



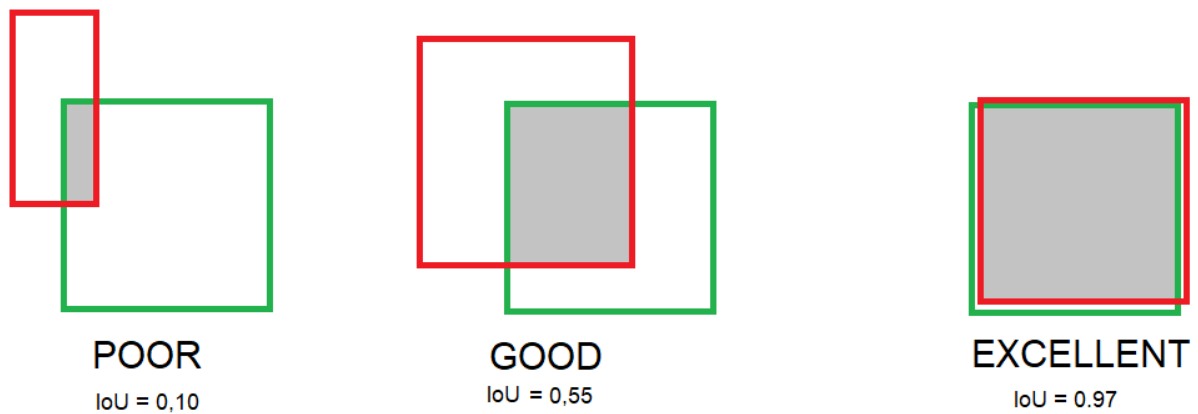
*Supplement of*

## **Deep learning accurately identifies fjord benthic foraminifera**

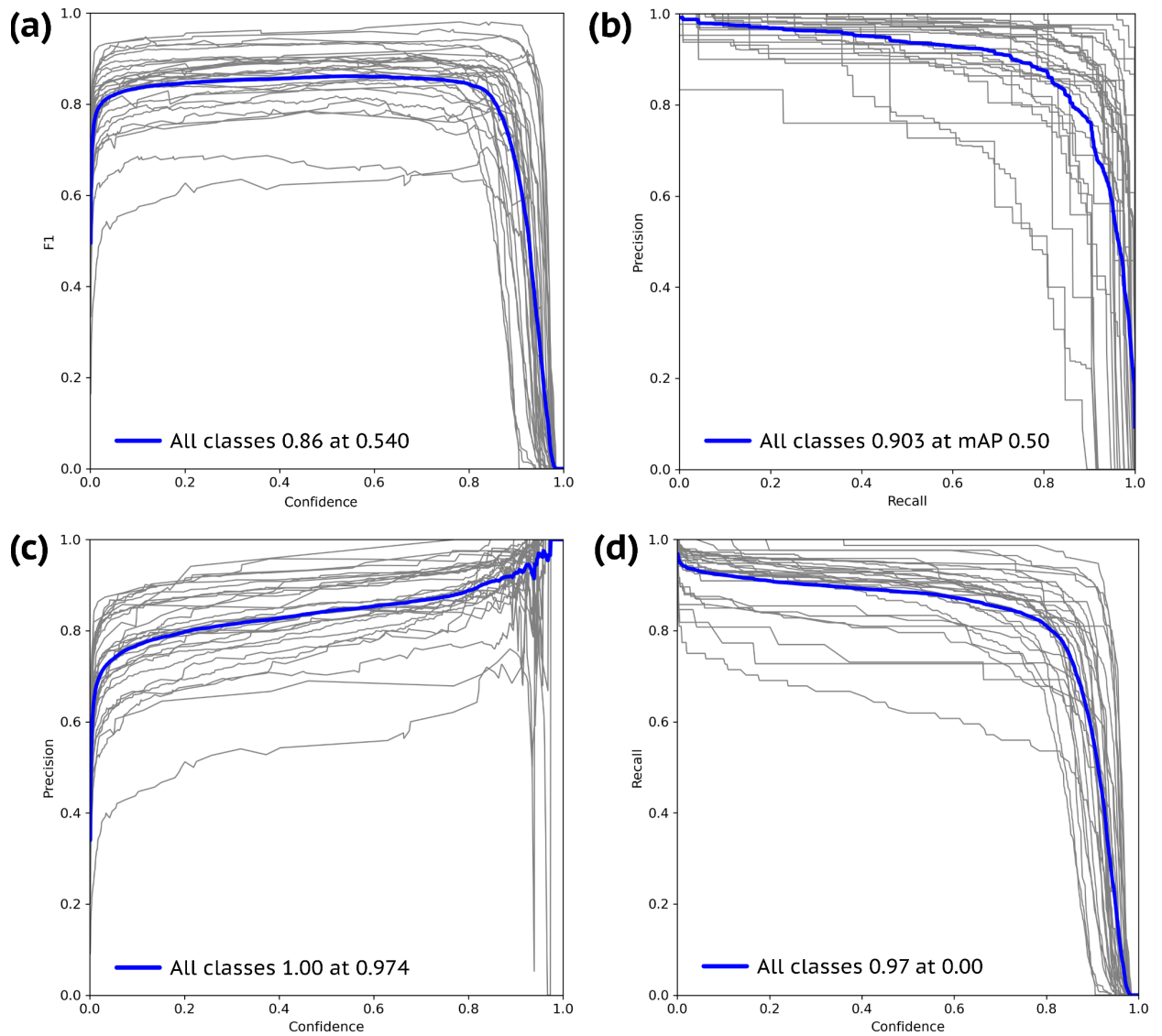
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**Figure S1. Illustration of the IoU measure. The green bounding box is the ground truth, and the red is the detected bounding box. IoU depends on the threshold defined by the user, so a threshold can be higher or lower than the ones depicted in the figure.**



**Figure S2.** Evaluation metrics for the best performing model, exp 50, at different confidence thresholds. The blue line represents the optimal confidence threshold for maximizing (a) F<sub>1</sub> score (max value 0.86, confidence threshold 0.540), (c) precision (max value 1.00, confidence threshold 0.974), and (d) recall (max value 0.97, confidence threshold 0.0). The Precision-Recall (PR) curve is shown in (b), with the area under the curve equal to 0.903 at a mean average precision (mAP) of 0.50. The area under the curve indicates strong model performance with high precision and recall.

**Figures S3-S9:** Examples of images taken during the SEEPS II cruise. They are here to illustrate the performance of the model on unpicked samples imaged in micropaleontological tray to showcase the excellent ability of the model to ignore sediment, detrital grains and faecal pellets present in images.



Figure S3



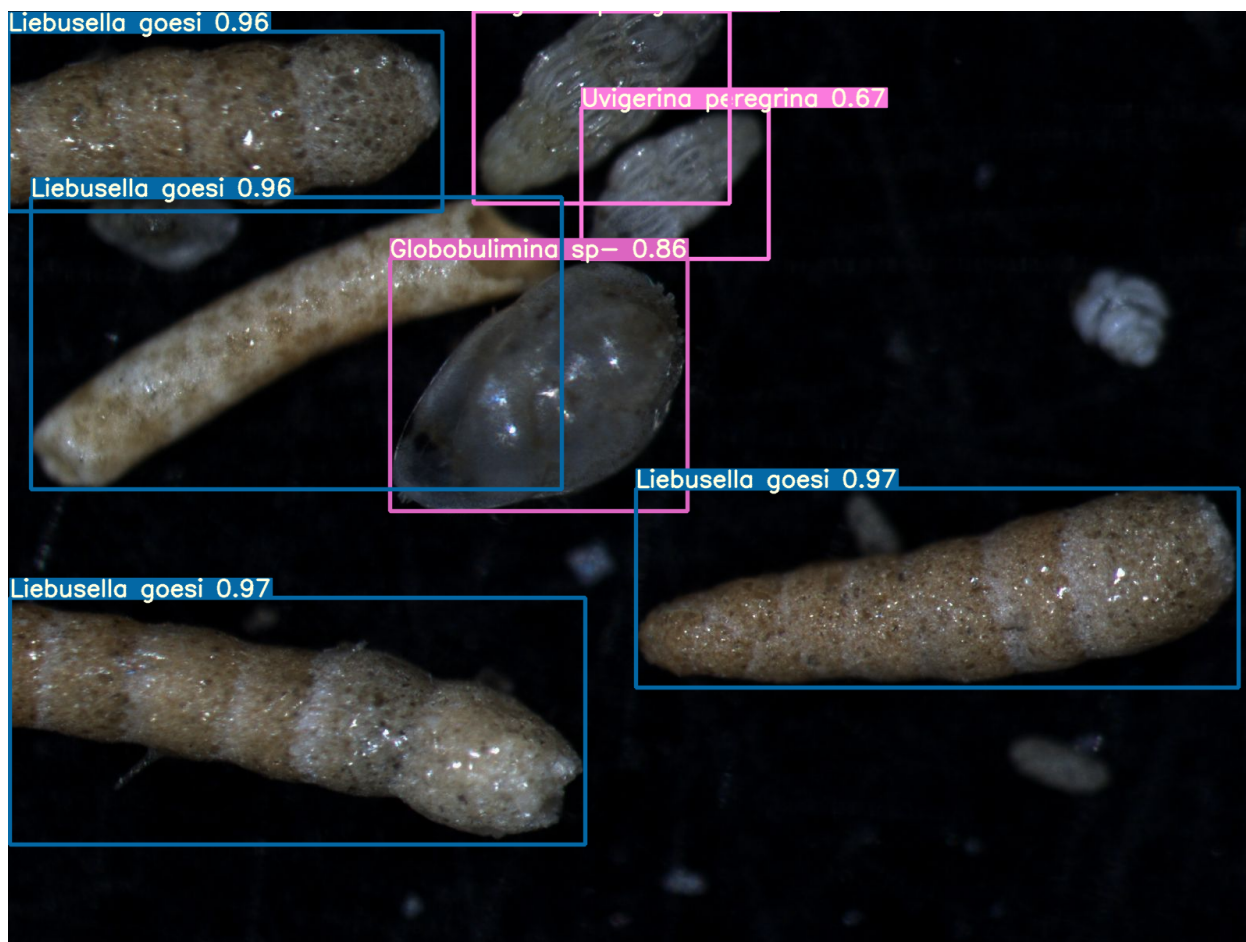
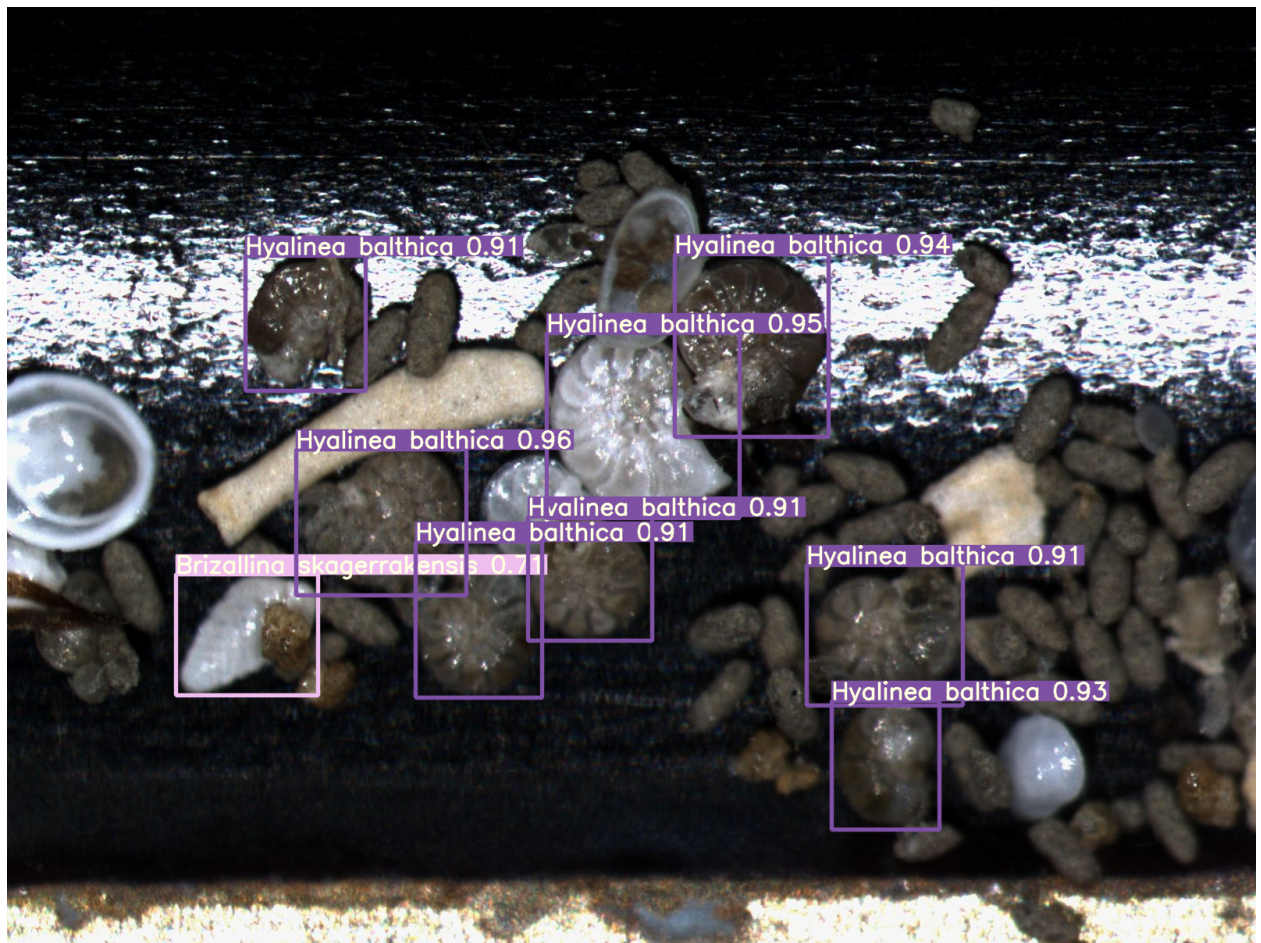


Figure S4

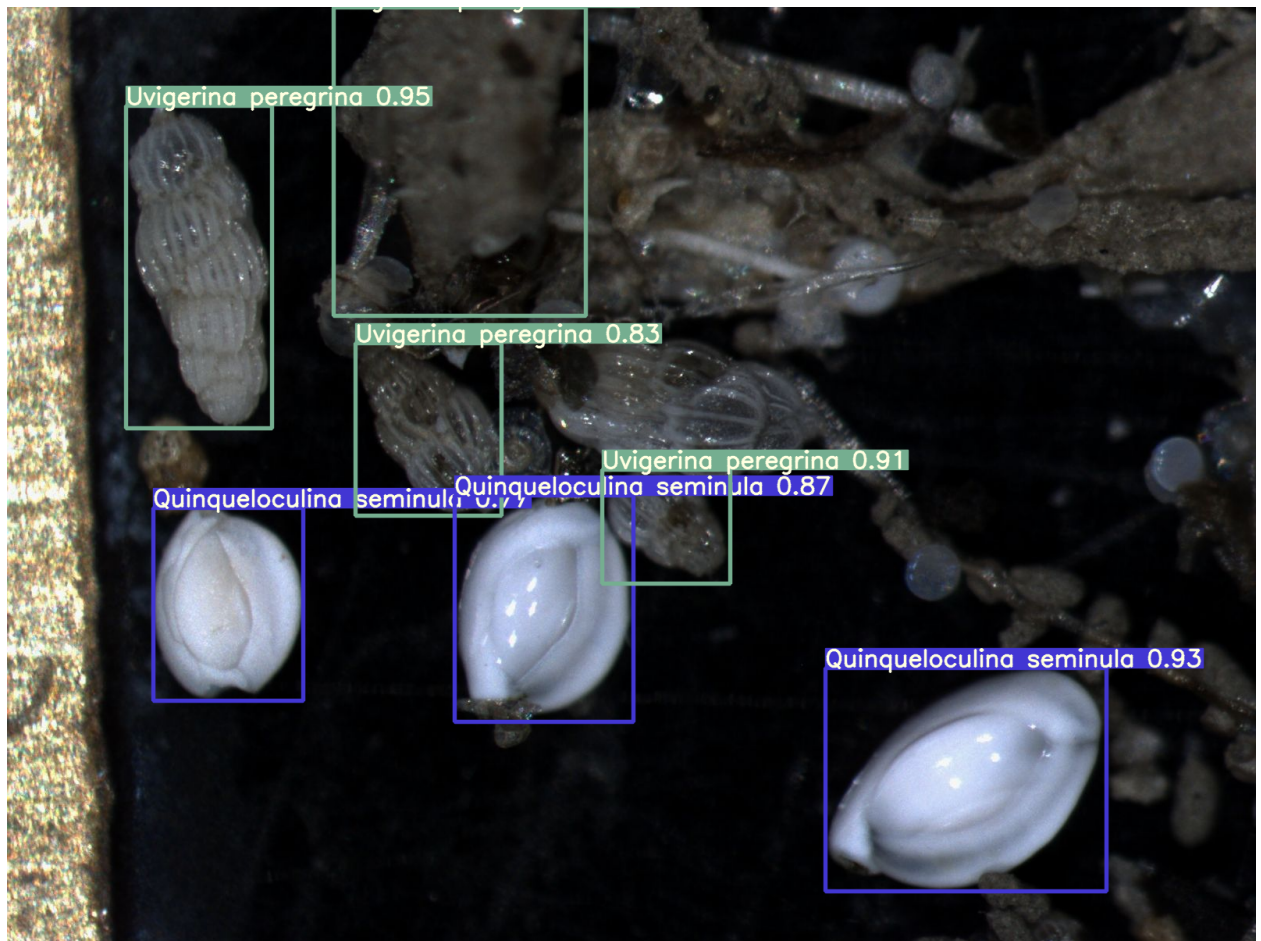


Figure S5



**Figure S6**





**Figure S7**

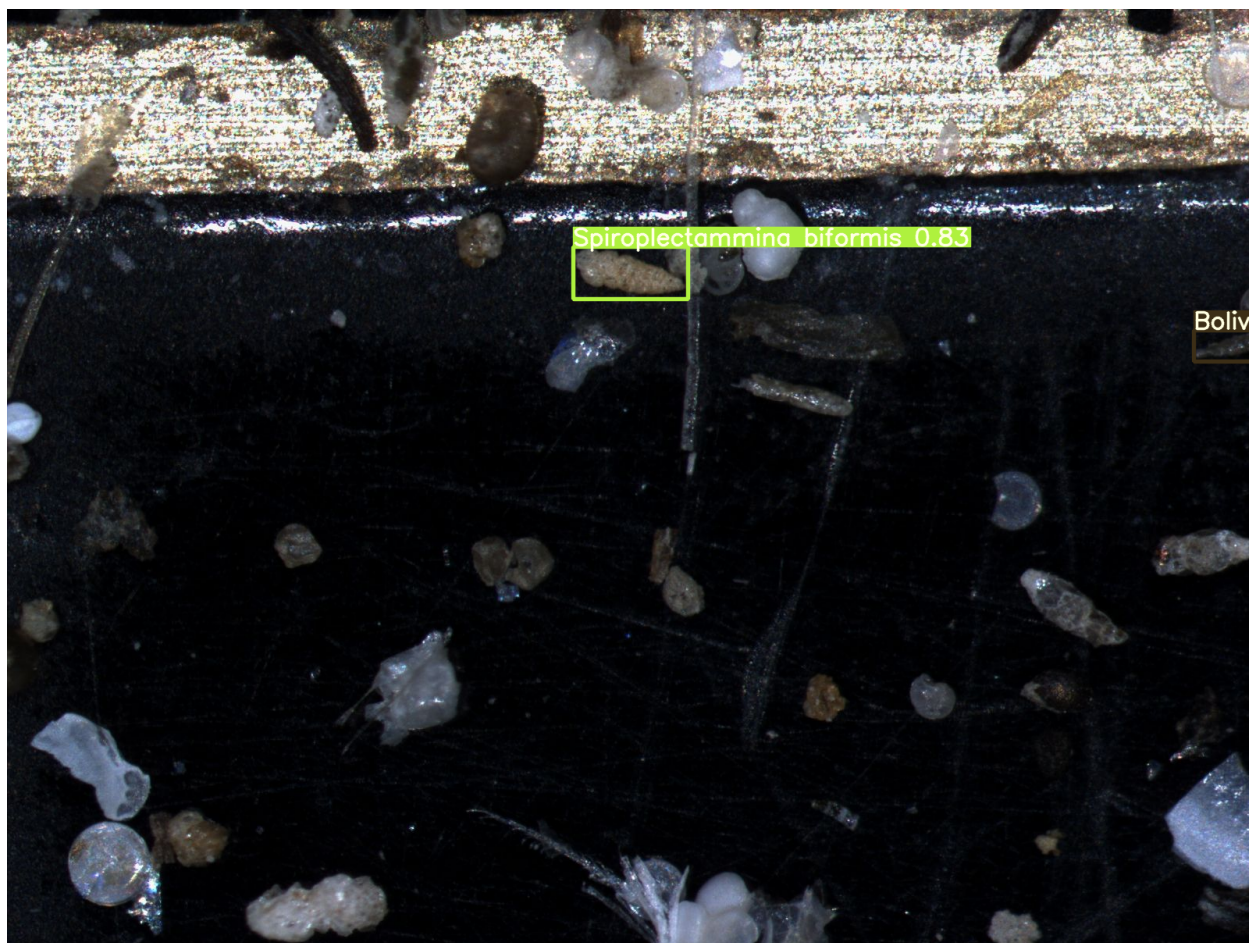
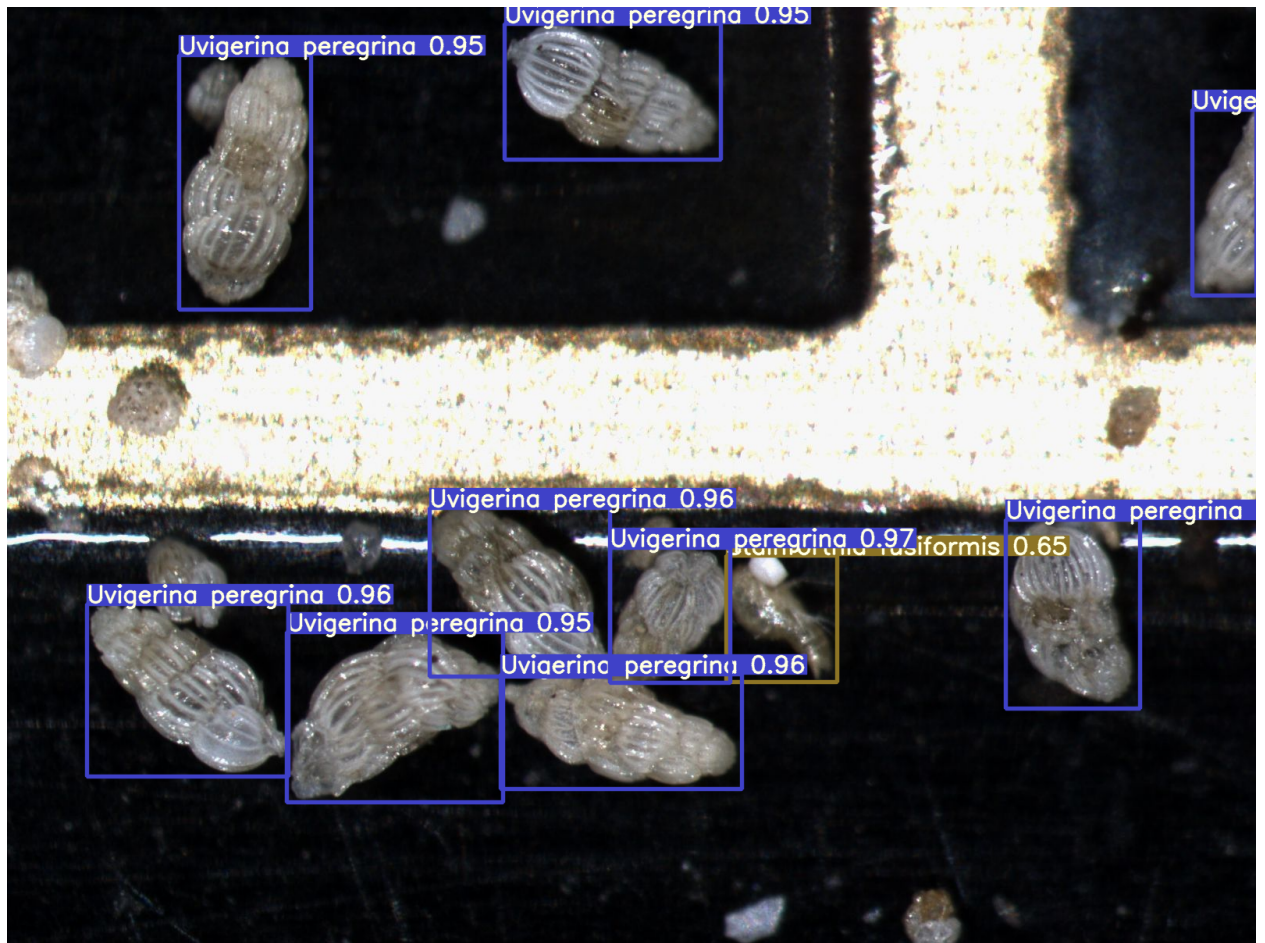


Figure S8



**Figure S9**

**Table S1. List of all trained YOLO models, both successful or failed.**

Model	P	R	mAP@.5	mAP@.5:.95	model architecture
exp 1	failed	failed	failed	failed	YOLOv7E6E@640
exp 2	failed	failed	failed	failed	YOLOv7E6E@640
exp 3	failed	failed	failed	failed	YOLOv7E6E@640
exp 4	0.765	0.670	0.740	0.598	YOLOv7W6@1280
exp 5	0.781	0.797	0.830	0.658	YOLOv7@640
exp 6	failed	failed	failed	failed	YOLOv7W6@1280
exp 7	0.748	0.740	0.784	0.592	YOLOv7@640
exp 8	0.781	0.747	0.821	0.632	YOLOv7@640
exp 9	failed	failed	failed	failed	YOLOv7W6@1280
exp 10	0.868	0.855	0.889	0.696	YOLOv7@640
exp 11	failed	failed	failed	failed	YOLOv7E6E@640



exp 12	failed	failed	failed	failed	YOLOv7E6E@640
exp 13	failed	failed	failed	failed	YOLOvE6E@1280
exp 14	0.616	0.196	0.0697	0.0383	YOLOv7@640
exp 15	0.700	0.617	0.648	0.499	YOLOv7E6E@1280
exp 16	failed	failed	failed	failed	YOLOv7W6@1280
exp 17	failed	failed	failed	failed	YOLOv7W6@1280
exp 18	failed	failed	failed	failed	YOLOv7W6@1280
exp 19	failed	failed	failed	failed	YOLOv7W6@1280
exp 20	failed	failed	failed	failed	YOLOv7W6@1280
exp 21	failed	failed	failed	failed	YOLOv7W6@1280
exp 22	failed	failed	failed	failed	YOLOv7W6@1280
exp 23	failed	failed	failed	failed	YOLOv7W6@1280
exp 24	failed	failed	failed	failed	YOLOv7W6@1280
exp 25	failed	failed	failed	failed	YOLOv7E6E@1280
exp 26	failed	failed	failed	failed	YOLOv7E6E@1280
exp 27	failed	failed	failed	failed	YOLOv7E6E@1280
exp 28	failed	failed	failed	failed	YOLOv7E6E@1280
exp 29	failed	failed	failed	failed	YOLOv7E6E@640
exp 30	failed	failed	failed	failed	YOLOv7E6E@1280
exp 31	failed	failed	failed	failed	YOLOv7E6E@640
exp 32	failed	failed	failed	failed	YOLOv7E6E@640
exp 33	failed	failed	failed	failed	YOLOv7E6E@1280
exp 34	failed	failed	failed	failed	YOLOv7x@640
exp 35	failed	failed	failed	failed	YOLOv7x@640
exp 36	failed	failed	failed	failed	YOLOv7E6E@1280
exp 37	failed	failed	failed	failed	YOLOv7x@640
exp 38	failed	failed	failed	failed	YOLOv7E6E@1280
exp 39	failed	failed	failed	failed	YOLOv7x@640
exp 40	failed	failed	failed	failed	YOLOv7E6E@1280
exp 41	failed	failed	failed	failed	YOLOv7E6E@640
exp 42	failed	failed	failed	failed	YOLOv7E6E@640
exp 43	failed	failed	failed	failed	YOLOv7E6E@1280
exp 44	0.652	0.225	0.101	0.058	YOLOv7x@640
exp 45	0.757	0.681	0.688	0.512	YOLOv7x@640
exp 46	0.911	0.352	0.198	0.087	YOLOv7x@640
exp 47	0.775	0.587	0.558	0.321	YOLOv7@640
exp 48	0.781	0.555	0.598	0.381	YOLOv7@640
exp 49	0.742	0.596	0.620	0.281	YOLOv7@640

exp 50	0.877	0.882	0.903	0.699	YOLOv7x@640
exp 51	0.797	0.849	0.867	0.661	YOLOv7E6E@640
exp 52	0.862	0.863	0.895	0.690	YOLOvE6E@1280
exp 53	0.833	0.853	0.870	0.680	YOLOv7E6E@640
exp 54	0.811	0.821	0.850	0.650	YOLOv7@640
exp 55	0.784	0.851	0.795	0.625	YOLOv7@640
exp 56	0.845	0.874	0.887	0.620	YOLOv7x@640
exp 57	0.832	0.721	0.820	0.589	YOLOv7@640
exp 58	0.827	0.883	0.888	0.691	YOLOv7@640

**Table S2. Performance of model exp 50 on individual species. Counts refer to pre-augmented dataset.**

Species	Precision	Recall	mAP* <sub>@.5</sub>	mAP <sub>@.5:.95</sub>	Count
<i>Adercotryma glomerata</i>	0.862	0.888	0.883	0.574	725
<i>Ammodiscus sp.</i>	0.893	0.895	0.915	0.713	774
<i>Ammonia sp.</i>	0.905	0.902	0.953	0.715	1279
<i>Ammoscalaria pseudospiralis</i>	0.957	0.919	0.971	0.843	169
<i>Bathysiphon acuta</i>	0.687	0.898	0.750	0.579	87
<i>Bolivina pseudopunctata</i>	0.779	0.855	0.844	0.508	1221
<i>Brizallina skagerrakensis</i>	0.916	0.907	0.944	0.796	307
<i>Bulinina marginata</i>	0.920	0.947	0.964	0.780	2325
<i>Cassidulina laevigata</i>	0.908	0.880	0.910	0.731	804
<i>Cibicides lobatulus</i>	0.768	0.796	0.838	0.712	549
<i>Eggerelloides medius</i>	0.553	0.731	0.691	0.522	97
<i>Eggerelloides scaber</i>	0.862	0.931	0.946	0.765	1590
<i>Elphidium excavatum</i>	0.818	0.880	0.888	0.619	1343
<i>Globobulimina sp.</i>	0.939	0.976	0.989	0.905	335
<i>Hyalinea balthica</i>	0.925	0.949	0.975	0.867	1719
IOL**	0.843	0.976	0.947	0.550	169
<i>Leptohalysis catella</i>	0.850	0.948	0.878	0.607	203
<i>Liebusella goesi</i>	0.828	0.935	0.955	0.846	211
<i>Nonionella sp. T1</i>	0.852	0.918	0.937	0.703	1507
<i>Nonionella turgida</i>	0.709	0.619	0.699	0.519	299
<i>Nonionellina labradorica</i>	0.899	0.887	0.925	0.797	664
<i>Pyrgo williamsoni</i>	0.901	0.810	0.887	0.800	73
<i>Quinqueloculina seminula</i>	0.976	0.727	0.856	0.755	72
<i>Quinqueloculina stalkerii</i>	0.778	0.833	0.824	0.611	187



<i>Reophax</i> sp.	0.827	0.904	0.923	0.709	396
<i>Spiroplectammina biformis</i>	0.842	0.822	0.825	0.631	341
<i>Stainforthia fusiformis</i>	0.826	0.933	0.916	0.610	1737
<i>Textularia earlandi</i>	0.794	0.914	0.881	0.635	2105
<i>Uvigerina peregrina</i>	0.937	0.987	0.996	0.883	215

\* mAP: Mean average precision

\*\* IOL: Inner Organic Linings of foraminifera, remaining after dissolution of calcareous shells.