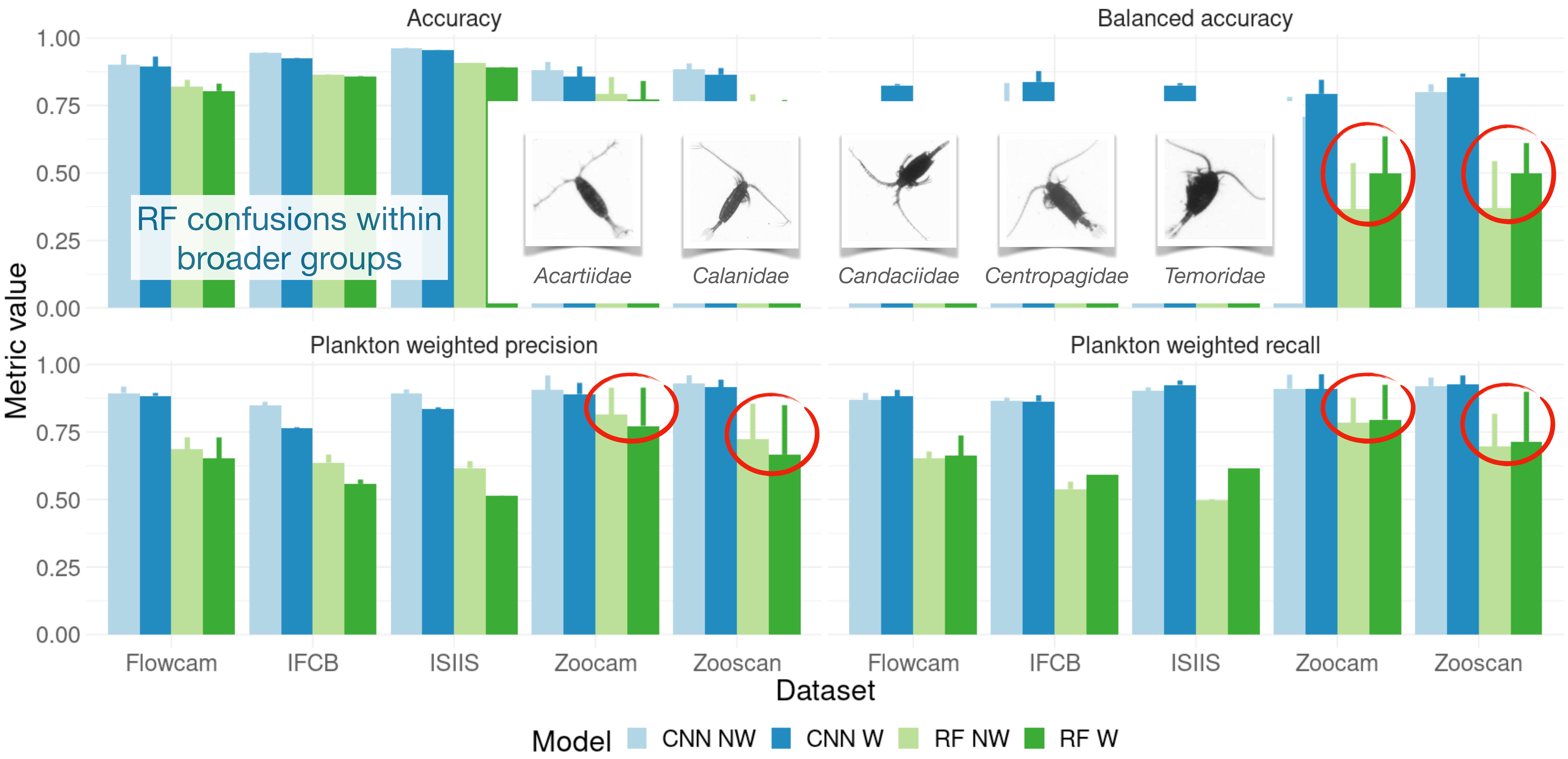
Model performances on detailed and broader classes



RF confusions within broader groups

Results

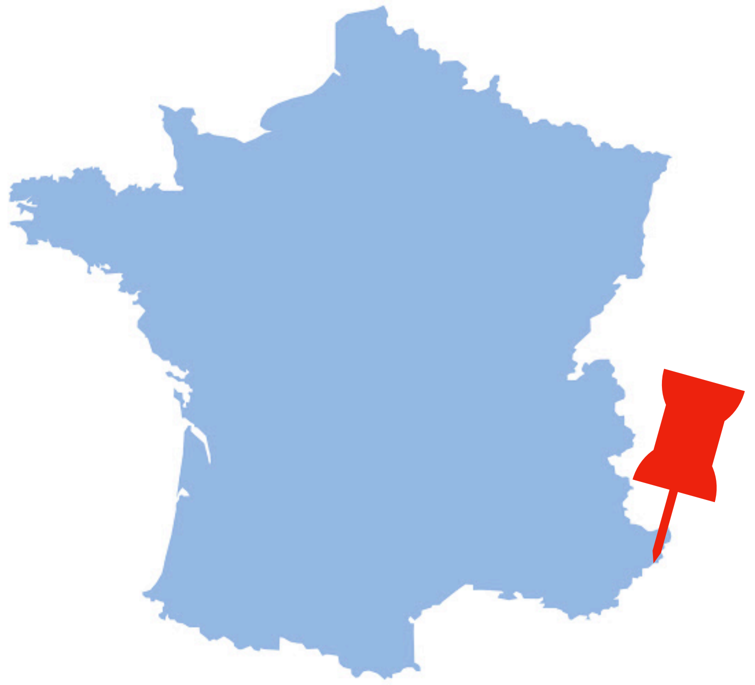
Model performances on detailed and broader classes

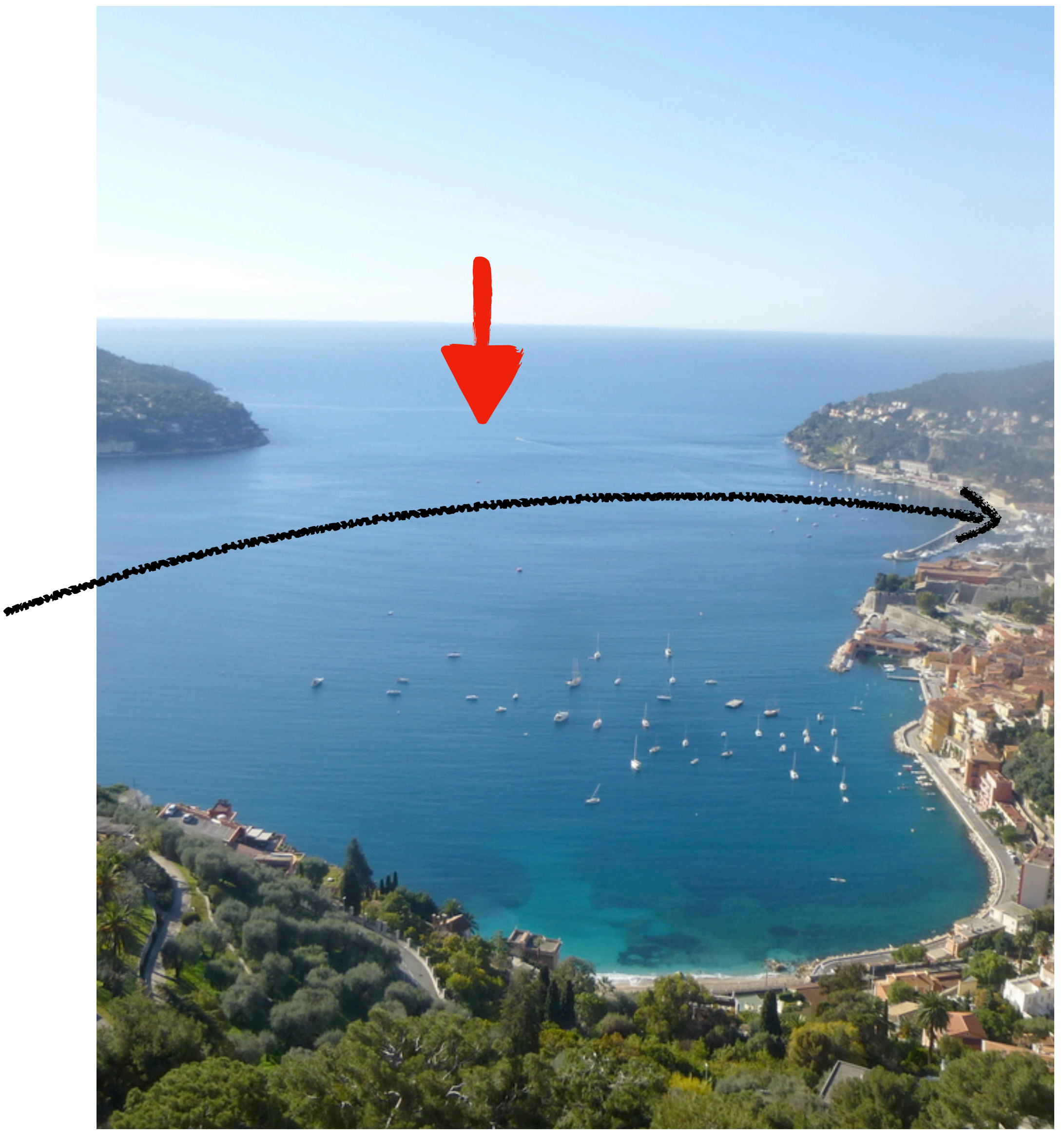


RF confusions within broader groups

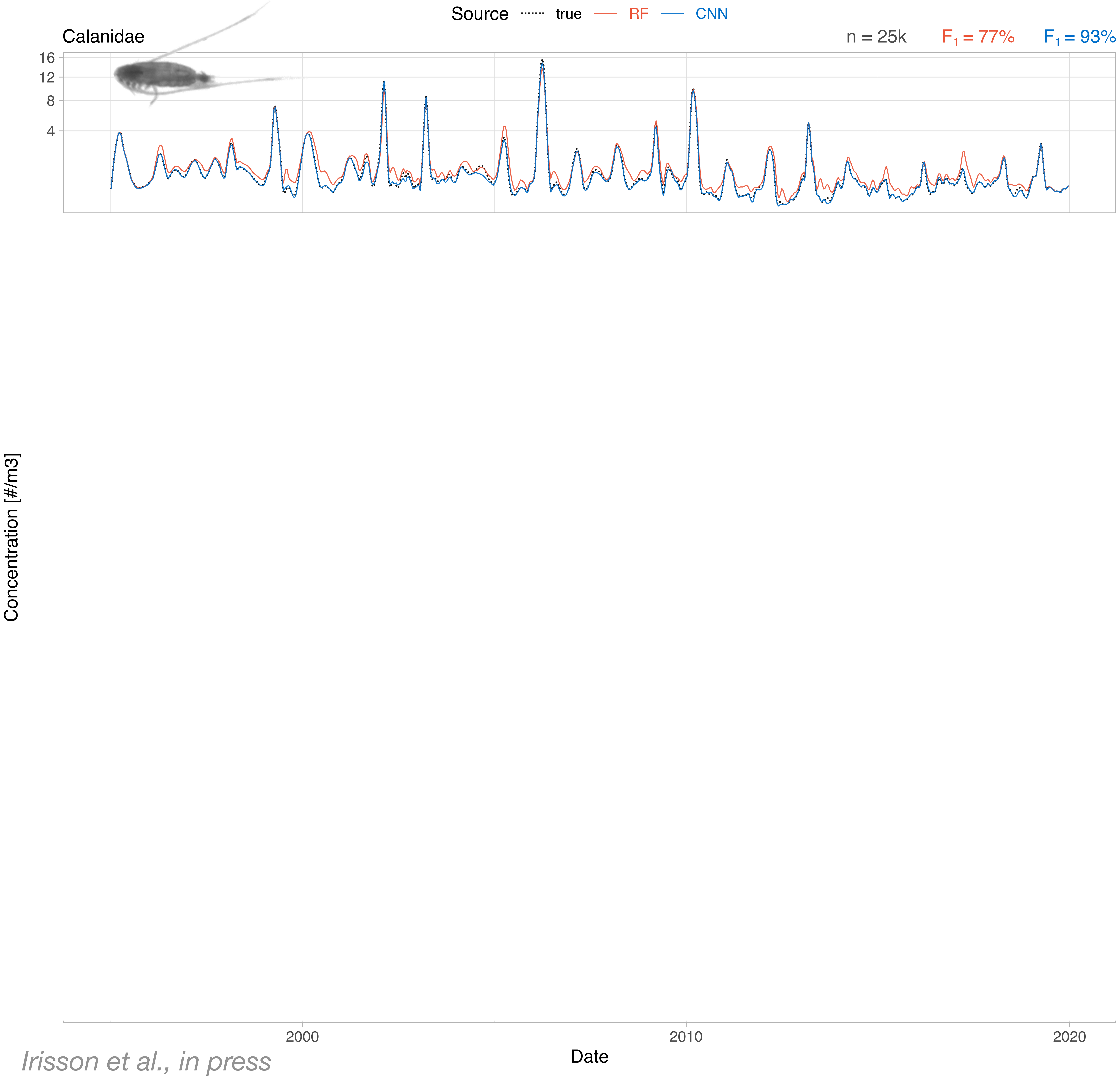
Application

Villefranche-sur-Mer





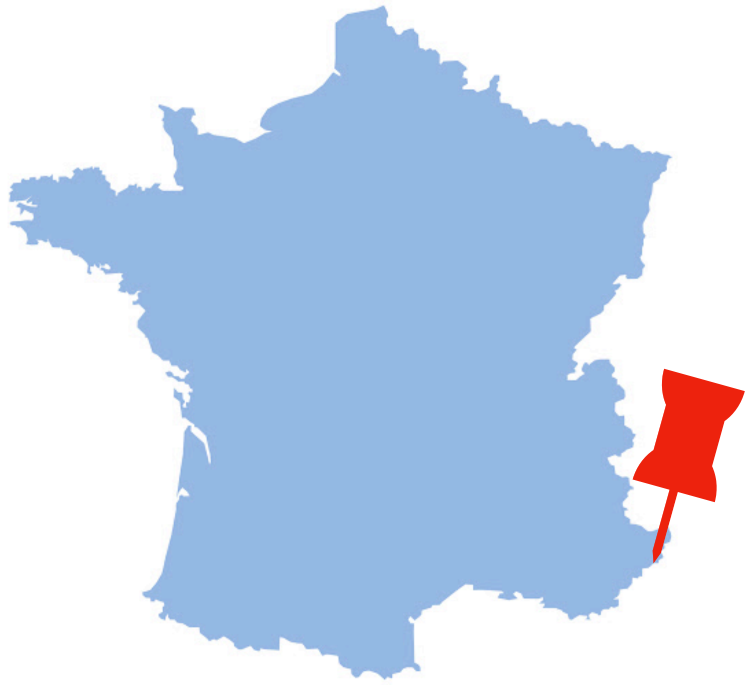
LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE



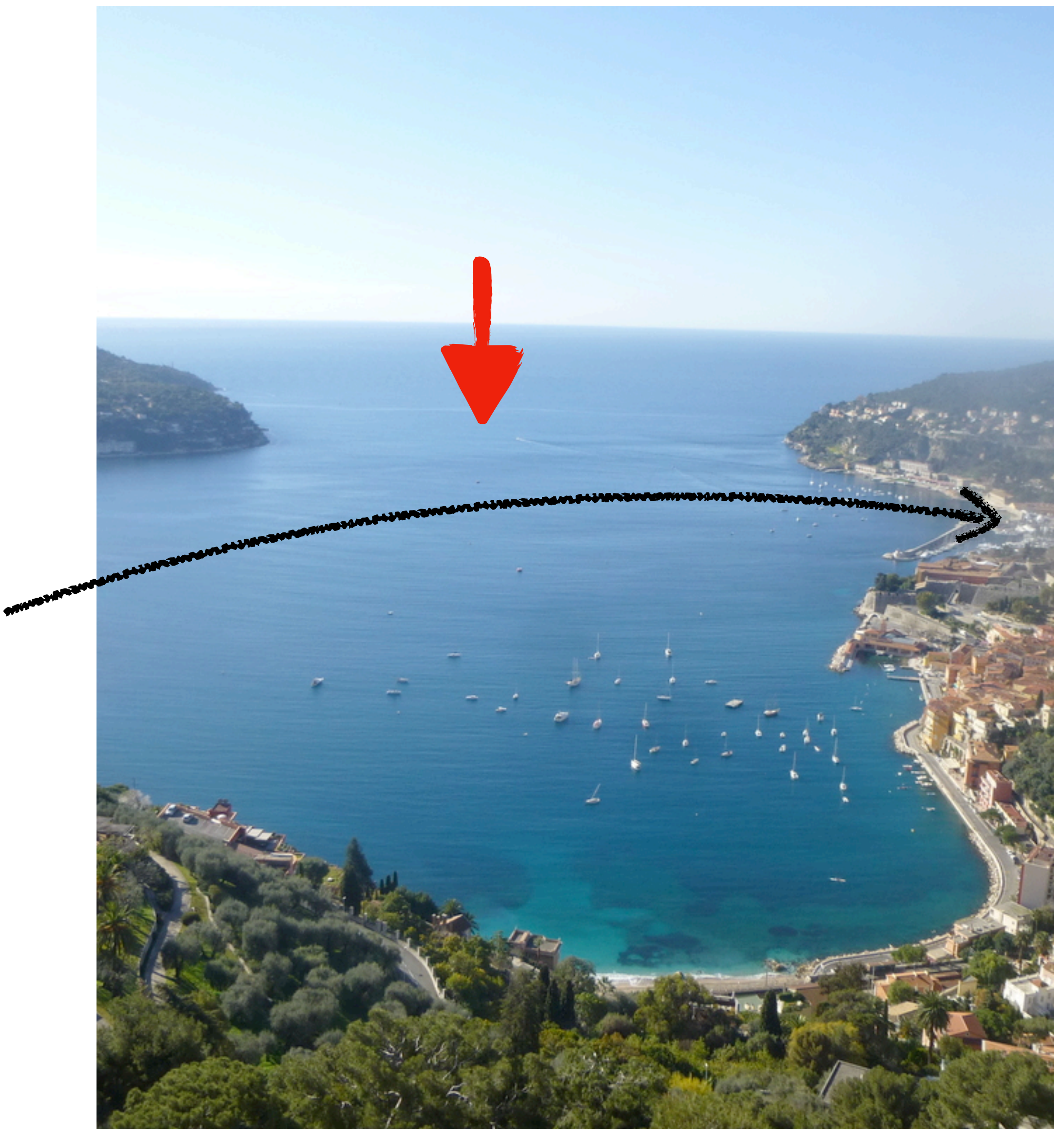
Irisson et al., in press

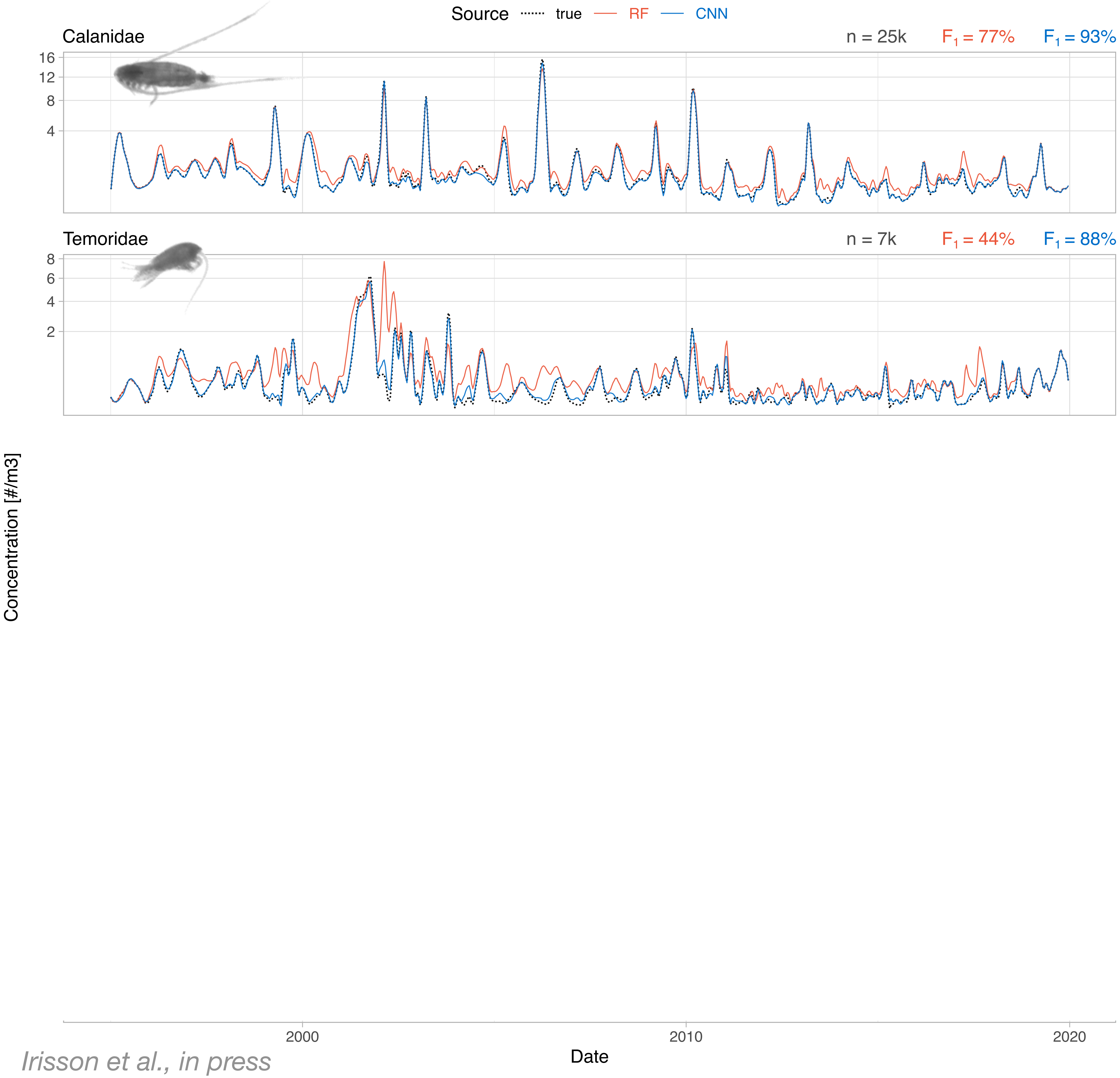
Application

Villefranche-sur-Mer



LÔV LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE

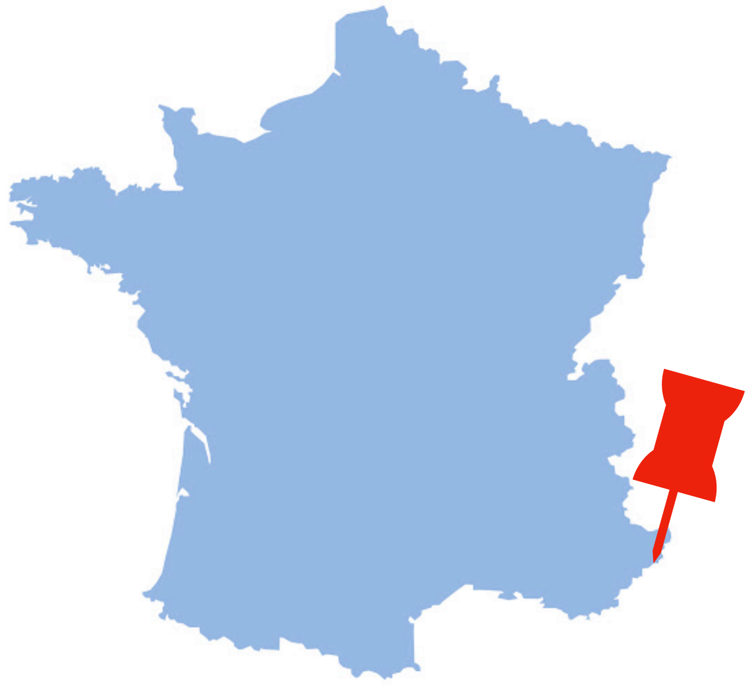




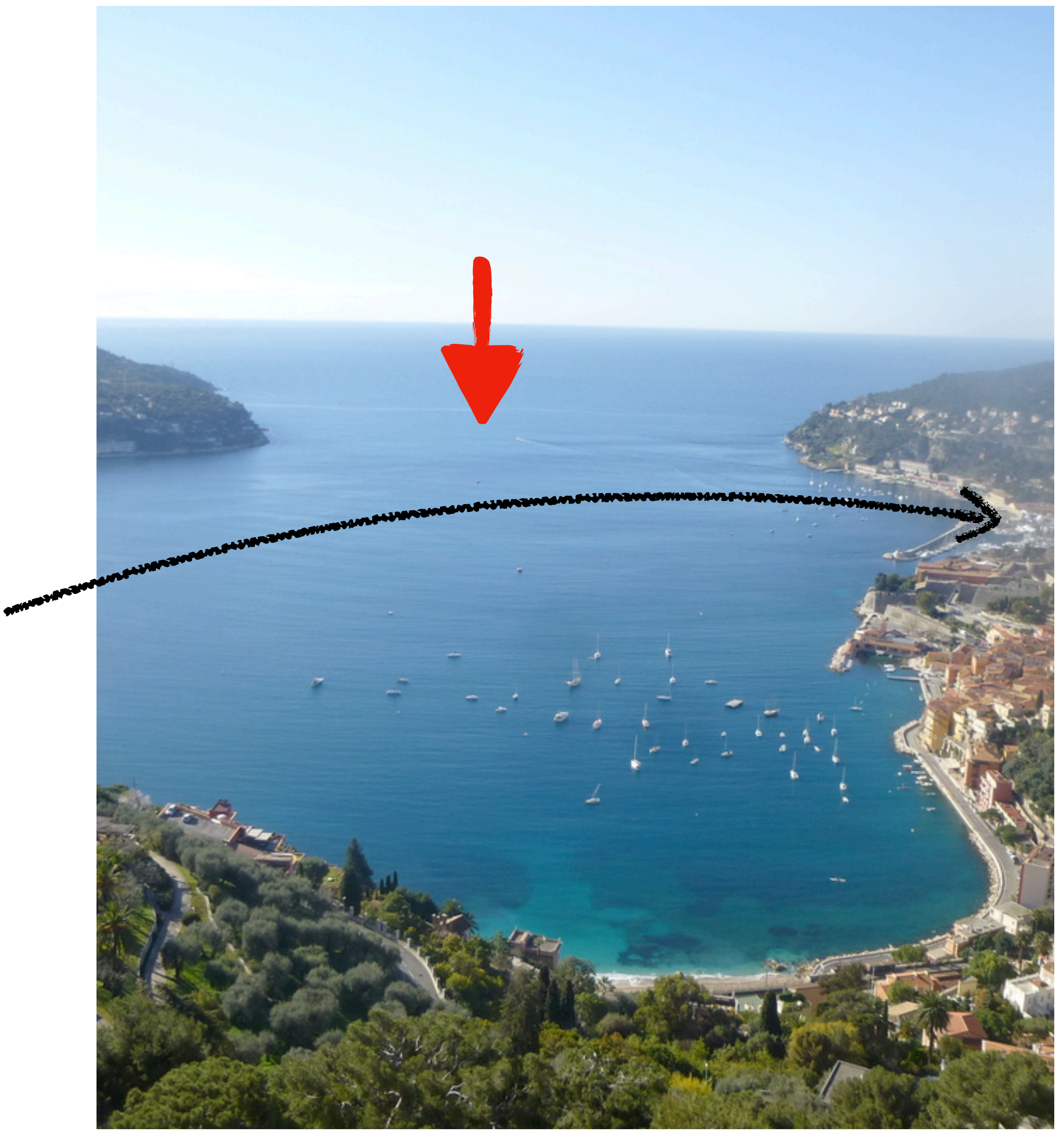
Irisson et al., in press

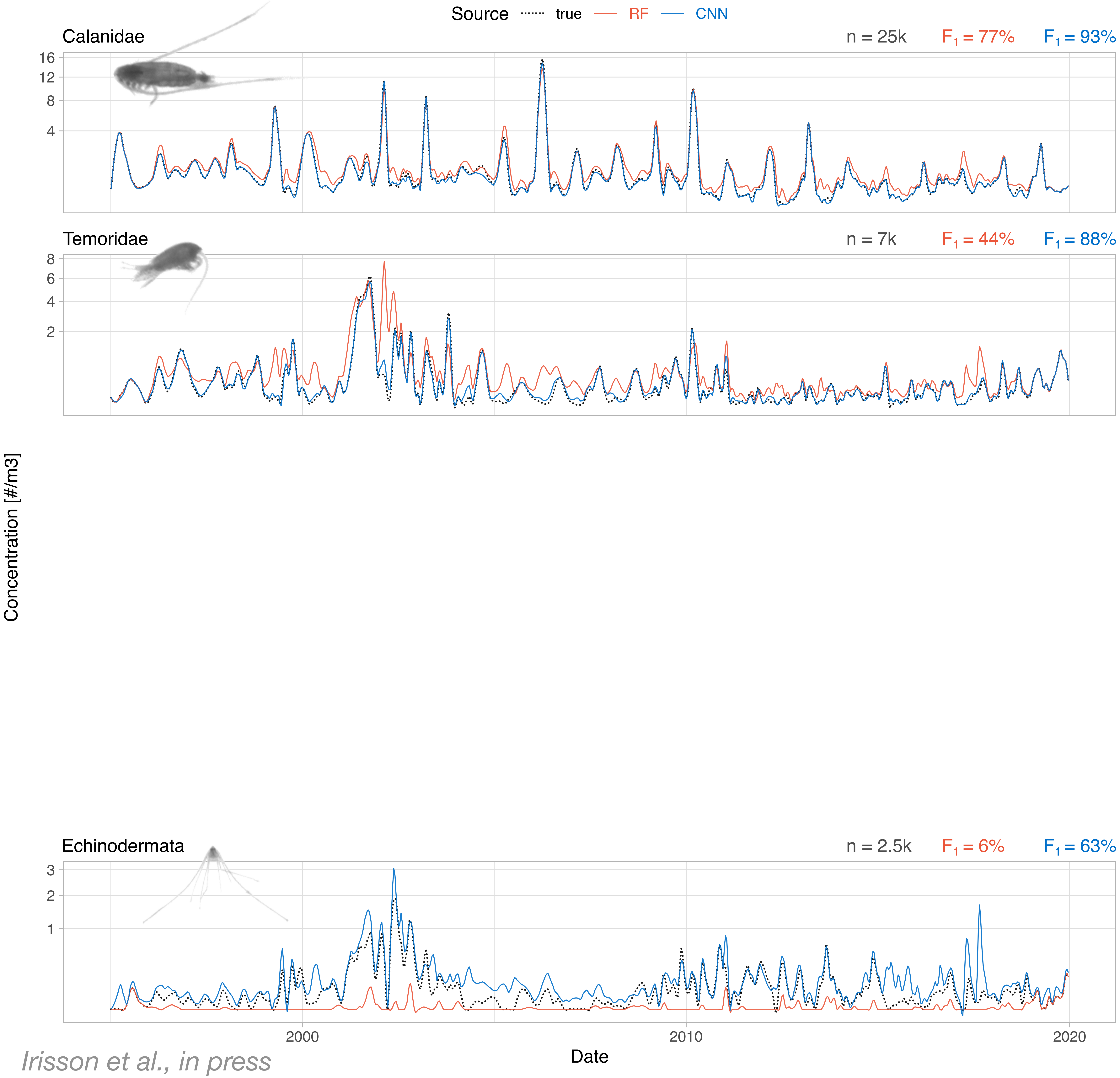
Application

Villefranche-sur-Mer



LÖV LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE

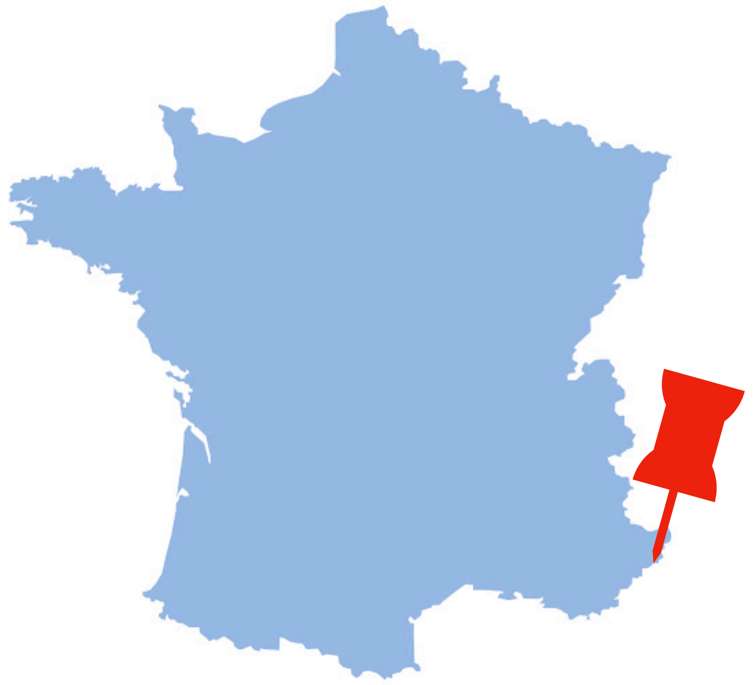




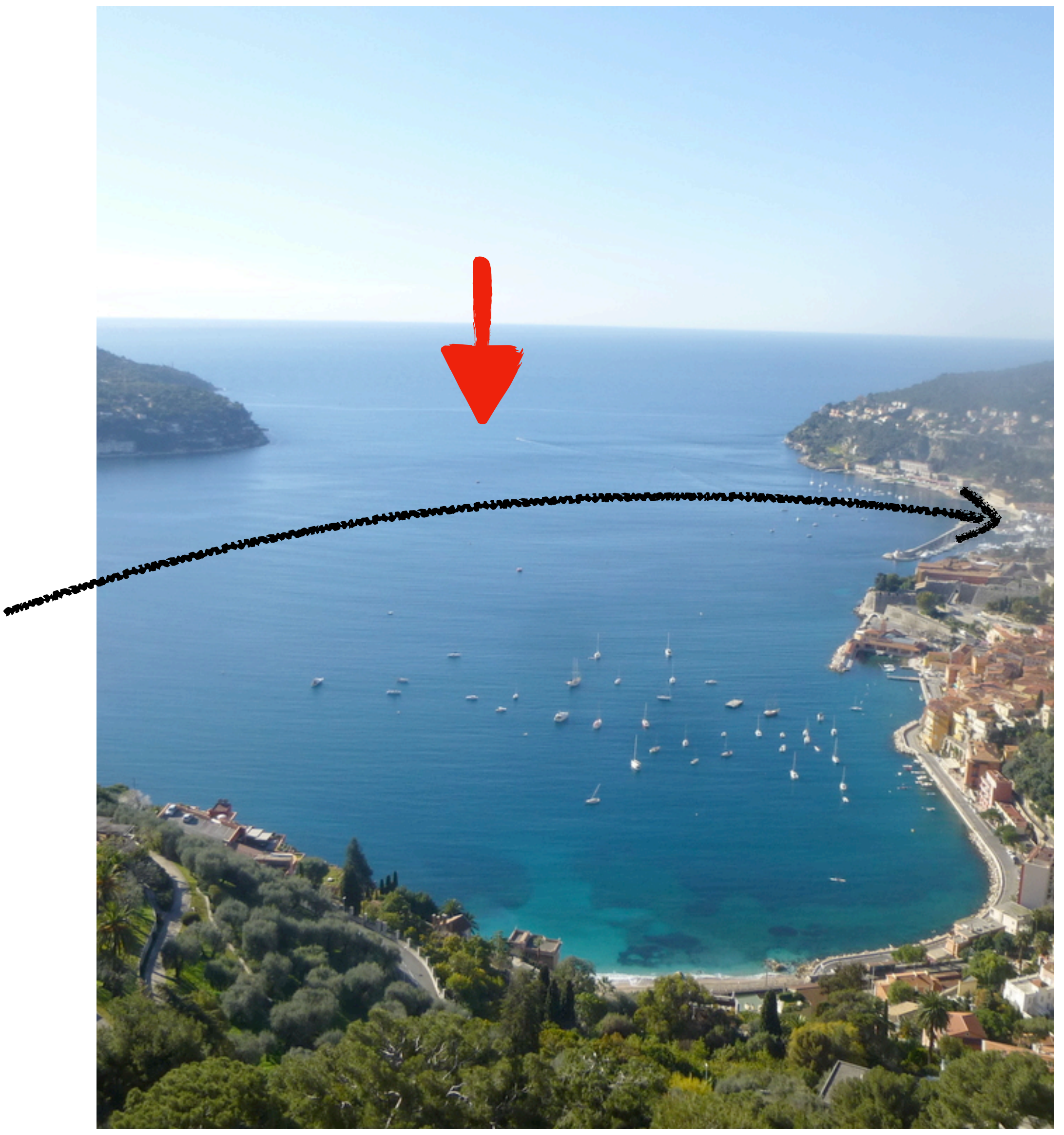
Irisson et al., in press

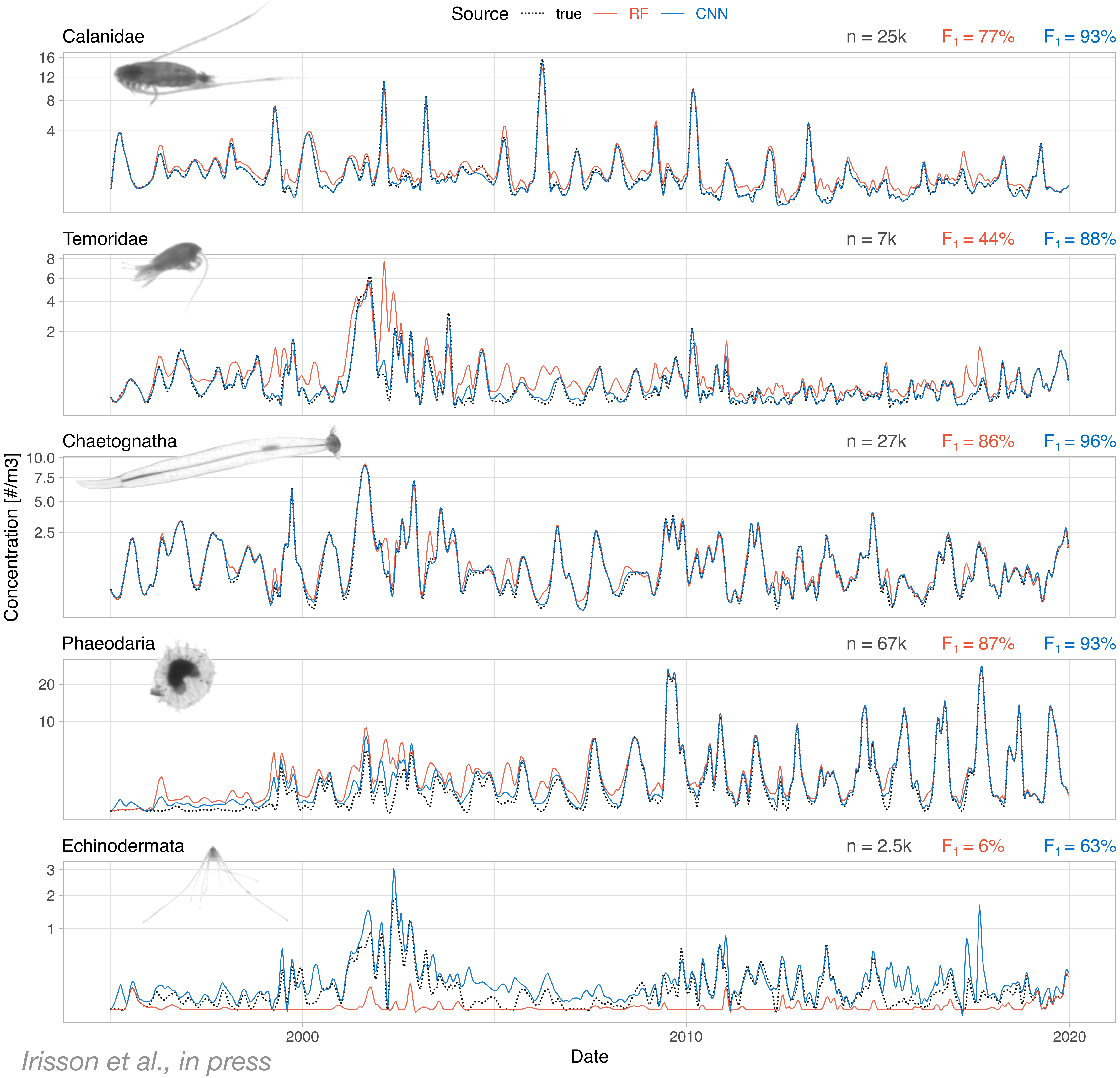
Application

Villefranche-sur-Mer



LOV LABORATOIRE D'OCÉANOGRAPHIE DE VILLEFRANCHE





Irisson et al., in press

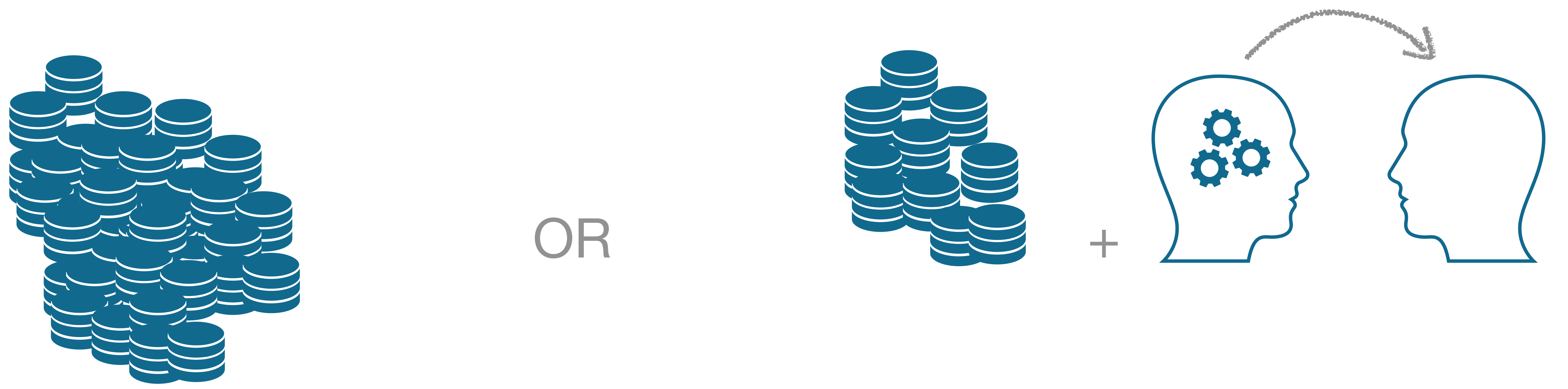
Discussion

Discussion

- time and power consumption

Discussion

- time and power consumption
- data availability



Lots lots lots lots lots lots of data

OR

Lots of data

+

Transfer learning

Discussion

- time and power consumption

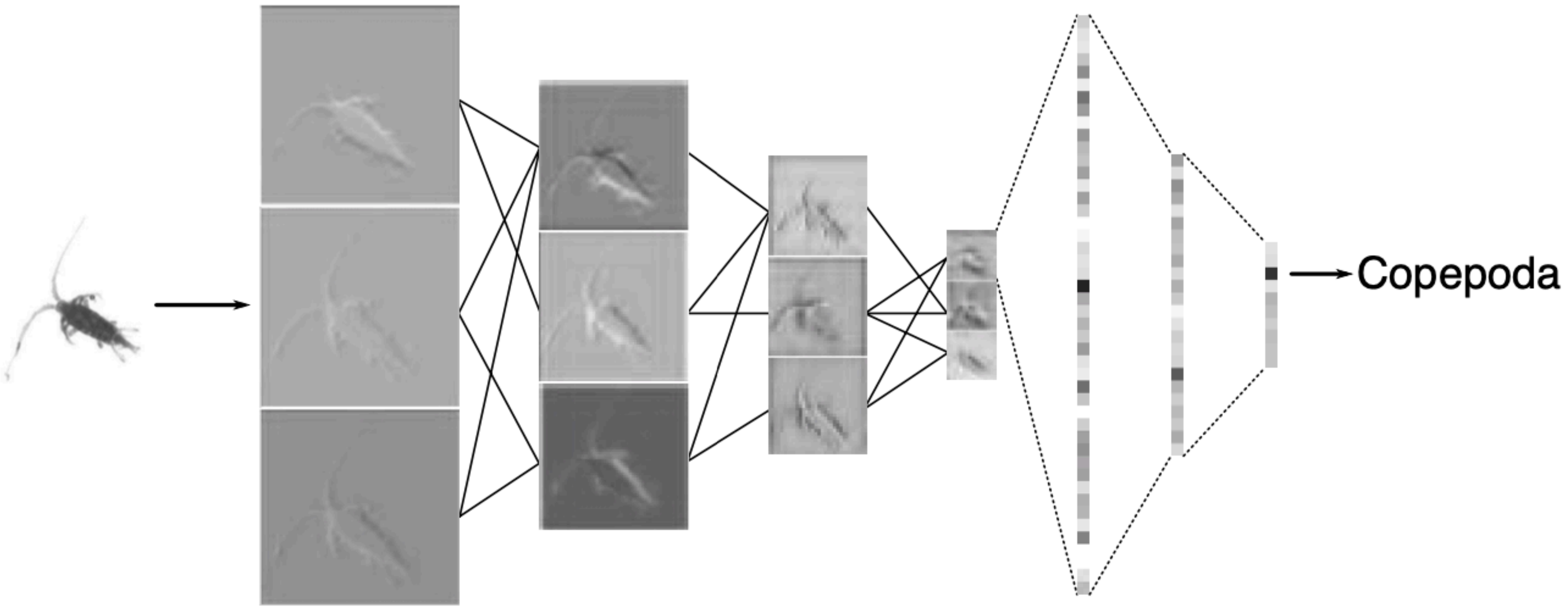
Lots lots lots lots lots lots of data

- data availability

OR

Lots of data + Transfer learning

- objects size



Discussion

- time and power consumption

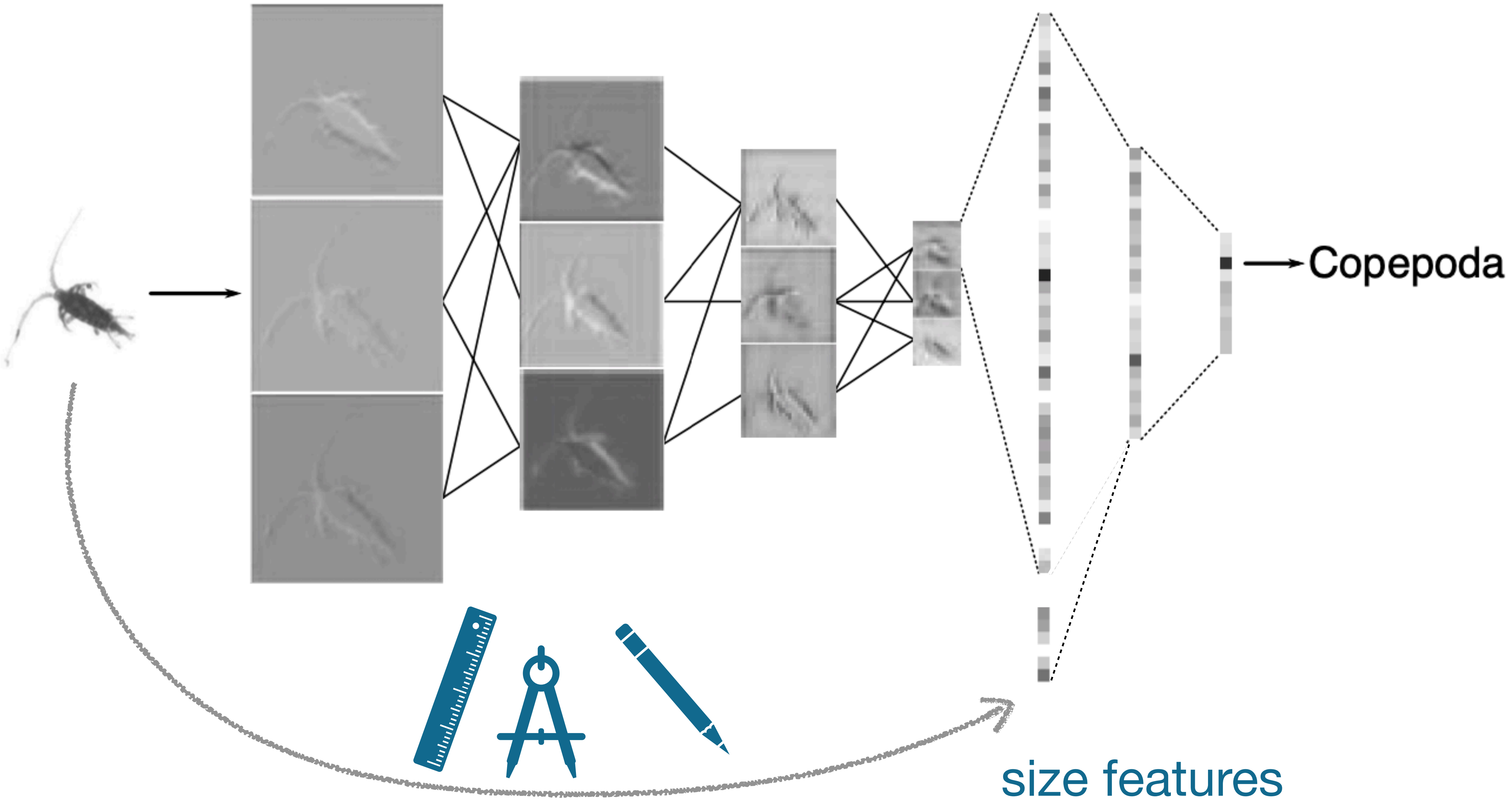
- data availability

Lots lots lots lots lots lots of data

OR

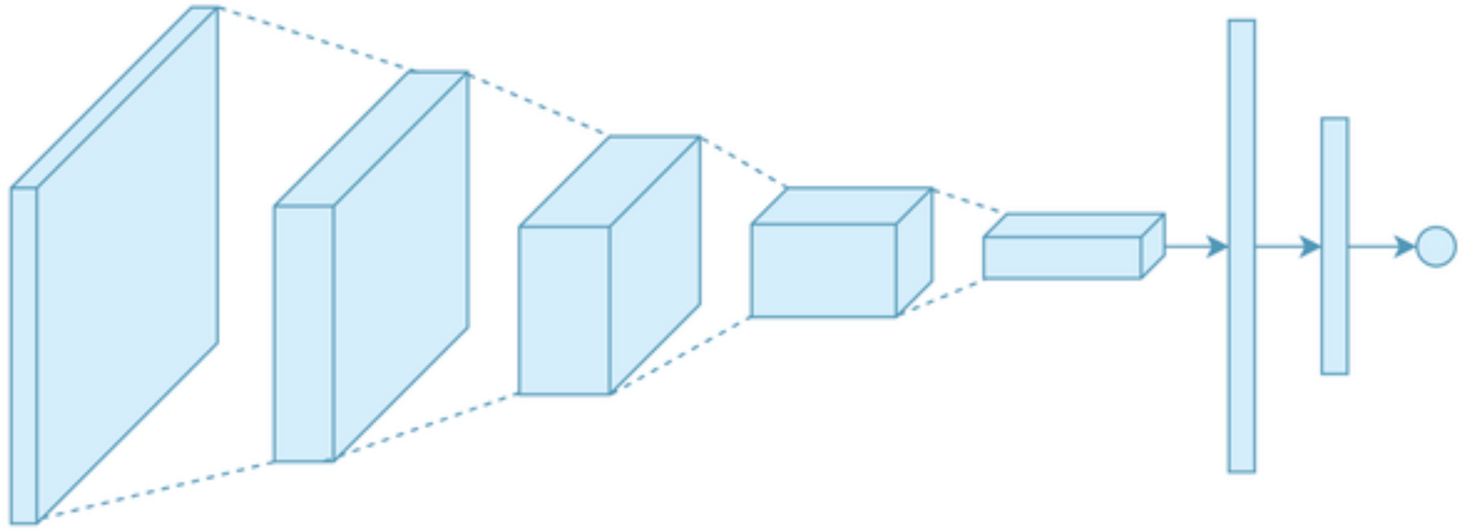
Lots of data + Transfer learning

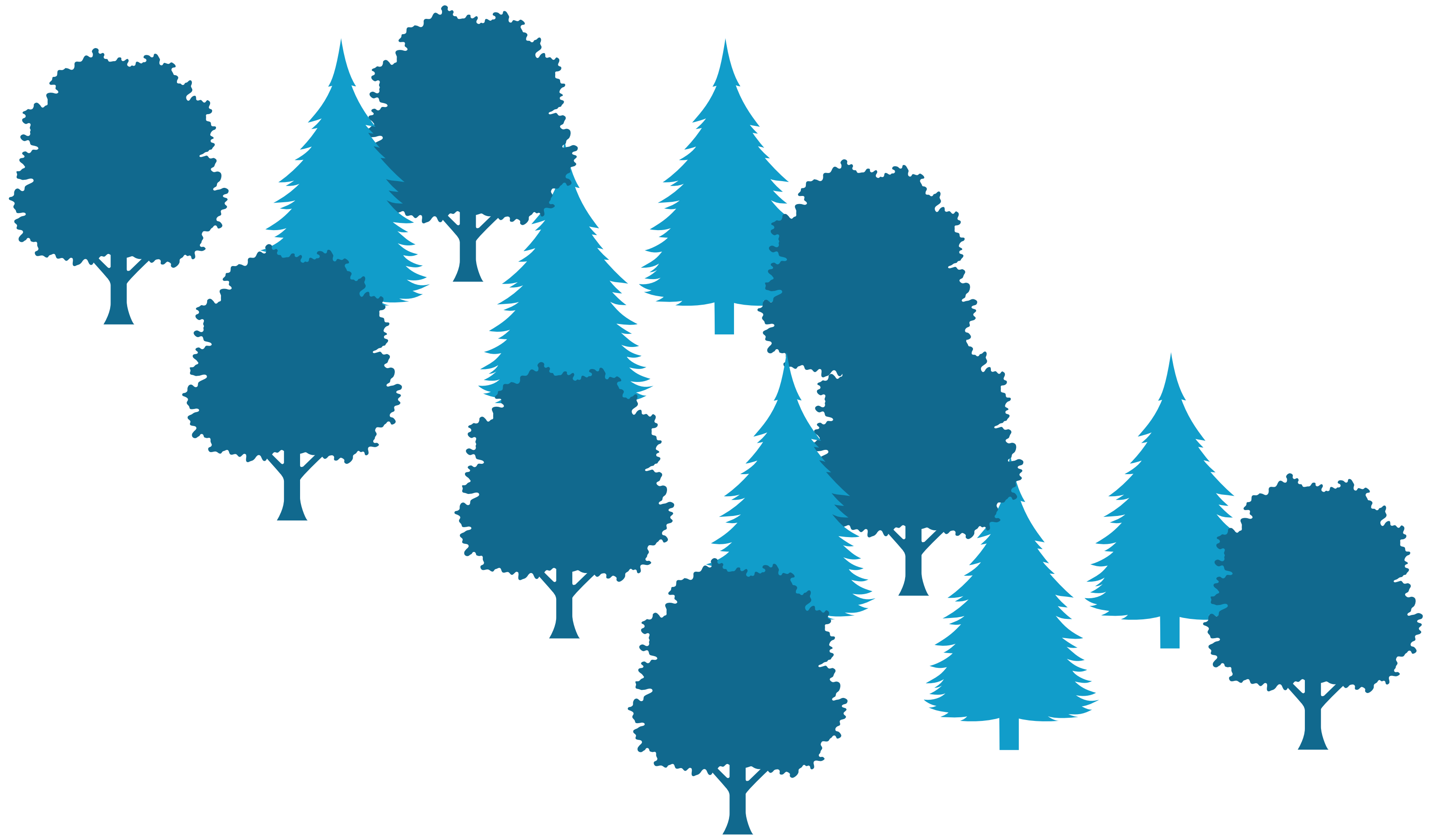
- objects size


Copepoda
size features

Conclusion

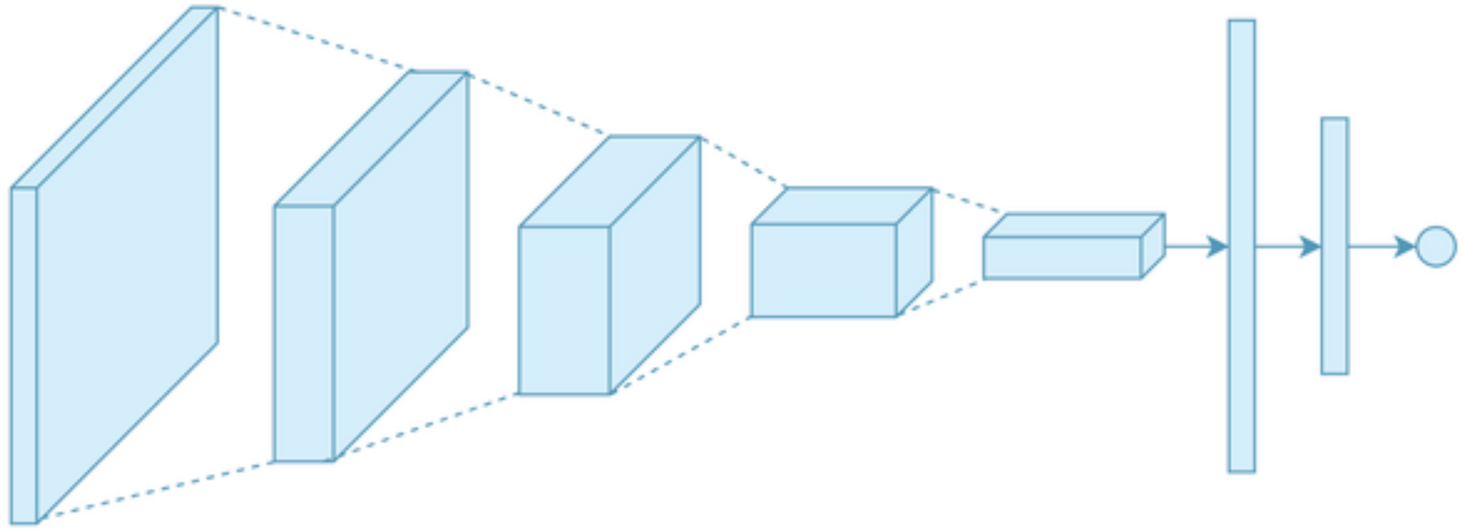
- Abundant plankton: RF ~ CNN
- CNN: more details on small classes
    - rare organisms
    - detailed taxonomy
    - low concentrations
- Manual validation





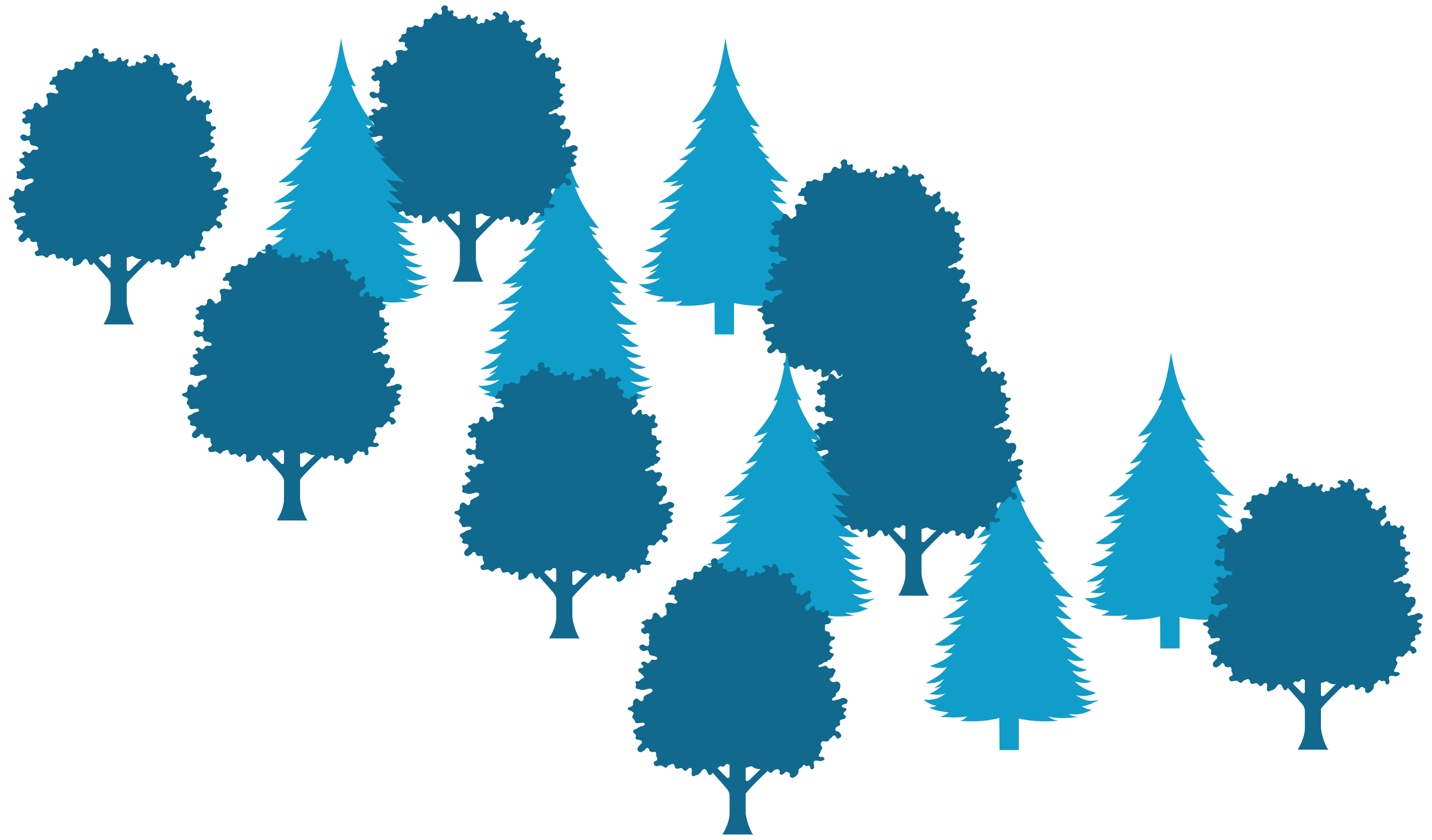
Conclusion

- Abundant plankton: RF ~ CNN
- CNN: more details on small classes
  - rare organisms
  - detailed taxonomy
  - low concentrations
- Manual validation



Thank you

Thelma Panaïotis
thelma.panaiotis@imev-mer.fr

https://github.com/ThelmaPana/plankton_classif_benchmark