



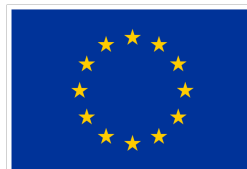
A project funded by  
the Horizon Europe  
Programme

# Tcl/Tk in environmental science: An example from the European GES4SEAS project



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11–12 July 2024, Vienna

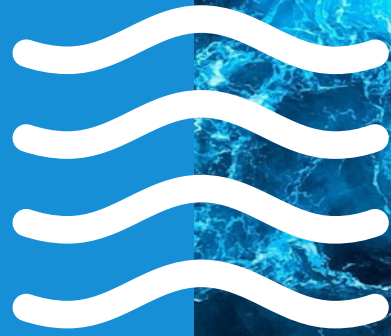


Funded by  
the European Union



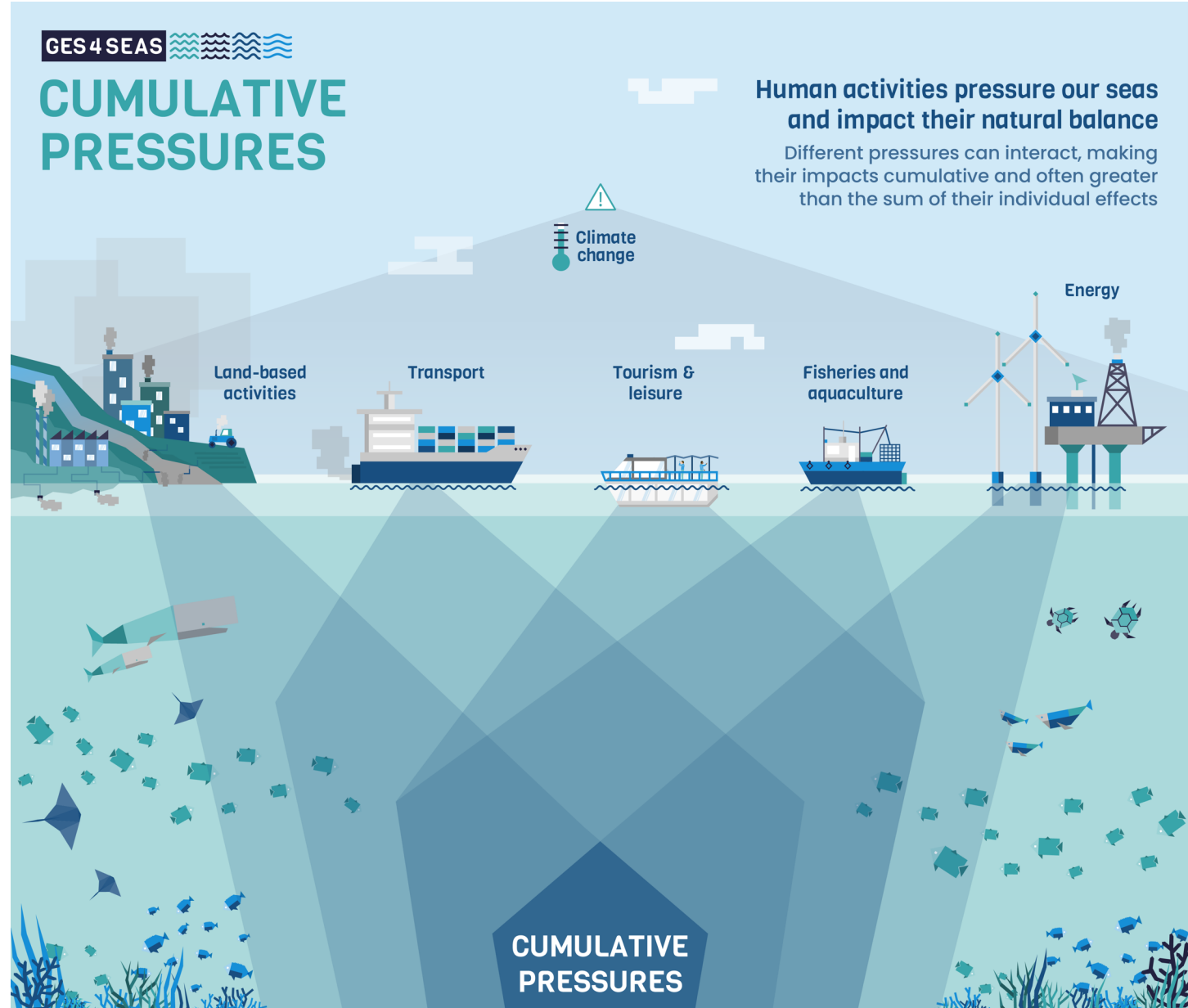
01

What is  
GES4SEAS  
about?





Achieving **Good Environmental Status** FOR maintaining ecosystem **SErvices**, by **ASsessing** integrated impacts of cumulative pressures



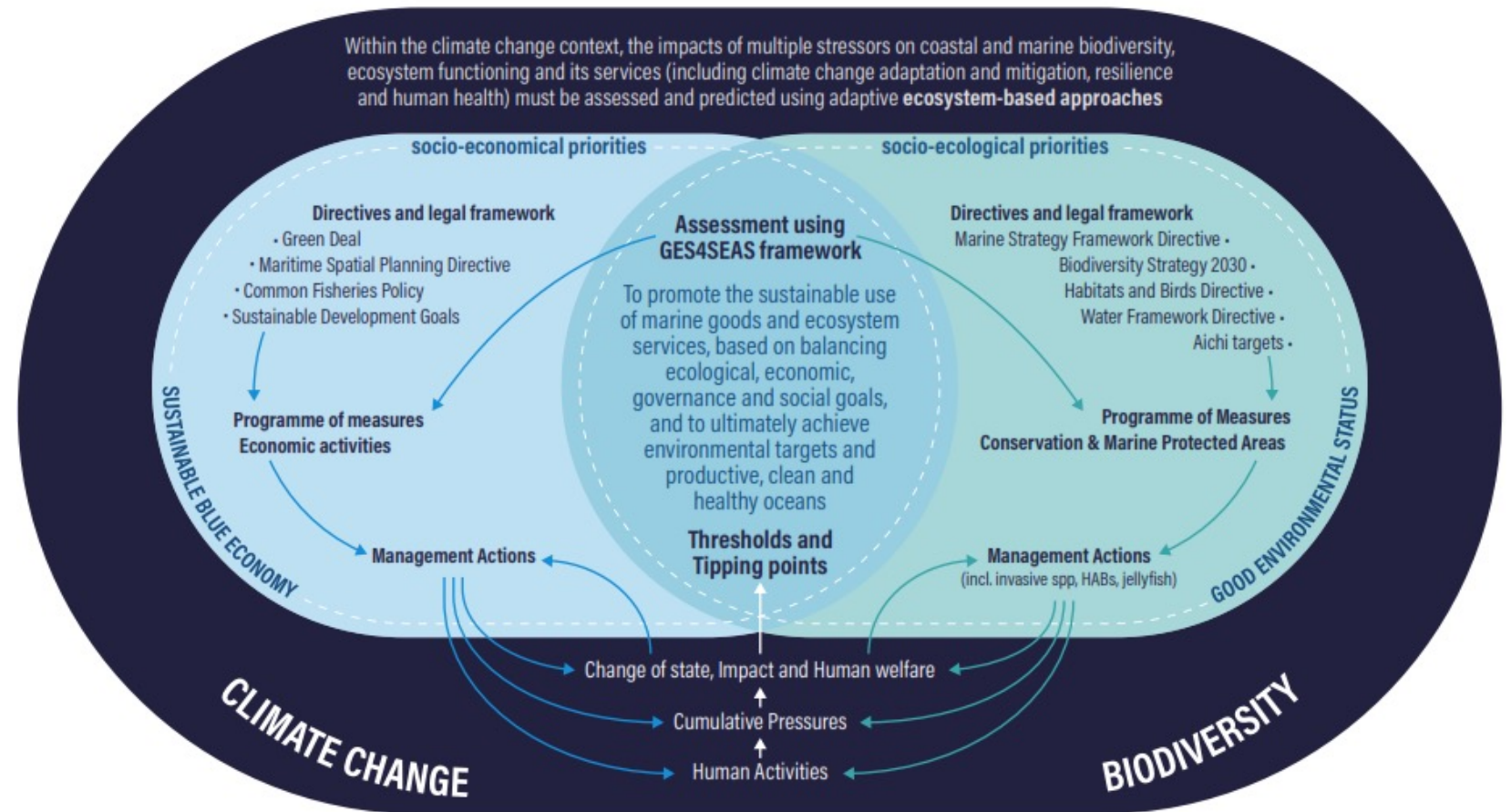


Development of an innovative **toolbox** in the context of an adaptive ecosystem-based management (EBM).

This will allow competent authorities to assess and predict the effect of multiple human pressures (including climate change) at the national, sub-regional, regional and European level.

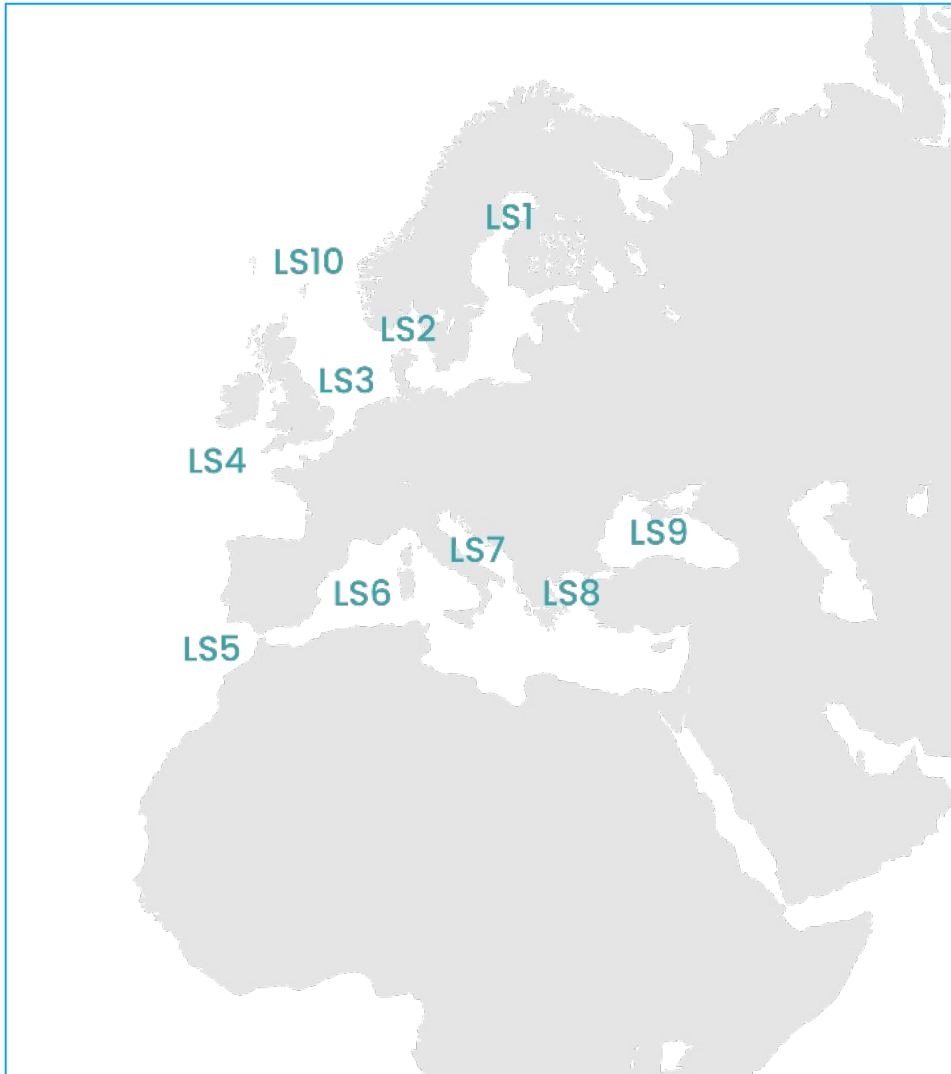
This will then give guidance for measures needed to achieve Good Environmental Status (GES).

## Environmental assessment is complex!





## Learning sites – local, regional and European scale (and Pacific)



Toolbox ... testing, validation, improvement

LS1: Gulf of Bothnia

LS2: Kattegat

LS3: North Sea (Netherlands)

LS4: Celtic Sea

LS5: Deep Atlantic-Mediterranean transition

LS6: Western Mediterranean

LS7: Adriatic Sea

LS8: Aegean Sea

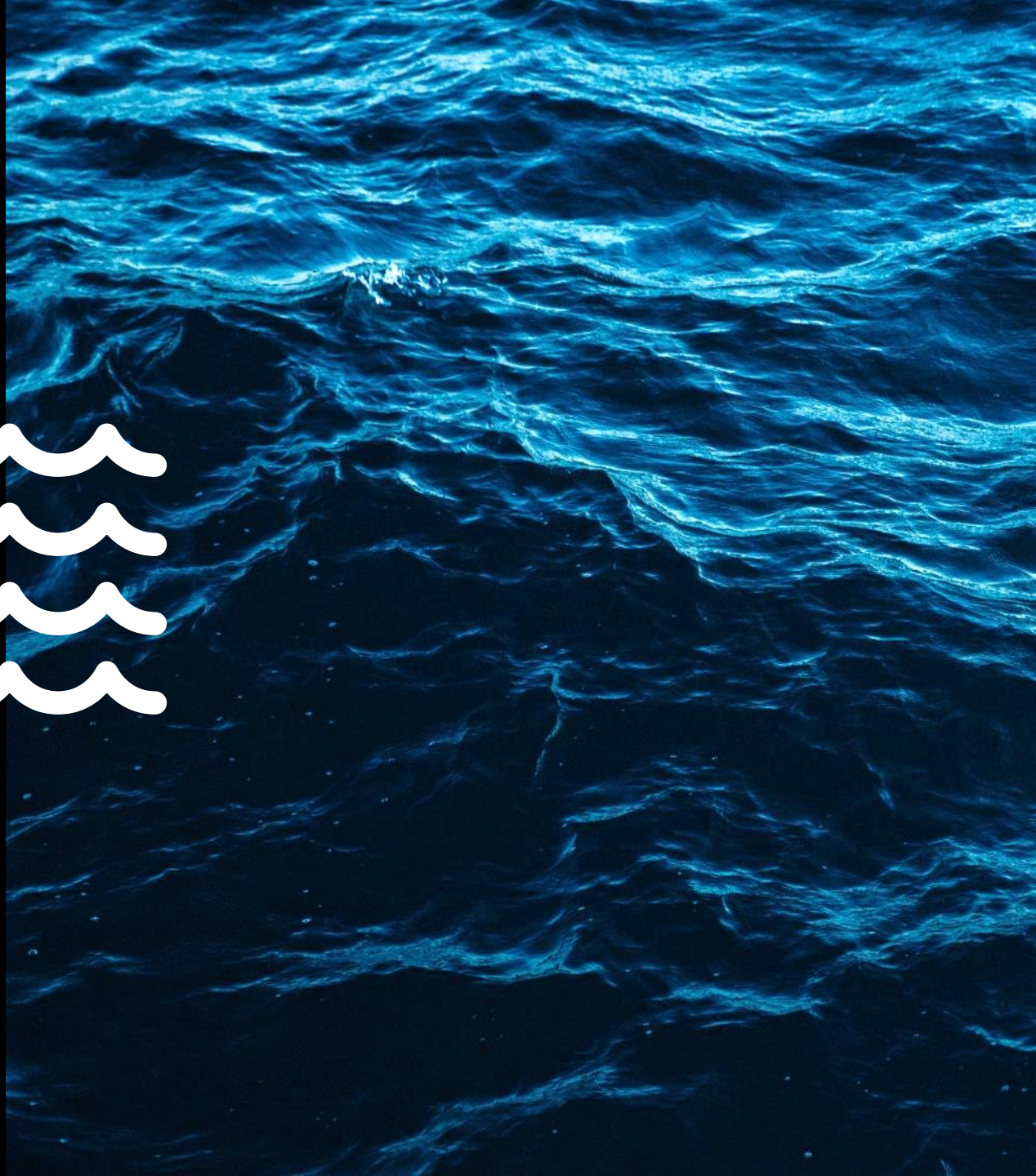
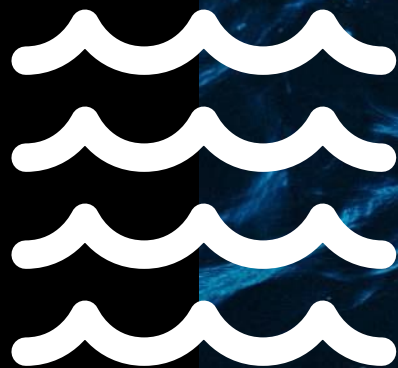
LS9: Black Sea

LS10: Whole Europe's Seas

LS11: French Polynesia (Pacific)

02

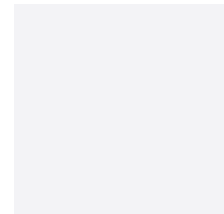
The toolbox





## Some facts and numbers ...

- cross-platform application (Windows, macOS; Linux planned)
- deployment as Mac bundle on macOS, freewrap executable on Windows
- currently  $\approx$  14,100 lines of Tcl code (14,800 including comments)
- Packages:
  - sqlite3 – application database and storage
  - tablelist – GUI (navigation, table and hierarchy display)
  - ooxml (tdom) – Excel file import & export
  - uuid (from tcllib) – metadata creation





GES4SEAS: The Toolbox, version 1.2

**Home**

- Projects
- Tags
- Collections

**Data**

- Background data
- User data

**Analysis**

- Analysis templates
- Analysis evaluations

Last projects

- LS7\_ver2
- Artificial Sea
- PRUEBA BoB 20240416
- LS Kattegat v1.1**
- Halpern LS Kattegat (test)
- LS Kattegat v0.6
- LS Kattegat v0.4

**Title** LS Kattegat v1.1  
**Location** /Users/Torsten/Tcl/own/GES4SEAS/Projects/LS-Kattegat-v1.1.db  
**Last modified** 2024-04-22 23:41:09

Open project

+ - ✎ 📄

Multiple projects





GES4SEAS: The Toolbox, version 1.2 - Project: LS Kattegat v1.1

**Home**  
Projects  
Tags  
Collections

**Data**  
Background data  
User data  
**Analysis**  
Analysis templates  
Analysis evaluations

Title
birds_fulmar
birds_alcid
birds_scoter
birds_eider2008
birds_diver2006
birds_merganser2008
birds_ltd
cfs_pel_fish_herring
cfs_ben_fish_hake
cfs_pel_fish_mackerel
cfs_ben_fish_sole
cfs_pel_fish_norwaypout
cfs_crayfish_cragon
cfs_pel_fish_sprat
<b>cfs_ben_fish_plaice</b>
cfs_ben_fish_sandeel
cfs_ben_fish_haddock
cfs_crayfish_nephrops
cfs_ben_fish_cod
cfs_ben_fish_turbot
cfs_crayfish_pandalus
cfs_pel_fish_saithe
fish_rare_atlantichalibut
fish_rare_greaterforkbeard
fish_rare_thornbackray
fish_rare_skates
fish_rare_spottedray
fish_rare_atlanticcatfish
fish_rare_ling

**Title** cfs\_ben\_fish\_plaice  
**Size** 625 (+) x 756 (+)

+ - [edit] [copy] [share]

Zoom in Zoom out Zoom to all

Import & export of spatial and thematic datasets



GES4SEAS: The Toolbox, version 1.2 - Project: Artificial Sea

**Home**  
Projects  
Tags  
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Background data  
User data

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Analysis templates  
Analysis evaluations

Name
CEA 2008 w values
<b>CEA 2009 w values</b>
EC coverage
overlap
simple cumulation (sum of products)
sum

**Title** CEA 2009 w values

```
graph LR; EC[ecosystem components] --> CEA[CEA]; P[pressures] --> CEA; S[sensitivities] --> CEA;
```

ecosystem components

pressures

sensitivities

CEA

Add block ...

Create new analysis from template ...

Flexible custom analysis templates using graphical „modeler“



## Toolbox components – “Analysis templates”

Define the general block properties:

**Name\*** ecosystem components

**Short code**

**Block type\***  Data block  Action block

**Relationship\*** All definitions must be met

**Definitions\***

Classification	Management stage	State	+	-
Classification	Ecosystem component	Biotic component	+	-

**Description**

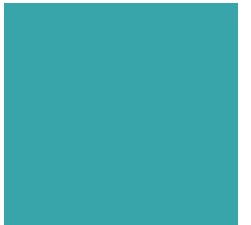
Cancel Previous Next OK

Easy definition of model building blocks – using own GUI package „toolworks“



## toolworks package – example

```
twForm::Form blockWiz_p1 -dialog 0 -path $pagel.f -ok {} -cancel {}
blockWiz_p1 add entry -label [mc Name]* -value $blockData(modelblock)
blockWiz_p1 add entry -label [mc "Short code"] -value $shortcode
blockWiz_p1 add radiogroup -label [mc "Block type"]* \
    -items [list data [mc "Data block"] action [mc "Action block"]] \
    -checkedValue $blockData(mb_type) -command ::gui::analysisTemplateBlockNewEdit2
blockWiz_p1 add combobox -label [mc Relationship]* -keyed 1 -defaultkey $relDefault -values $relList
blockWiz_p1 add query -label [mc Definitions]* -returnformat {id+ value} \
    -default $blockData(mb_definition,data) -definition {
    choice -label Classification -id 14
    -value {select dataset_id from md_item_dataset where}
    -children {choice -label "Management stage" -id 18 -value {} -children {
        choice -label Driver -id 19 -value {md_element_id=19}
        choice -label Activity -id 20 -value {md_element_id=20}
        choice -label Pressure -id 21 -value {md_element_id=21}
        ...
    }}
blockWiz_p1 add text -label [mc Description] -height 10 -value $blockData(mb_comment)
```





# Toolbox components – “Analysis templates”

**Edit block - Step 1 of 2**

Define the general block properties:

**Name\*** CEA

**Short code**

**Block type\***  
 Data block  
 Action block

**Definition\***  
 Cumulation Cumulative impact score (based on Halpern et al. 2008)

**Description**

Cancel Previous Next OK

EC as presence/absence  
 EC with values  
 EC with values and hierarchical structure  
 EC as ES with values  
 EC as ES with values and hierarchical structure

CEA

sensitivities

Add block ...

Create new analysis from template ...





GES4SEAS: The Toolbox, version 1.2 - Project: LS Kattegat v1.1

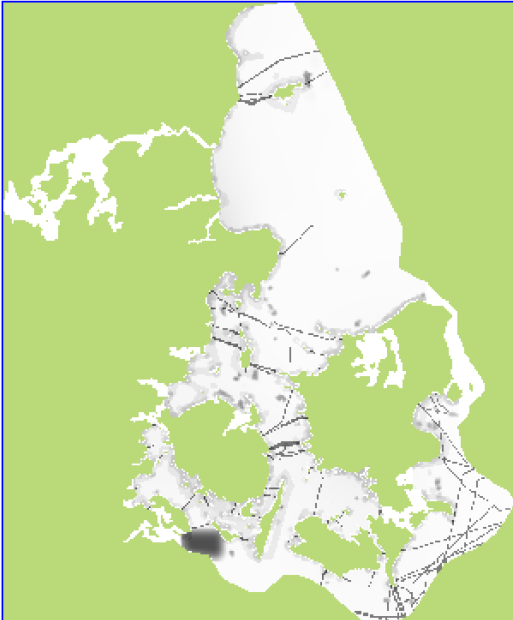
**Home**  
Projects  
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User data

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Analysis templates  
Analysis evaluations

Name
CEA (birds)
CEA (full)
CEA 2
shipping

**Title** CEA (birds)  
**Size** 625 (↔) x 756 (±)  
**Analysis template** CEA based on Halpern et al. (2008)  
**Last evaluation** 2024-06-13 09:54:54  
**Validitv** valid



Zoom in    Zoom out    Zoom to all

Run analysis ...

+   -      

Running analysis & map output



## GDAL package – example

```
(GES4SEAS) 5 % gdal info data/sedimenttyp.gpkg infoArray -layer sedimenttyp
```

```
(GES4SEAS) 6 % parray infoArray
```

```
infoArray(BBox) = 4288478.4498 3425249.644 4628478.4498 3552749.644
```

```
infoArray(bandCount) = 1
```

```
infoArray(dataType,1) = Float32
```

```
infoArray(dataTypeName,1) = Thirty two bit signed integer
```

```
infoArray(driver) = GPKG
```

```
infoArray(maxValue,1) = 254.0
```

```
infoArray(minValue,1) = 12.0
```

```
infoArray(nodataValue,1) = 0.0
```

```
infoArray(projection) = PROJCS["ETRS89-extended / LAEA
```

```
Europe",GEOGCS["ETRS89",DATUM["European_Terrestrial_Reference_System_1989",SPHEROID["GRS
```

```
1980",6378137,298.257222101,AUTHORITY["EPSG","7019"]],AUTHORITY["EPSG","6258"]],PRIMEM["Greenwich",0,AUTHORI
```

```
TY["EPSG","8901"]],UNIT["degree",0.0174532925199433,AUTHORITY["EPSG","9122"]],AUTHORITY["EPSG","4258"]],PROJ
```

```
ECTION["Lambert_Azimuthal_Equal_Area"],PARAMETER["latitude_of_center",52],PARAMETER["longitude_of_center",10
```

```
],PARAMETER["false_easting",4321000],PARAMETER["false_northing",3210000],UNIT["metre",1,AUTHORITY["EPSG","90
```

```
01"]],AXIS["Northing",NORTH],AXIS["Easting",EAST],AUTHORITY["EPSG","3035"]]
```

```
-----
```

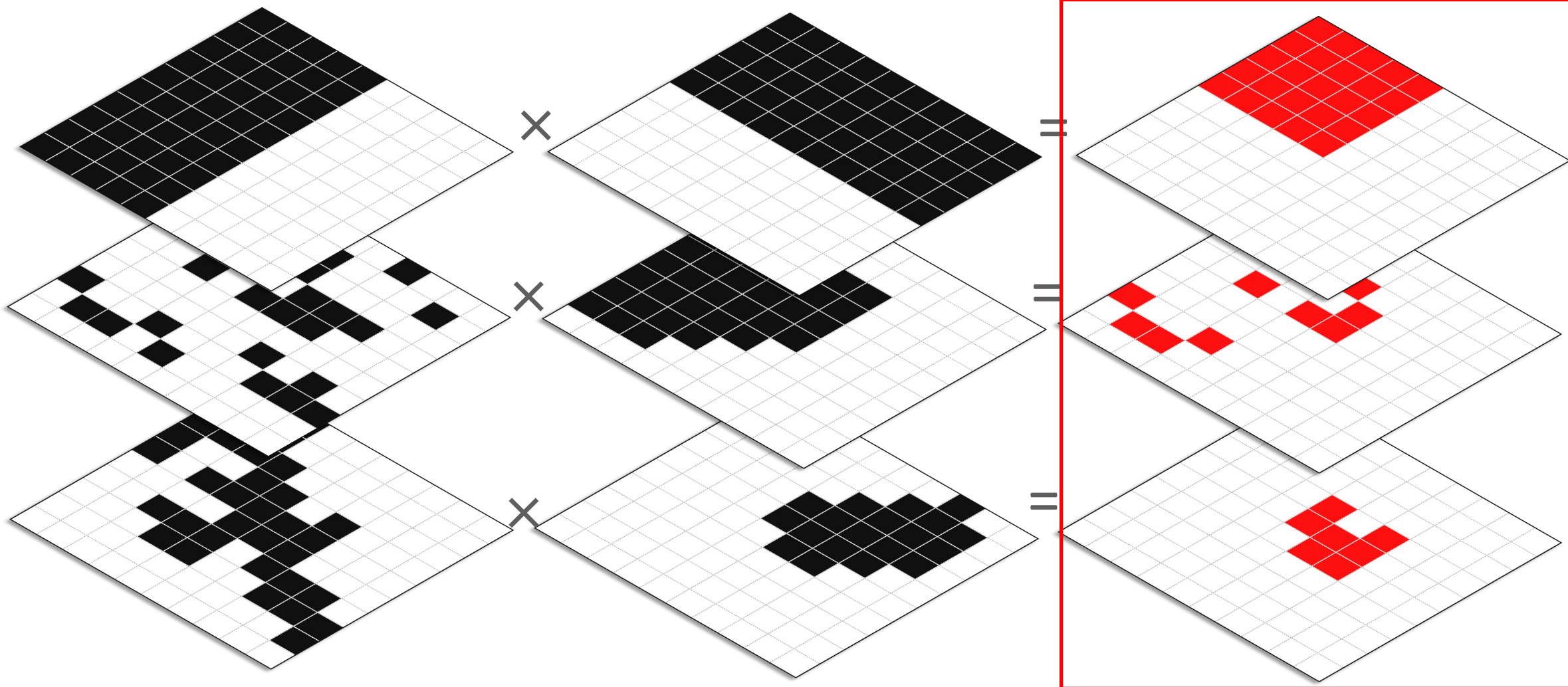
```
set valueList [gdal read data/sedimenttyp.gpkg infoArray -layer sedimenttyp]
```



Ecosystem Component

Pressure

Effect / Impact

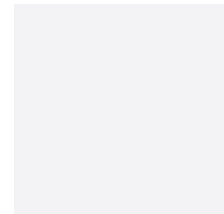






## Typical calculation case ...

- Size: 625 x 756 cells (each cell 500 x 500 m) = 472,500 cells
- Layers: 51 ecosystem components, 41 pressures
- →  $51 \times 41 = 2,091$  combinations of layers per cell
- →  $2,091 \times 472,500 = 987,997,500$  individual calculations
- Calculation time on a recent Mac mini  $\approx 2,5$  minutes





## Future until 2026 ...

- many more feature coming on a monthly basis as the project is on-going
- speed up calculations: vecTcl?
- embedding Tcl & R as scripting languages
- release GDAL package as open source (GDAL is a beast with  $\approx$  12–50 dependencies)
- release toolworks package as open source (mostly custom megawidgets)

... and I can't wait to bring the toolbox to Tcl 9!



Torsten Berg

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[www.ges4seas.eu](http://www.ges4seas.eu)



Thank you!

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