EcoWin.NET model box division
Stakeholder feedback and changes to model layout

PESCA working document

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Summary

Following a review of stakeholder inputs, we propose a box layout for the EcoWin.NET ecological model of 76 boxes, with 38 boxes in the upper water column layer and 38 boxes in the lower layer. The detailed analysis, results, and their justification, are presented in the text below.

Analysis

This document reviews the comments of various stakeholders on the EcoWin.NET model box division for PESCA. Stakeholder views and comments were analyzed and organized into a table where the main concerns were the box sizes in the inlets and coves because they have different characteristics in the mouth and shallow heads. For a better understanding of proposals maps were made to visualize the box boundaries where changes were suggested.

Table 1 – Summary of stakeholder comments

Stakeholders / name	Organization	Comments	Location	Boxes	Fig.
Duane	Calm Cove Oyster Co.	◆ Moving the south delineation line for box 5 to deep water Pt.	◆ Totten Inlet ◆ Oyster Bay	5 6	Figure 2 - Summary of stakeholder proposals for the Eco Win. NET model boxes. In yellow

					are the boxes that could have boundary changes
John L.	Chelsea Farms	◆ New delimitation in the boxes that separates the shallow head zones from the inlets mouths **Reasons:** Different concentration values of O_2, N, and P between the shallow head ends and the areas nearer the mouths	◆ Budd Inlet ◆ Eld Inlet ◆ Other Inlets	1 2	Figure 4
Mindy Roberts	Washington State Department of Ecology	◆ Divide the north Carr Inlet (box 24) into two around Allen Point; **Reasons:** ▪ It has different temperature, oxygen, nutrient, and chlorophyll regimes; these conditions could have some influence in the shellfish growth model; ▪ use DO model of South and Central Puget Sound for these regions to confirm; **Suggestions:** ▪ To keep the same number of boxes: join 19 and 20, 25 and 26, and 21 and 22 to focus on the finger inlets	◆ North Carr Inlet	**Divide**: 24 **Join:** 19-20, 21-22, 25-26	Figure 5

Sue	Nisqually Indian Tribe	◆ Divide Henderson into two blocks **Reasons:** The local pollution; differences between crops location - geoduck culture occurs in the mouth, and oysters near the head of the inlet		16	Figure 6
Steve	Arcadia Point Shellfish Co.	◆ The same as Duane	◆ Totten Inlet	5	Figure 2 - Summary of stakeholder proposals for the Eco Win. NET model boxes. In

				yellow are the boxes that could have boundary changes	
Joth Davis	Baywater Shellfish Farm	◆ The same as Mindy **Suggestions:** ▪ Divide the major inlets into sections based on relative depth and distance from the mouths of the inlets; ▪ Analysis of PRISM data; ▪ Modelling for the tidal flow dynamics within and between the various south sound inlets;	◆ North Carr Inlet	**Divide**: 24 **Join:** 19-20, 21-22, 25-26	Figure 5

Vicki & Steve	Arcadia Point Shellfish	◆ Agrees with John L. and Joth Davis; ◆ Changing the division of the boxes because of the cove areas; **Suggestions:** ▪ Analyze the Shoreline Inventory and Characterization Report to this region to help in the boxes division (components of the report: predominant drift direction, wave and tidal current exposure, near shore geology, geomorphic shore form type, habitat, etc); ▪ Mention of social carrying capacity	◆ Budd Inlet ◆ Eld Inlet ◆ Stretch Island ◆ North Carr Inlet	1 2 14 **Divide**: 24 **Join:** 19-20, 21-22, 25-26	Figure 7 Figure 4 Figure 5
DF	Calm Cove Oyster Co.	◆ Mention of social carrying capacity			
Bill Dewey	Taylor Shellfish Farms	◆ Agrees with John L.; ◆ It is not necessary to divide Budd Inlet **Reasons:** Carrying capacity there won't be an issue for aquaculture since it will remain prohibited due to the LOTT sewage outfall ◆ Agrees with Mindy	◆ Eld inlet ◆ North Carr Inlet	2 **Divide**: 24 **Join:** 19-20, 21-22, 25-26	Figure 4 Figure 8

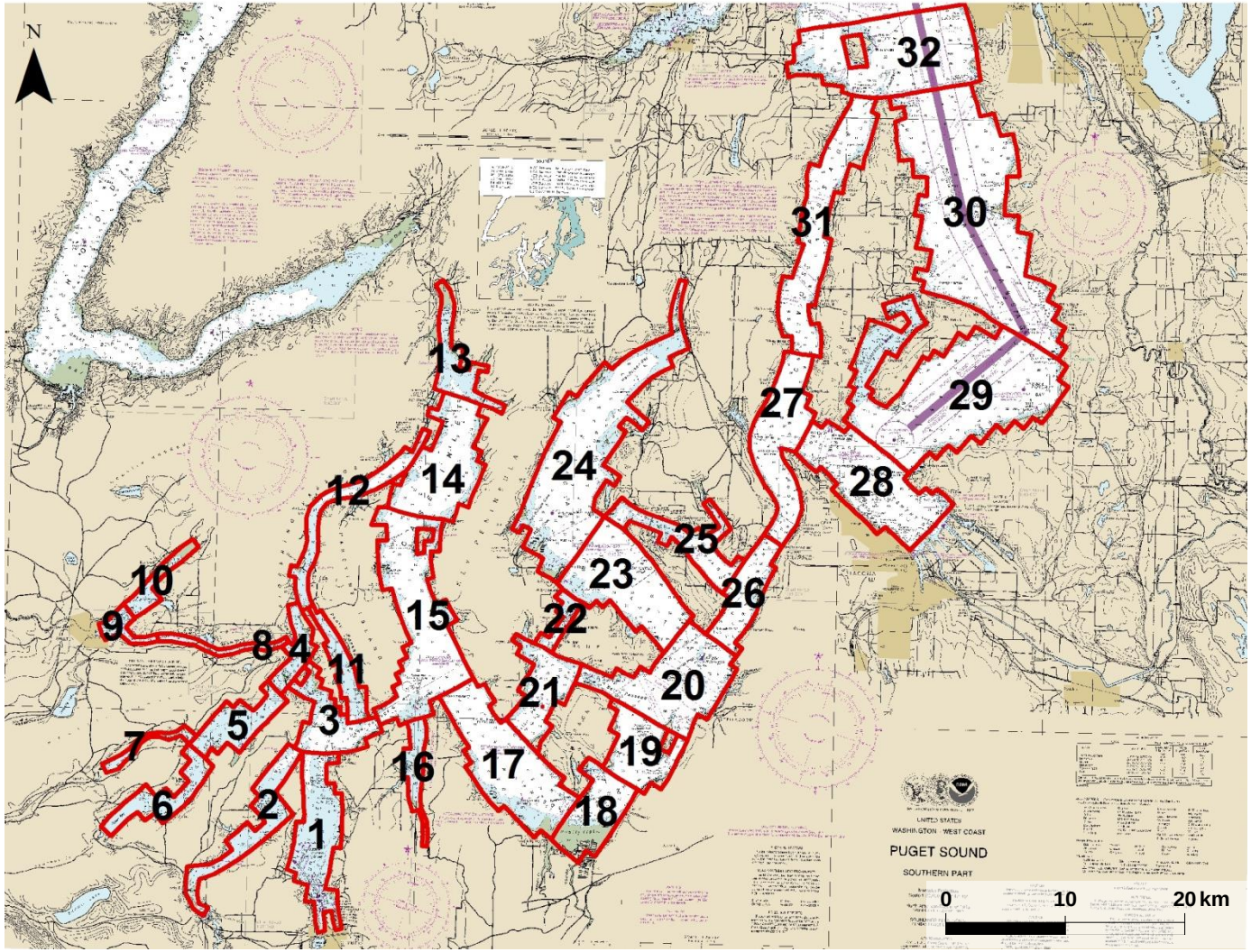


Figure 1 - EcoWin.NET model box proposal in January 2014

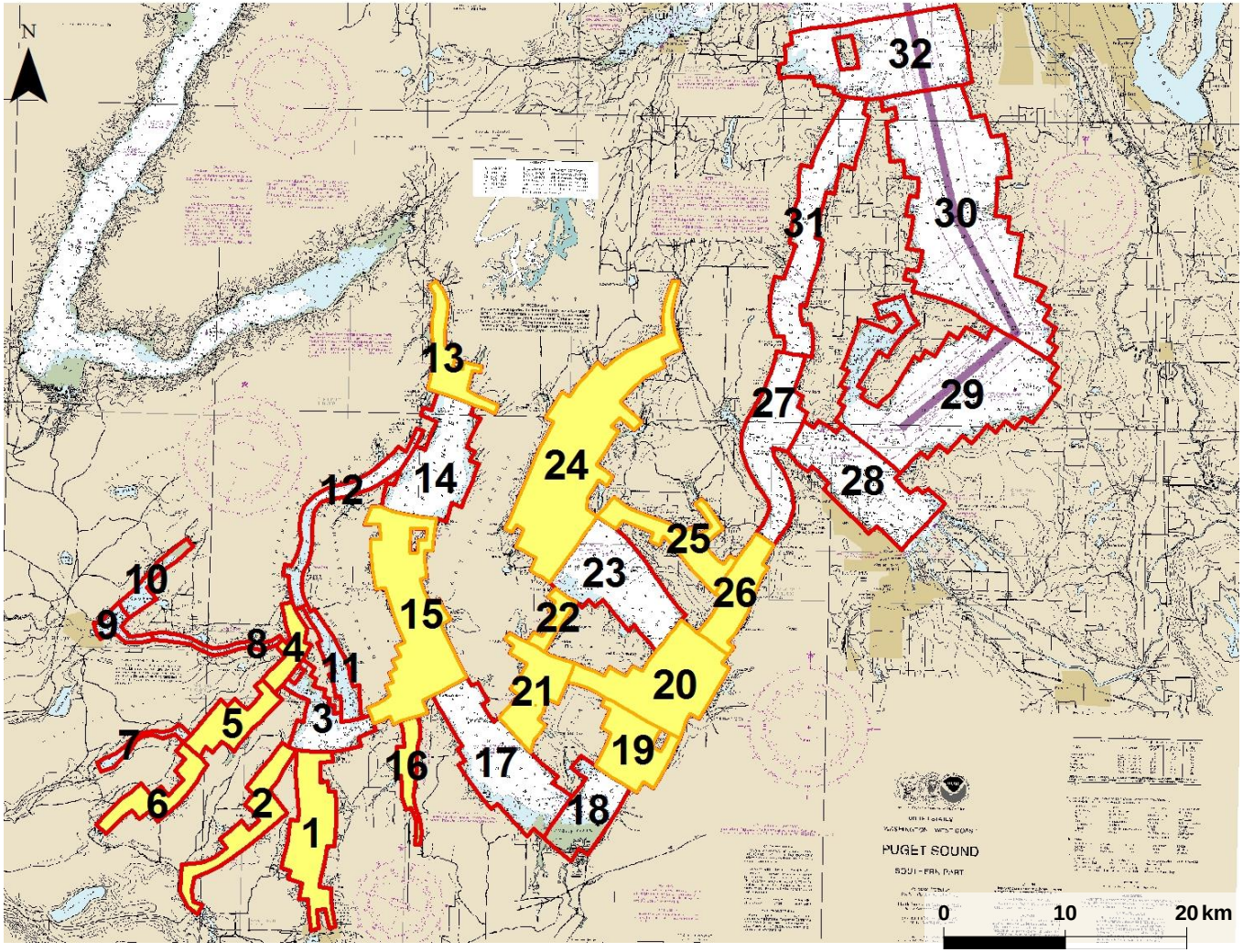


Figure 2 - Summary of stakeholder proposals for the EcoWin.NET model boxes. In yellow are the boxes that could have boundary changes

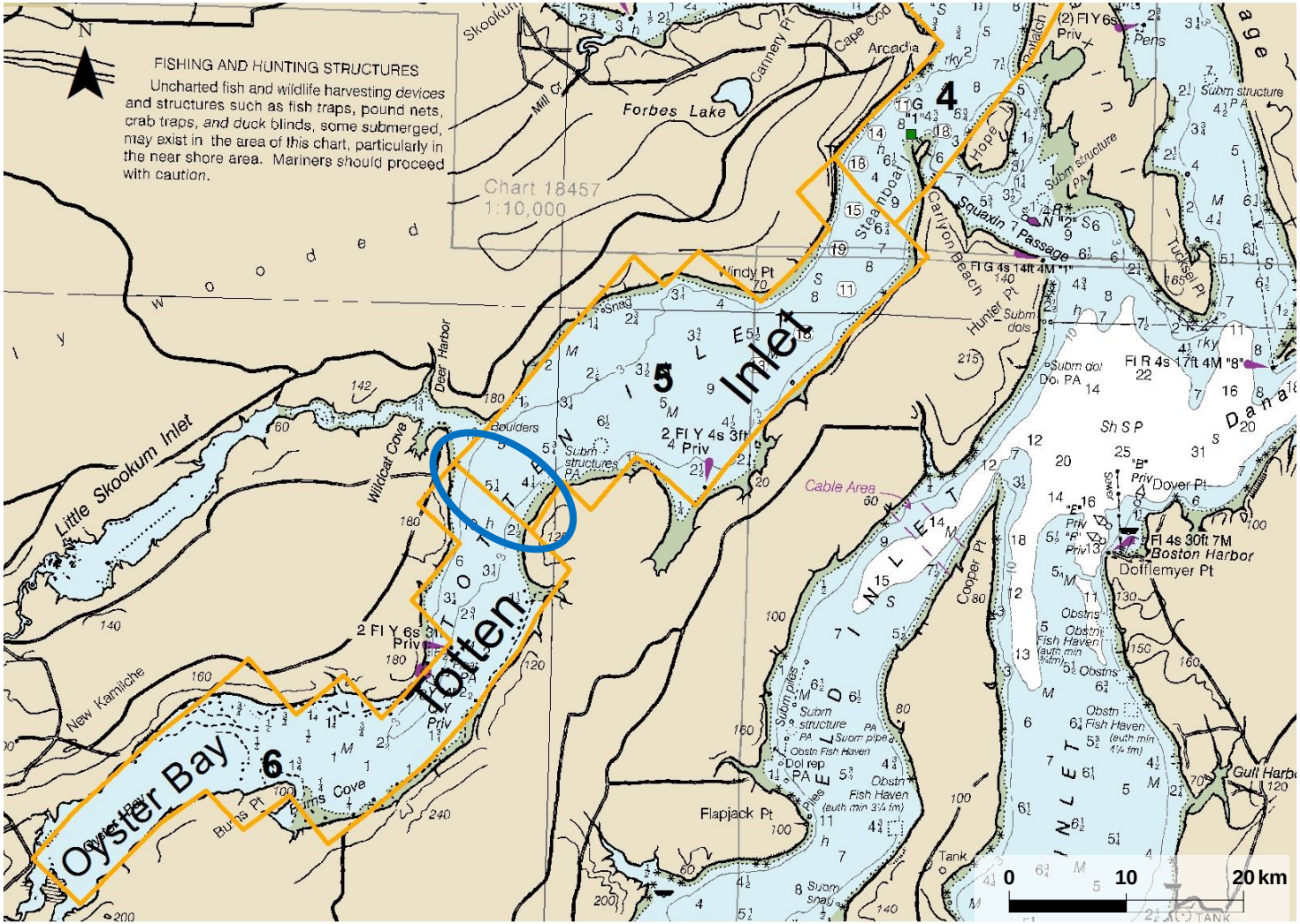


Figure 3 – Oyster Bay and Totten Inlet – alteration of the south boundary of box 5 to deeper waters

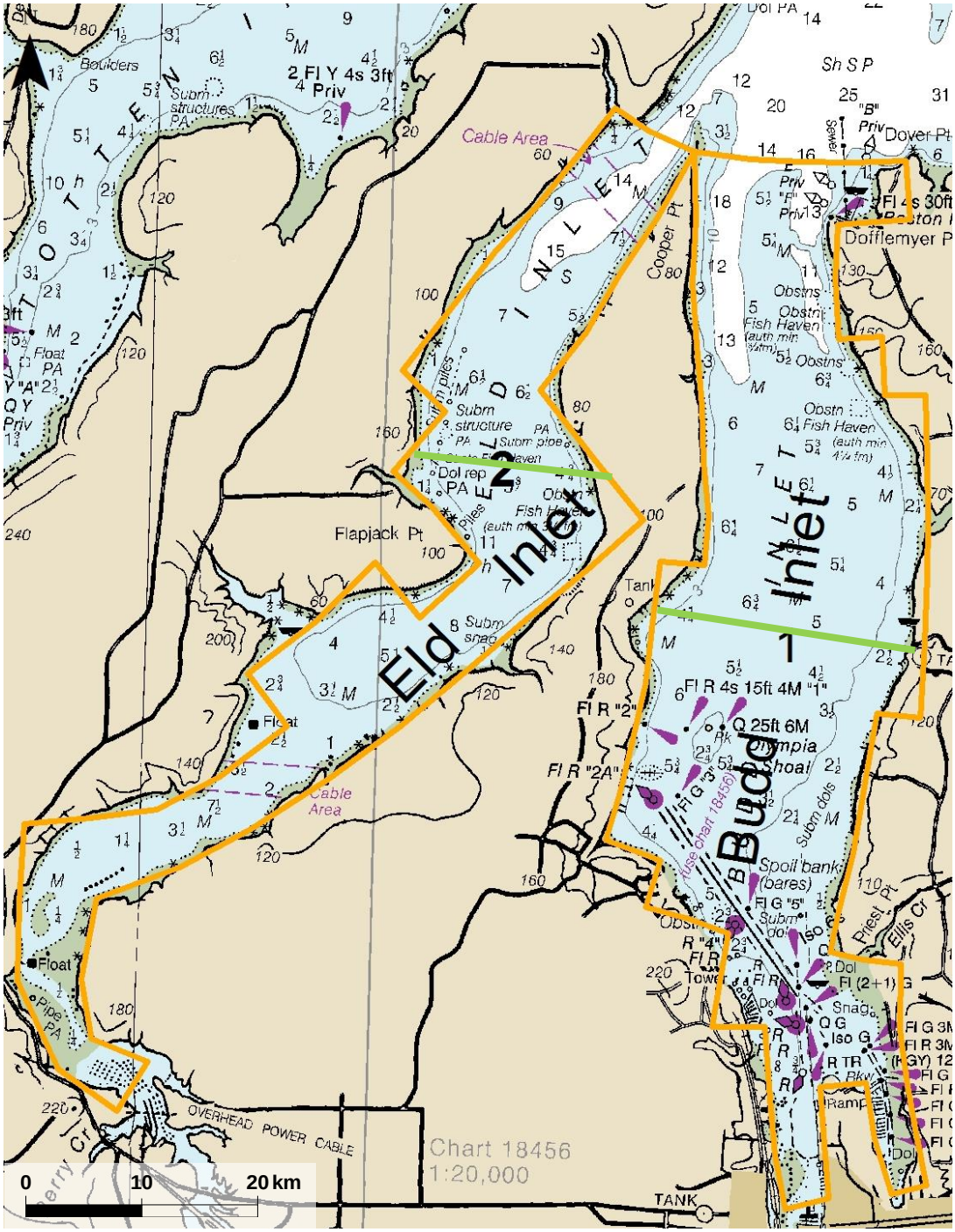


Figure 4 - New box boundaries to separate the shallow head zones from the inlets mouths, ex. Budd Inlet and Eld Inlet

Box	Area (km^2)	Volume (m^3)
1	21.9	89,360,775
2	14.3	46,990,719

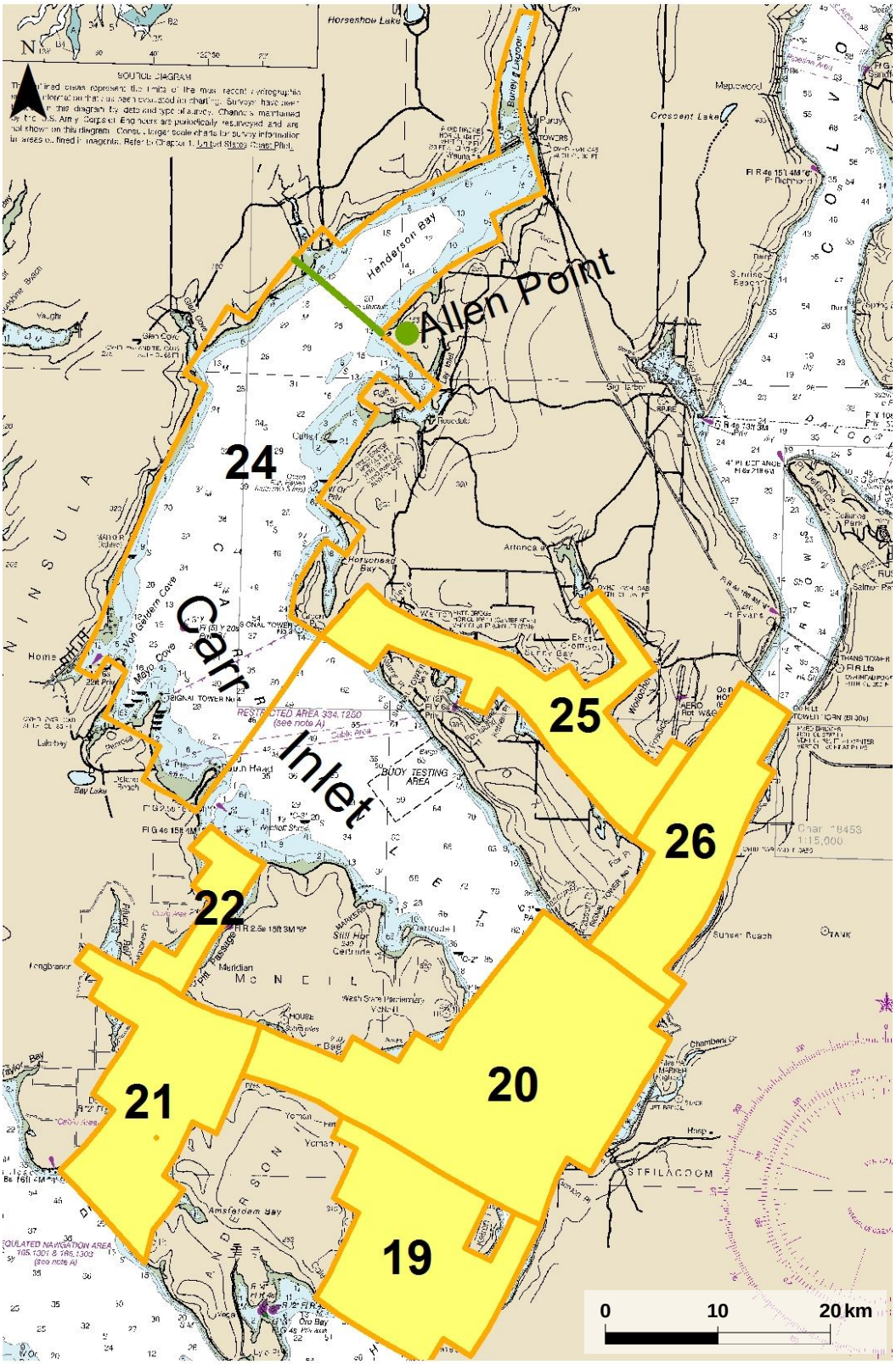


Figure 5 – Division of box 24 around Allen Point and the joining of the yellow boxes suggested by Mindy Roberts

Box	Area (km^2)	Volume (m^3)
24	58.3	4,222,004,655
Σboxes	92.5	5,519,870,620

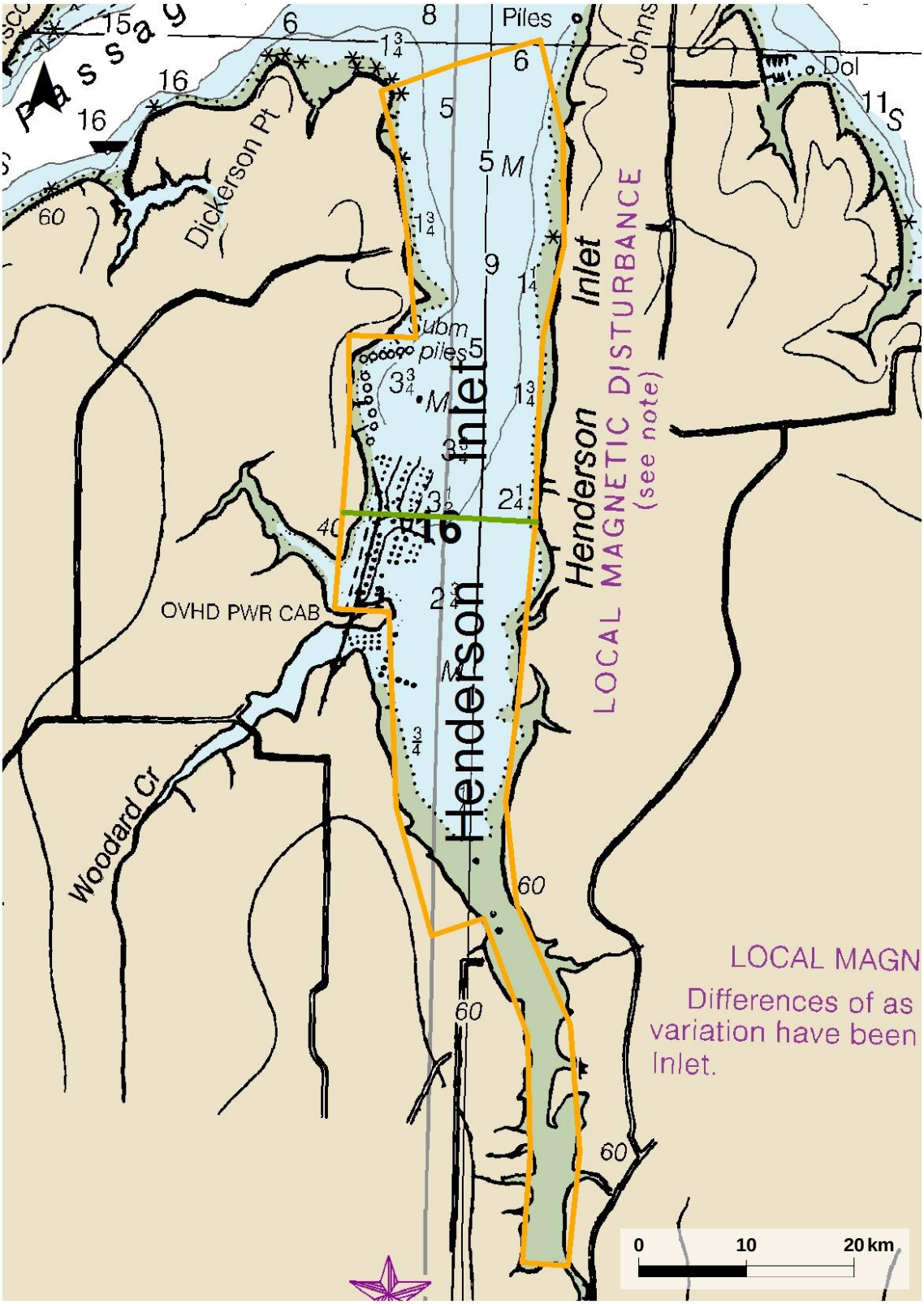


Figure 6 – Map with the alterations proposed for the Henderson Inlet. The green line represents the division of the 16th box into two, as suggested by the stakeholders

Box	Area (km^2)	Volume (m^3)
16	6.1	4,680,066

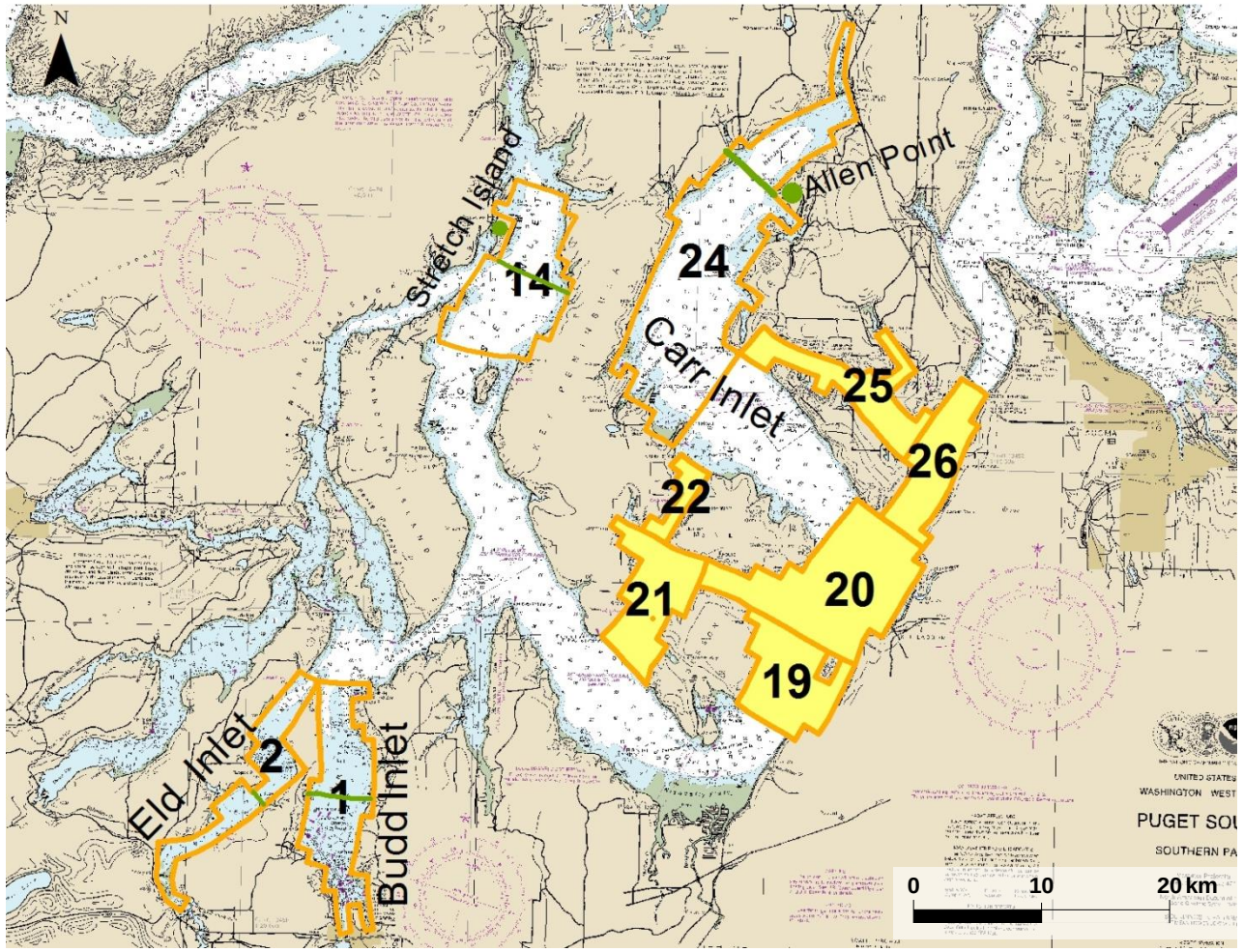


Figure 7 – Map with the suggestions for the division of most of the inlets. Representation of the proposal for box 14: a division around Stretch Island. The boxes in yellow are the ones to be joined together

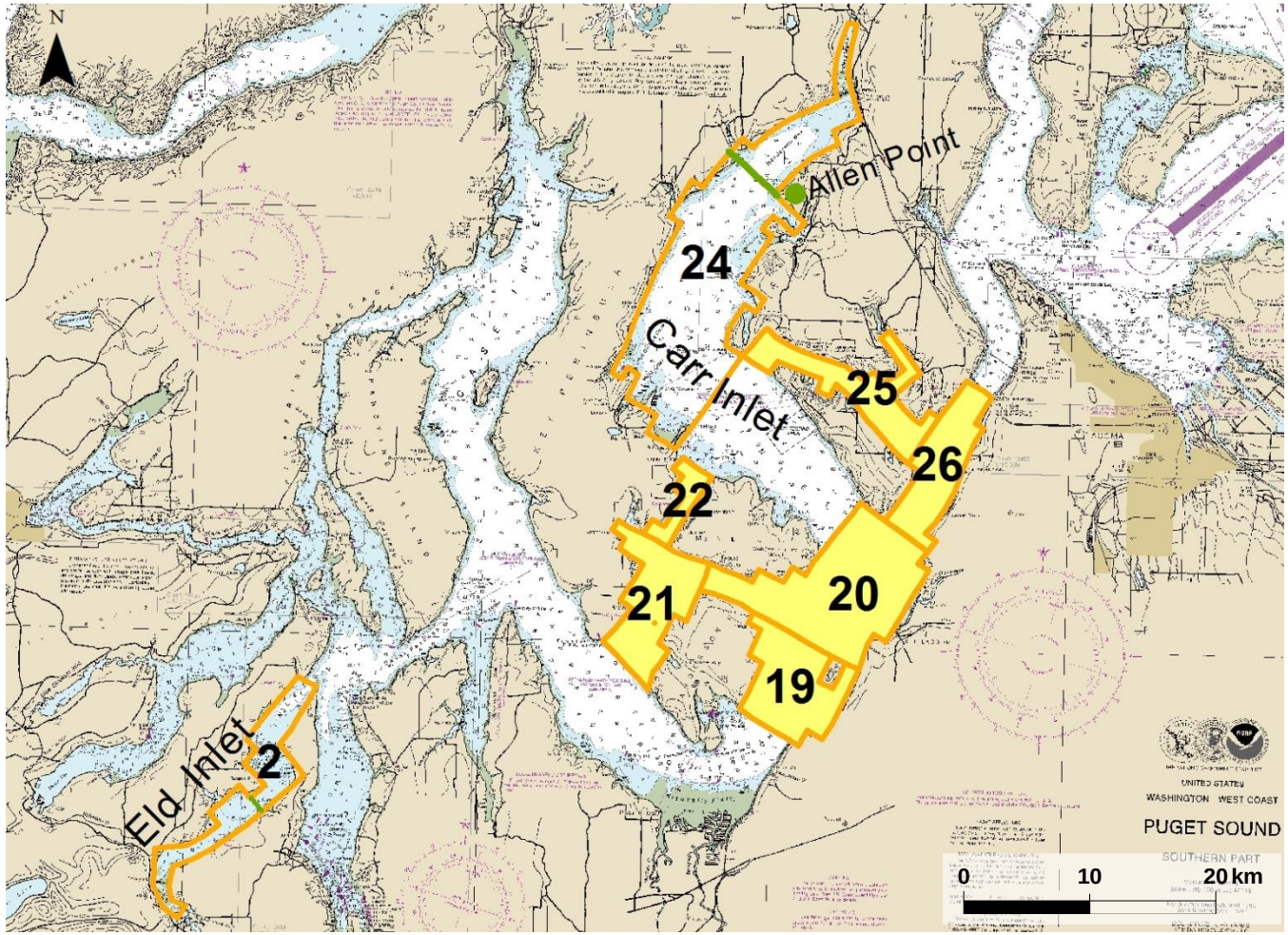


Figure 8 – More and less the same proposals as in Figure 7 except for Budd Inlet and Stretch Island, they do not need to be divided

Results

This analysis establishes the connections between the previous report “Definition of EcoWin.NET model boxes in South Puget Sound” and the suggestions made by the stakeholders for alterations of EcoWin.NET model boxes.

Puget Sound Morphology

One of the concerns expressed by the stakeholders was the differences in the Puget Sound morphology of the inlets. In the preview report, one of the methodologies applied to box division was the analysis of the physical data such as depth, temperature, salinity and the current velocity. In this analysis, and as suggested by the stakeholders, the shoreline morphology will be considered. The South Puget Sound shoreline is characterized by sweeping beaches interspersed with estuaries and lagoons. There is a significant difference between the inlets and the main basin. The inlets are characterized by shallow heads and deeper mouths with warmer waters and rich mudflats.

The new boxes were divided according to the different depths in inlets (Figure 9 &10)

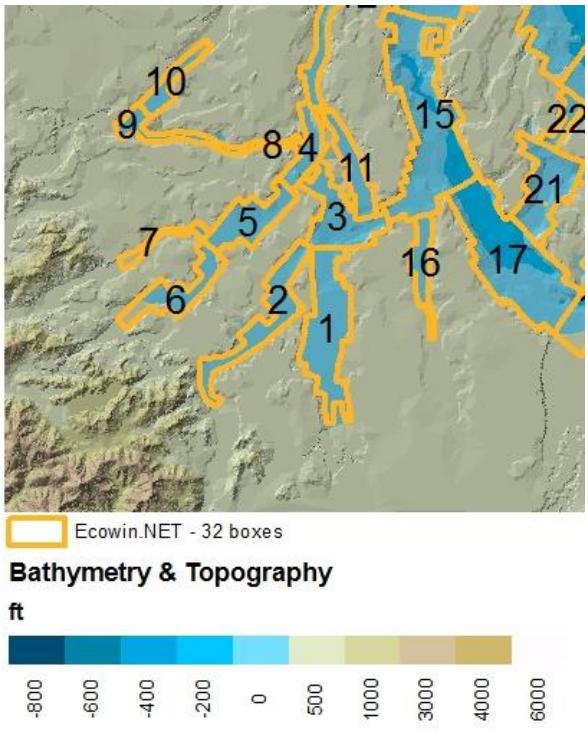


Figure 9 – Initial proposal for EcoWin.NET boxes

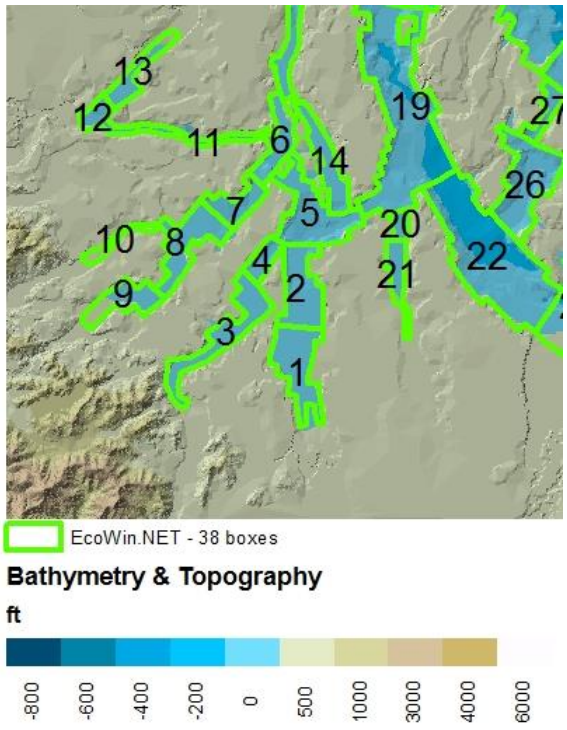


Figure 10 – EcoWin.NET boxes after the stakeholder suggestions

The intertidal areas are located at the heads and along the shoreline, Figure 11. This area represents 5% of the total area, 36 km^2.

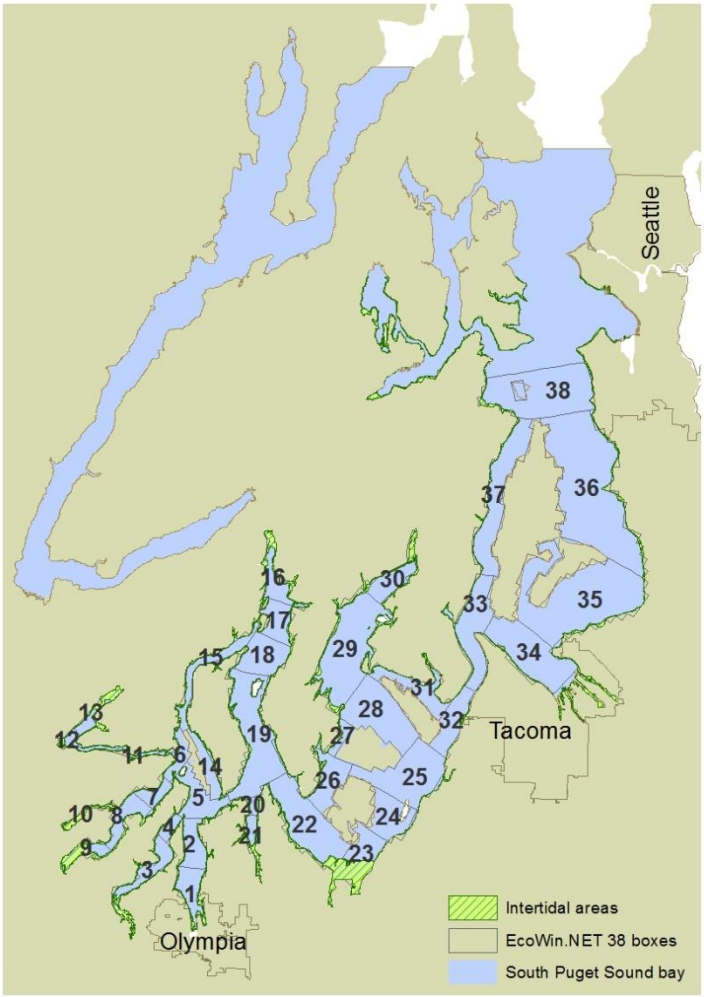


Figure 11 – Intertidal areas in Puget Sound and EcoWin.NET boxes

In this case, because of the new divisions, to check if the water volume in the boxes is appropriate for running the ecological model the percentage of intertidal area per box was calculated.

Table 2 – Percentage of intertidal area in Puget Sound bay per box. The higher percentages per box are in bold

Box	Intertidal area (sq. ft)	Intertidal area (m^2)	Box area (m^2)	Percentage intertidal
1	13,886,243	1,290,074	11,217,853	11.5
2	6,215,029	577,395	10,673,568	5.4
3	16,318,207	1,516,011	11,117,266	13.6
4	1,291,716	120,004	3,185,574	3.8
5	5,515,070	512,367	13,707,246	3.7
6	4,424,469	411,047	6,486,674	6.3
7	2,993,357	278,092	5,453,822	5.1
8	5,355,175	497,512	9,449,565	5.3
9	37,373,238	3,472,087	6,275,388	**55.3**
10	16,042,881	1,490,432	2,831,592	**52.6**
11	4,753,323	441,598	3,284,114	13.4
12	7,103,174	659,906	3,383,917	19.5
13	18,142,205	1,685,466	4,825,196	**34.9**
14	1,519,038	141,123	7,524,004	1.9
15	5,553,767	515,962	11,486,541	4.5
16	21,652,268	2,011,562	10,270,302	19.6
17	4,679,401	434,731	10,572,158	4.1
18	3,302,531	306,815	16,116,214	1.9
19	16,361,186	1,520,004	40,836,413	3.7
20	2,176,943	202,245	1,786,646	11.3
21	11,506,116	1,068,953	4,340,382	**24.6**
22	24,359,116	2,263,036	35,008,856	6.5
23	61,781,367	5,739,677	15,911,215	**36.1**
24	455,576	42,324	15,877,436	0.3
25	575,718	53,486	31,492,459	0.2
27	2,476,922	230,114	3,490,189	6.6
28	1,032,792	95,950	30,790,210	2.7
29	27,321,372	2,538,239	46,423,649	8.2
30	19,351,397	1,797,804	11,901,946	3.9
31	2,308,109	214,430	13,367,662	1.8
32	2,163,407	200,987	13,206,389	1.5
33	2,587,677	240,403	24,981,826	1.8
34	2,796,941	259,844	33,018,560	1.0
35	8,299,279	771,028	75,042,975	2.3
36	9,348,655	868,518	89,827,940	1.2
37	5,624,314	522,516	31,907,491	0.6
38	10,528,729	978,151	45,838,627	3.1

In bold are the boxes that have the higher intertidal proportions. These potentially present problems when running the model with a timestep typical for this kind of ecological model, i.e. 15 m – 60 m.

The preview report considers other variables such as nutrients and dissolved oxygen to define the boxes. These new boxes also were modified in view of the same variables. Below, Figure 12 &Figure 13, are some of the variables used to draw the boxes.

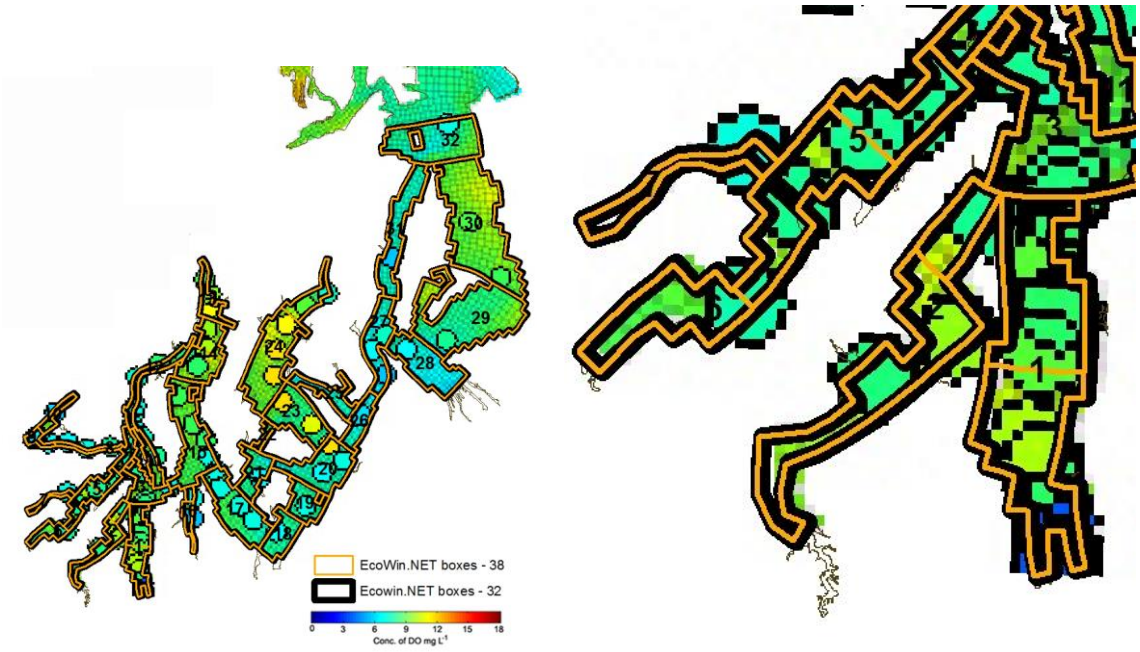
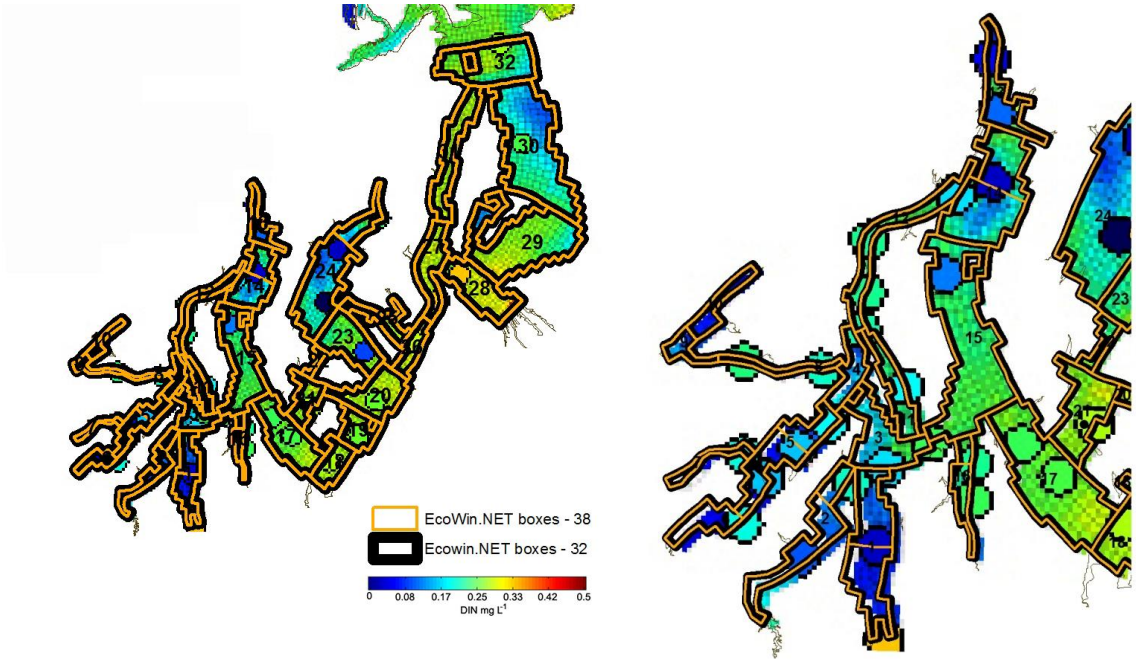


Figure 12 – a) DO concentration patterns in Puget Sound for September 2007 predicted by the hydrodynamic model; in black are the previous box divisions and in orange are the new ones; **b)** zoom of the new divisions, new boundaries in box 1, 2 and 5 (source: Ahmed, A. 2008)



a) b)

Figure 13 - a) DIN concentration patterns in Puget Sound for September 2007 predicted by the hydrodynamic model; in black are the previous boxes divisions and in orange are the new ones; **b)** zoom of the new divisions, new boundaries in box 1, 2 and 5 (source: Ahmed, A. 2008)

Box layout proposal with the modifications suggested by the stakeholders

Considering all the suggestions made, the previous constraints and respecting the hydrodynamic model domain, we propose the following boxes, Figure 14. In Table 3, the volumes, areas and approximate water residence time were calculated.

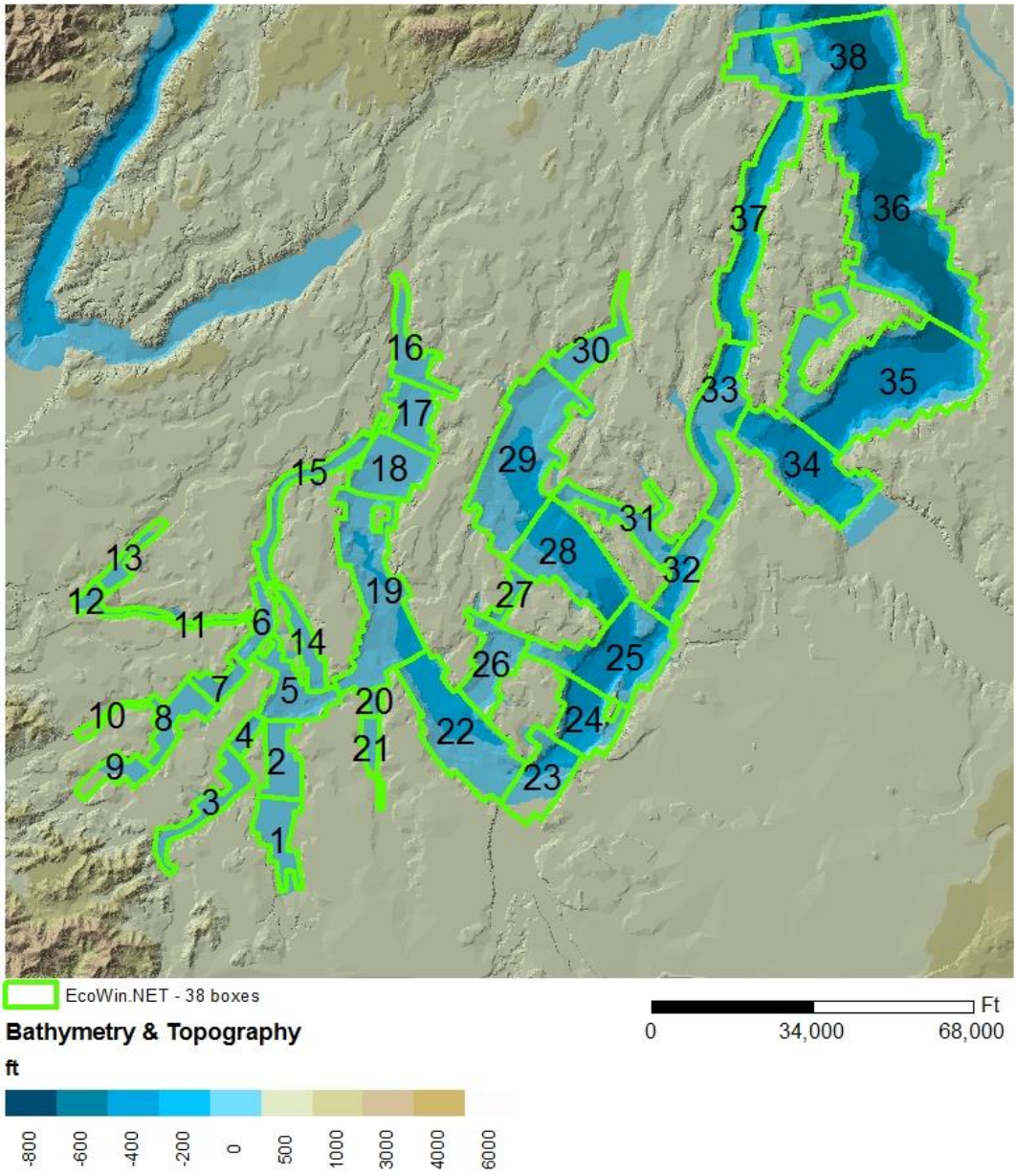


Figure 14 –38 model boxes proposed for South Puget Sound

Table 3 – EcoWin.NET boxes identification with the respective areas, volumes, flow, water height and water residence time

Box	$^{+}$W (m)	$^{++}$L (m)	$^{+++}A_1$ (m^2)	A_{GIS} (m^2)	*% A_1 *vs* A_{GIS}	Vol_{MLW} (m^3)	**H_{MLW} (m)	μ (m s^{-1})	*** Section area (m^2)	Q (m^3 s^{-1})	$^{\#}\tau$ (s)	τ (h)
1	2,593	4,654	12,068,280	11,217,853	7	8,320,173	0.74	0.128	1,923	246.2	33,798	9.4
2	2,215	4,990	11,052,887	10,673,568	3.4	81,041,086	7.59	0.265	16,818	4,456.7	18,184	5.1
3	1,278	8,742	11,170,192	11,117,266	0.5	8,072,870	0.73	0.174	928	161.5	49,994	13.9
4	975	2,977	2,903,331	3,185,574	-9.7	38,918,104	12.22	0.445	11,912	5,300.6	7,342	2.0
5	2,057	6,548	13,470,268	13,707,246	-1.8	248,832,608	18.15	0.612	37,341	22,853.0	10,888	3.0
6	896	6,851	6,141,479	6,486,674	-5.6	28,082,672	4.33	0.2	3,879	775.8	36,198	10.1
7	1,143	4,298	4,911,200	5,453,822	-11	73,321,632	13.44	0.514	15,367	7,898.4	9,283	2.6
8	1,999	5,486	10,969,991	9,449,565	13.9	16,895,100	1.79	0.312	3,574	1,115.1	15,151	4.2
9	1,080	6,289	6,789,548	6,275,388	7.6	2,736,257	0.44	0.074	471	34.8	78,521	21.8
10	610	5,182	3,158,703	2,831,592	10.4	669,750	0.24	0.653	144	94.2	7,109	2.0
11	508	7,407	3,761,068	3,284,114	12.7	1,947,816	0.59	0.334	301	100.6	19,356	5.4
12	445	6,637	2,954,336	3,383,917	-14.5	9,715,573	2.87	0.121	1,278	154.6	62,846	17.5
13	944	5,744	5,422,097	4,825,196	11	2,815,803	0.58	0.282	551	155.3	18,126	5.0
14	989	7,433	7,349,692	7,524,004	-2.4	15,269,036	2.03	1.496	2,007	3,002.6	5,085	1.4
15	791	13,065	10,335,384	11,486,541	-11.1	122,497,347	10.66	0.123	8,436	1,037.6	118,061	32.8
16	2,134	5,791	12,356,104	10,270,302	16.9	40,621,727	3.96	0.093	8,441	785.0	51,749	14.4
17	3,039	3,652	11,096,395	10,572,158	4.7	182,434,990	17.26	0.134	52,442	7,027.2	25,961	7.2
18	3,991	4,028	16,075,672	16,116,214	-0.3	393,117,614	24.39	0.293	97,351	28,523.9	13,782	3.8
19	3,474	11,149	38,735,571	40,836,413	-5.4	1,493,695,163	36.58	0.292	127,070	37,104.5	40,256	11.2
20	1,077	1,762	1,897,581	1,786,646	5.8	2,133,813	1.19	0.311	1,286	400.0	5,334	1.5
21	820	6,030	4,942,610	4,340,382	12.2	2,546,278	0.59	0.439	481	211.2	12,057	3.3
22	2,438	13,242	32,290,124	35,008,856	-8.4	1,631,237,717	46.60	0.455	113,599	51,687.4	31,560	8.8
23	3,088	5,519	17,043,709	15,911,215	6.6	525,385,241	33.02	0.396	101,965	40,378.2	13,012	3.6
24	3,040	4,960	15,081,243	15,877,436	-5.3	1,264,913,036	79.67	0.515	242,189	124,727.2	10,141	2.8
25	4,576	6,206	28,399,060	31,492,459	-10.9	2,911,537,107	92.45	0.367	423,060	155,263.0	18,752	5.2
26	2,903	5,332	15,481,174	15,198,835	1.8	406,509,903	26.75	0.292	77,644	22,672.0	17,930	5.0
27	970	3,623	3,512,901	3,490,189	0.6	21,456,120	6.15	0.164	5,963	978.0	21,940	6.1
28	2,897	9,378	27,171,454	30,790,210	-13.3	2,437,598,975	79.17	0.067	229,350	15,366.4	158,631	44.1
29	4,986	11,451	57,098,703	46,423,649	18.7	1,784,405,680	38.44	0.065	191,649	12,457.2	143,243	39.8
30	1,826	6,767	12,354,060	11,901,946	3.7	139,574,874	11.73	0.591	21,414	12,655.4	11,029	3.1
31	1,966	7,193	14,141,701	13,367,662	5.5	271,950,458	20.34	1.235	39,996	49,395.2	5,506	1.5
32	1,316	11,435	15,043,766	13,206,389	12.2	593,643,167	44.95	2.535	59,156	149,959.9	3,959	1.1
33	2,160	11,903	25,716,933	24,981,826	2.9	1,193,917,378	47.79	0.176	103,230	18,168.4	65,714	18.3
34	4,311	9,144	39,420,618	33,018,560	16.2	3,363,213,207	101.86	0.151	439,111	66,305.8	50,723	14.1
35	4,666	15,926	74,318,977	75,042,975	-1	7,239,908,488	96.48	0.16	450,161	72,025.7	100,518	27.9
36	5,029	16,589	83,428,091	89,827,940	-7.7	12,208,015,933	135.90	0.178	683,463	121,656.5	100,348	27.9
37	1,687	19,497	32,898,946	31,907,491	3	2,150,000,922	67.38	0.33	113,674	37,512.4	57,314	15.9
38	10,261	4,881	50,089,145	45,838,627	8.5	4,697,127,893	102.47	0.673	1,051,454	707,628.9	6,638	1.8

$^{+}$W - xsection | $^{+}$L - length | $^{+++}$ A_1 =L x W | *% = [(A_1-A_{GIS})/A_1] x 100 | **H_{MLW} = V/A | ***Section area = W x H_{MLW} | $^{\#}\tau$ = V/Q

Final proposal

After the numerical analysis the shallower boxes where identified (shown in red) These boxes could pose a problem but Table 3 indicates that the residence time is higher than the timestep normally used to run the EcoWin ecological model. On that basis we propose 38 horizontal boxes for South Puget Sound, with a two vertical layer scheme for a total of 76 boxes.

In this kind of upscaling exercise, we can only fully verify model stability after testing the fluxes supplied by the hydrodynamic model. In many situations where this approach has been followed (e.g. Long Island Sound, U.S., Huangdun Bay, China, Belfast Lough and Loch Creran, U.K., Saldanha Bay, South Africa) the first set of fluxes received from the hydrodynamic model is perfectly adequate, even in situations such Carlingford Lough and Strangford Lough (SMILE project) where there are substantial areas shallow channels and tidal flats. In some cases where there are numerical instabilities in the ecological model with a particular grid layout, a different grid needs to be used.

It is possible in PESCA that the first set of fluxes will have problems, but as far as we have been able to assess the present box layout, there are no compelling reasons to reduce the number of boxes and go against the general view of stakeholders. We strongly believe that local knowledge is critical both in producing the best possible model and to ensure of a broad uptake of the work by local community, which is clearly a key objective of PESCA.

Because of vertical stratification in South Puget Sound, it seems appropriate to propose that the horizontal layout of 38 boxes be divided vertically into two layers, an upper and lower one, based on the sigma-coordinate scheme implemented in the circulation model. The overall number of boxes would therefore be 76, i.e. 38 in the upper layer and 38 in the lower layer of the water column, and we would need water fluxes across those boundaries. We prefer to leave the decision of where to set that vertical limit (i.e. mid-water, 1/3 of the total depth, etc) to the group working on the circulation, because they have a fuller understanding of the vertical water column dynamics.