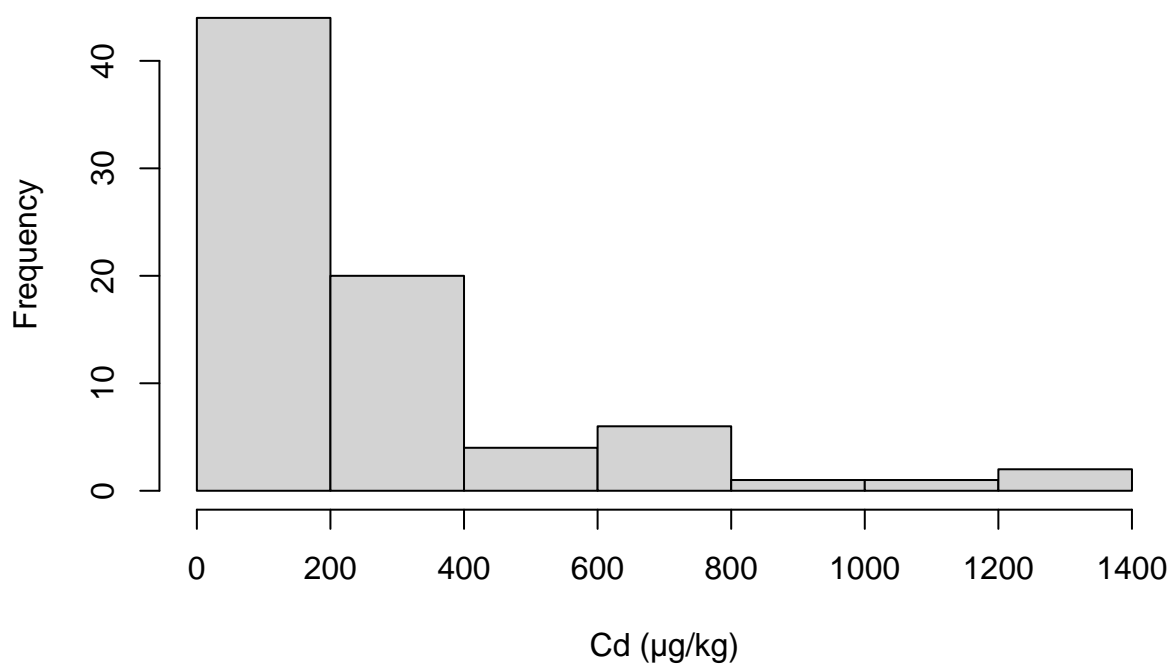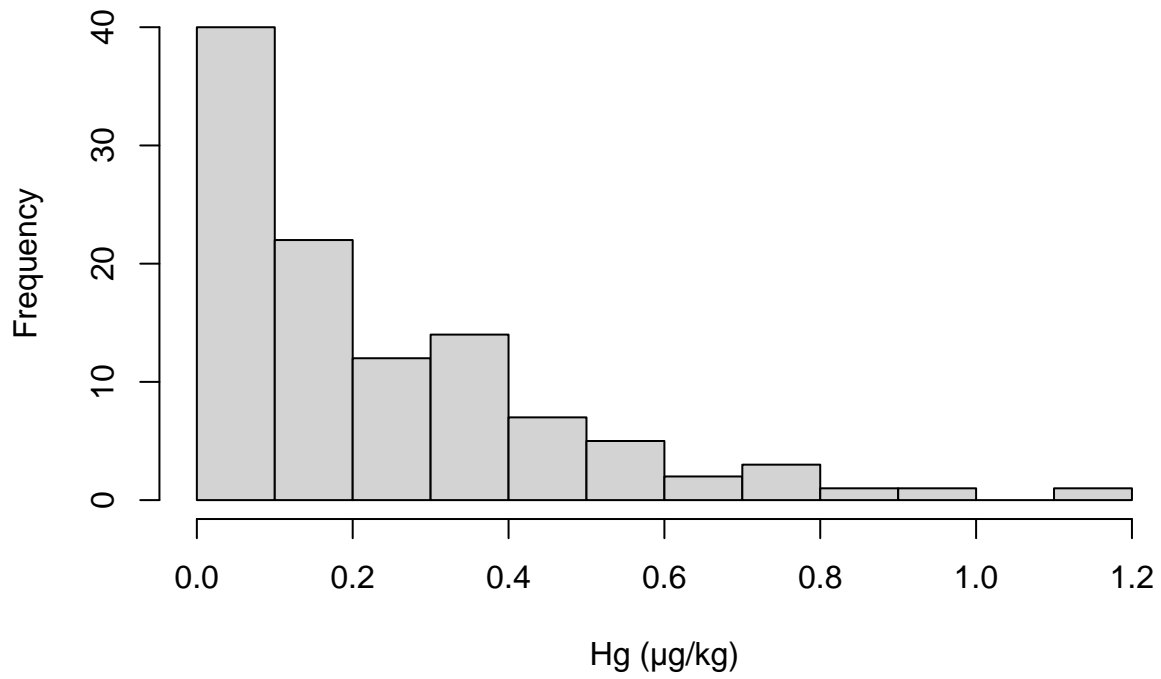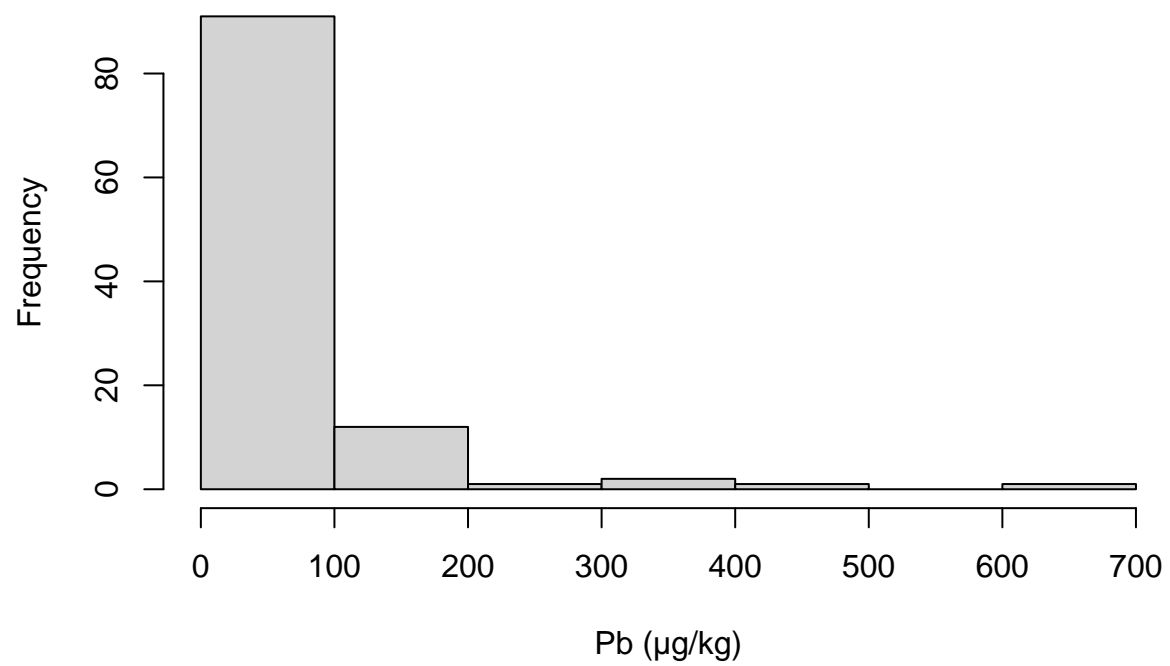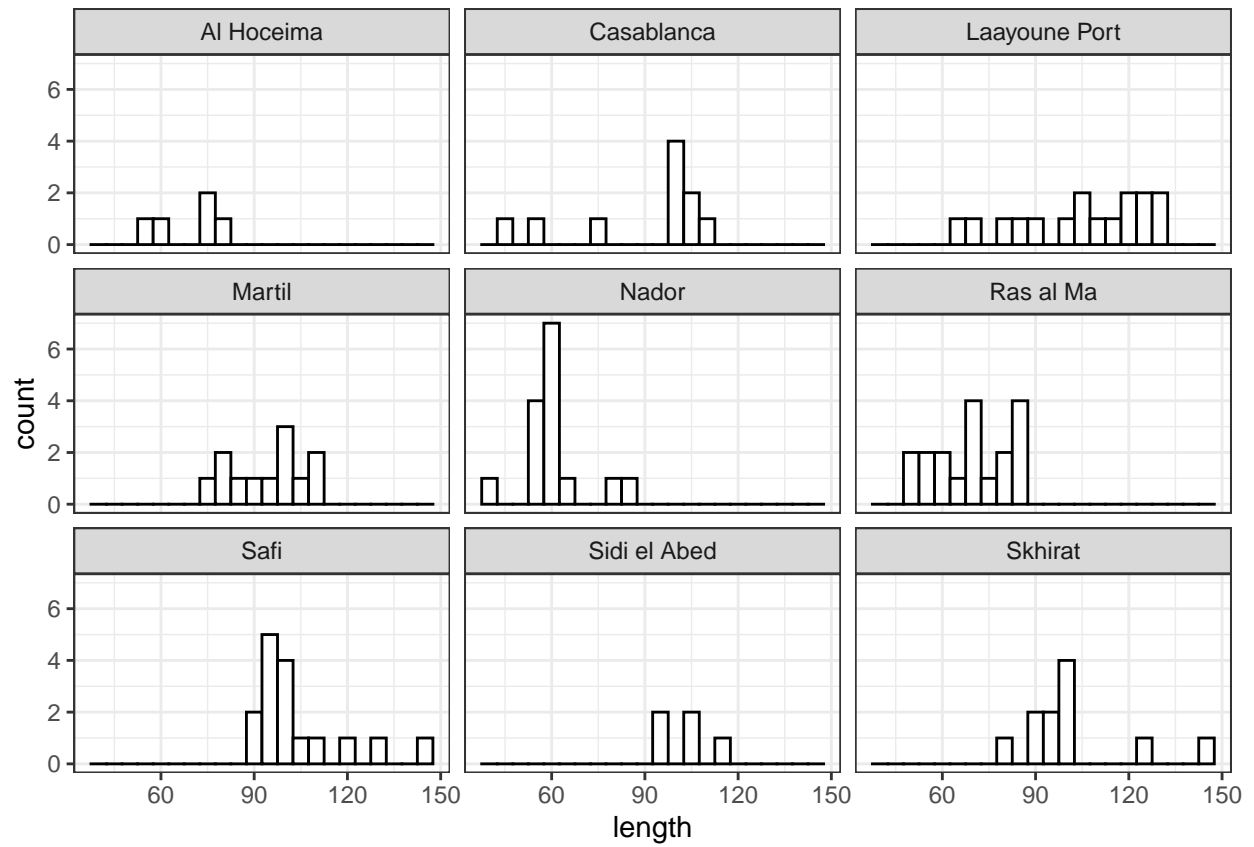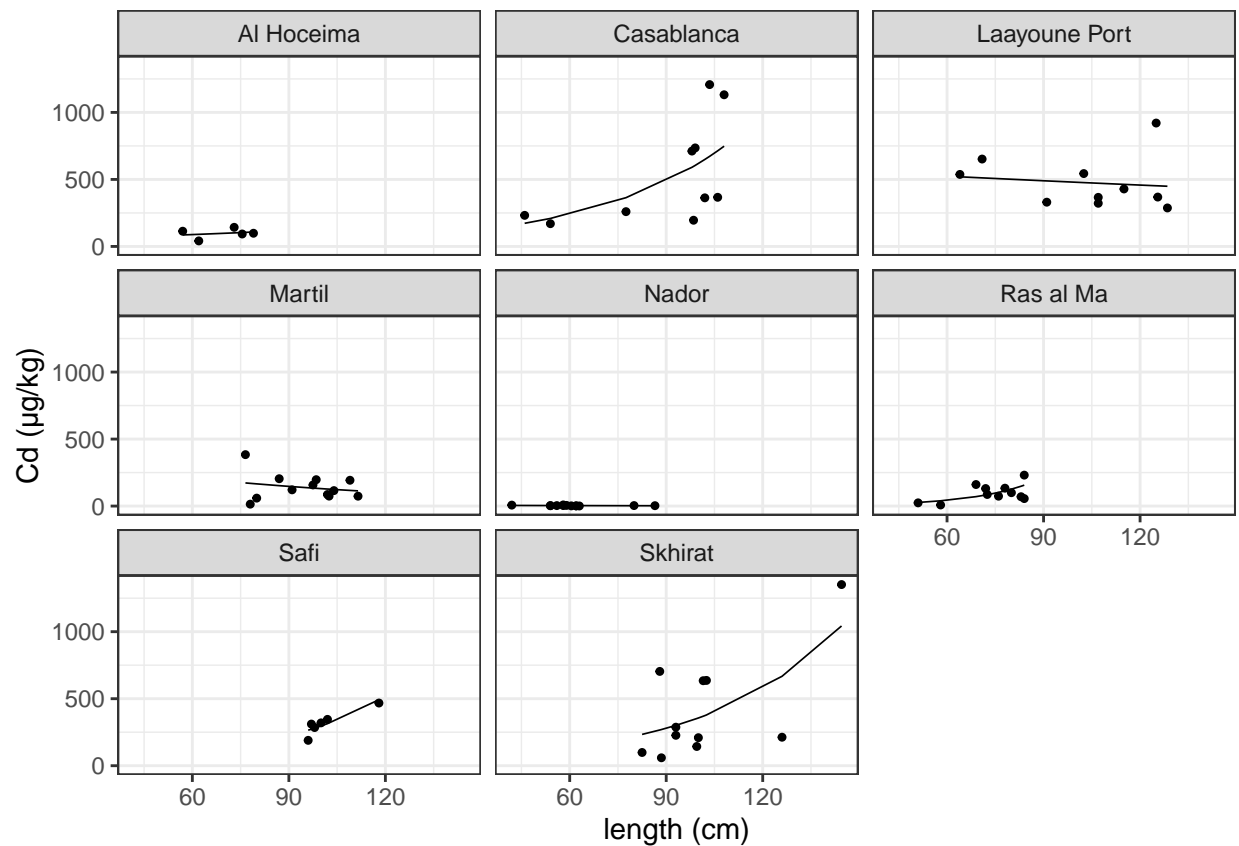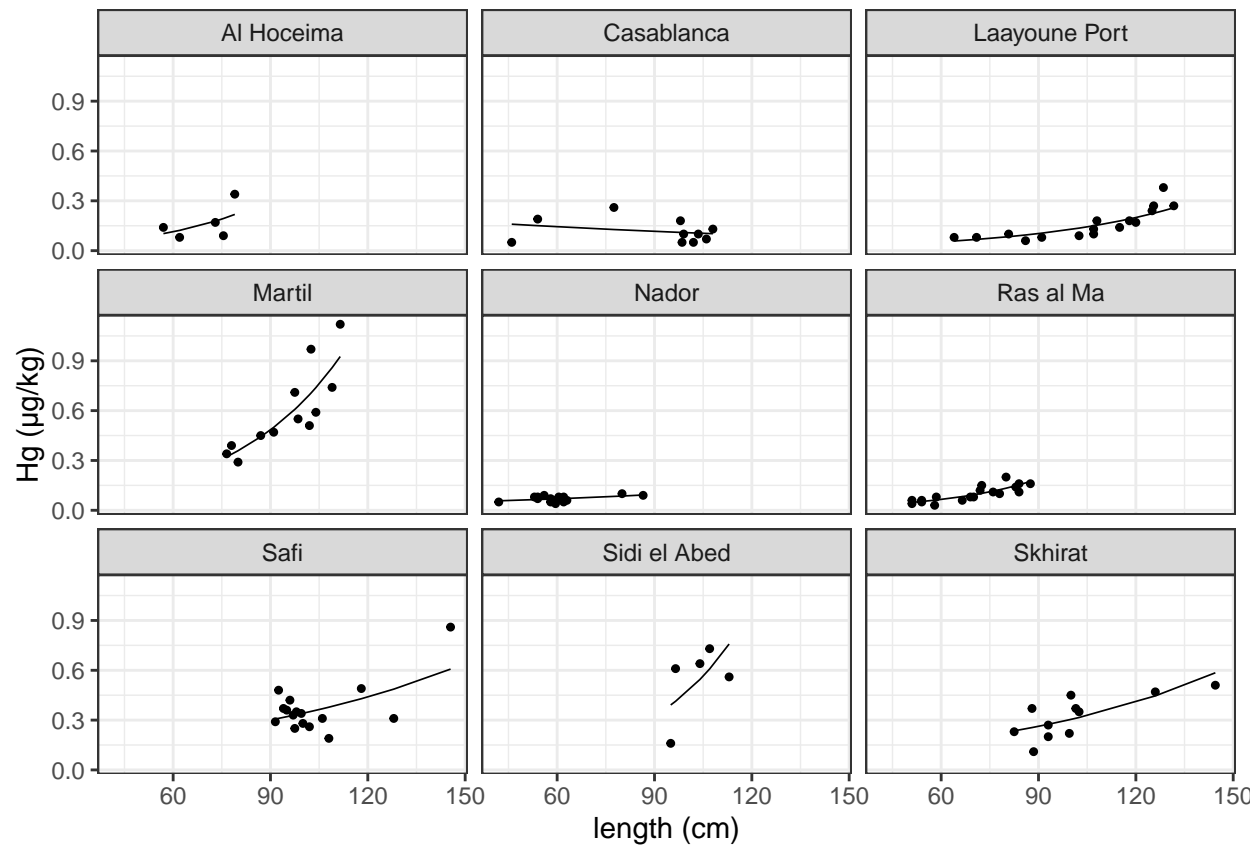conger

Initial data inspection

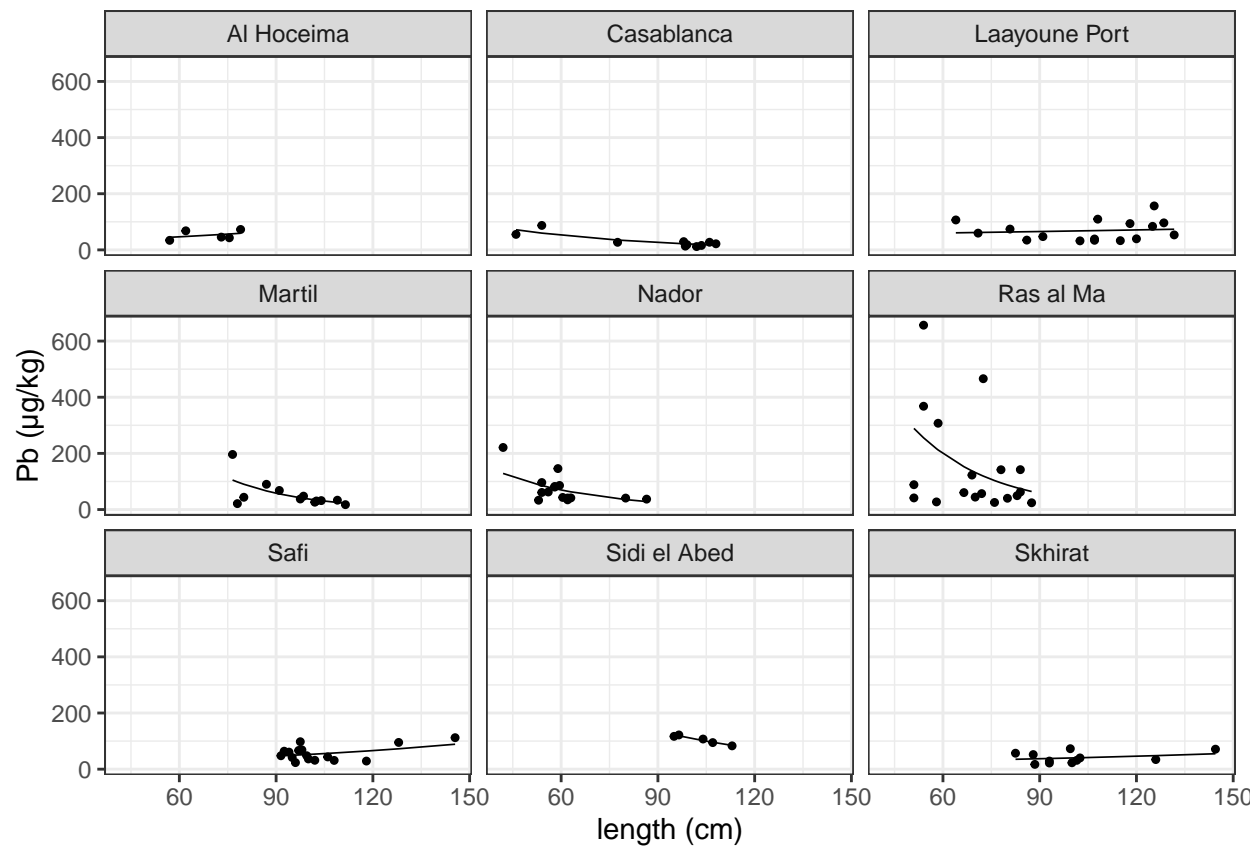**Fig 1** Overview of data distribution
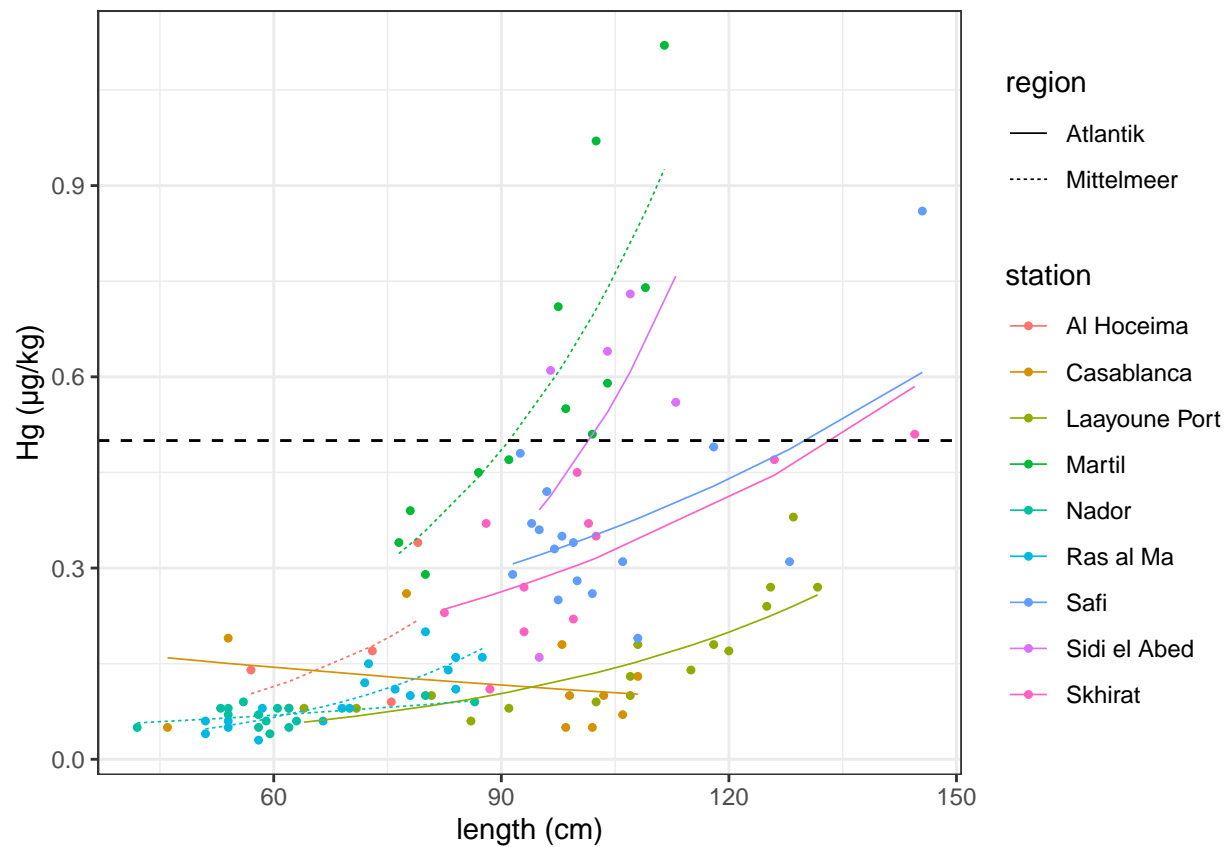
Plotting the model results

Fig 2a Raw data and GLM predictions of contaminat levels in Conger per Station as panel

6
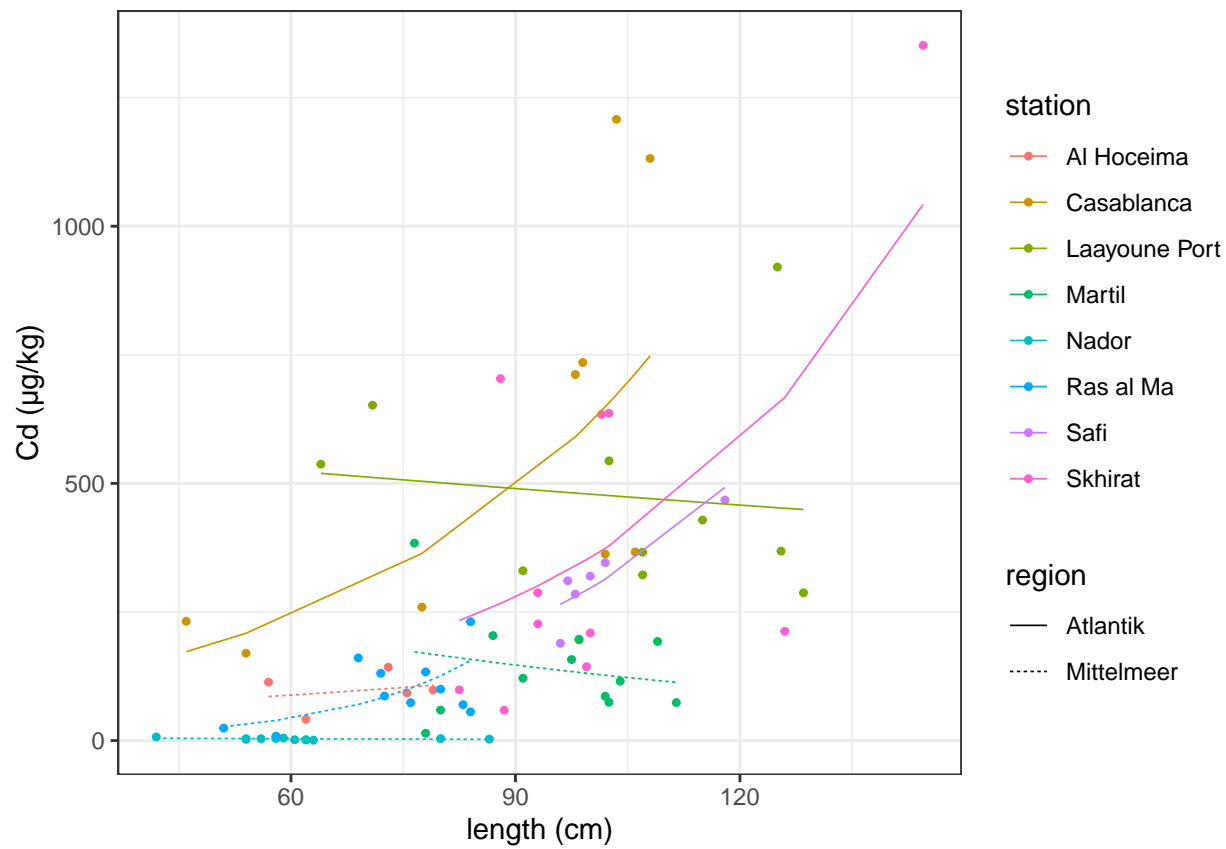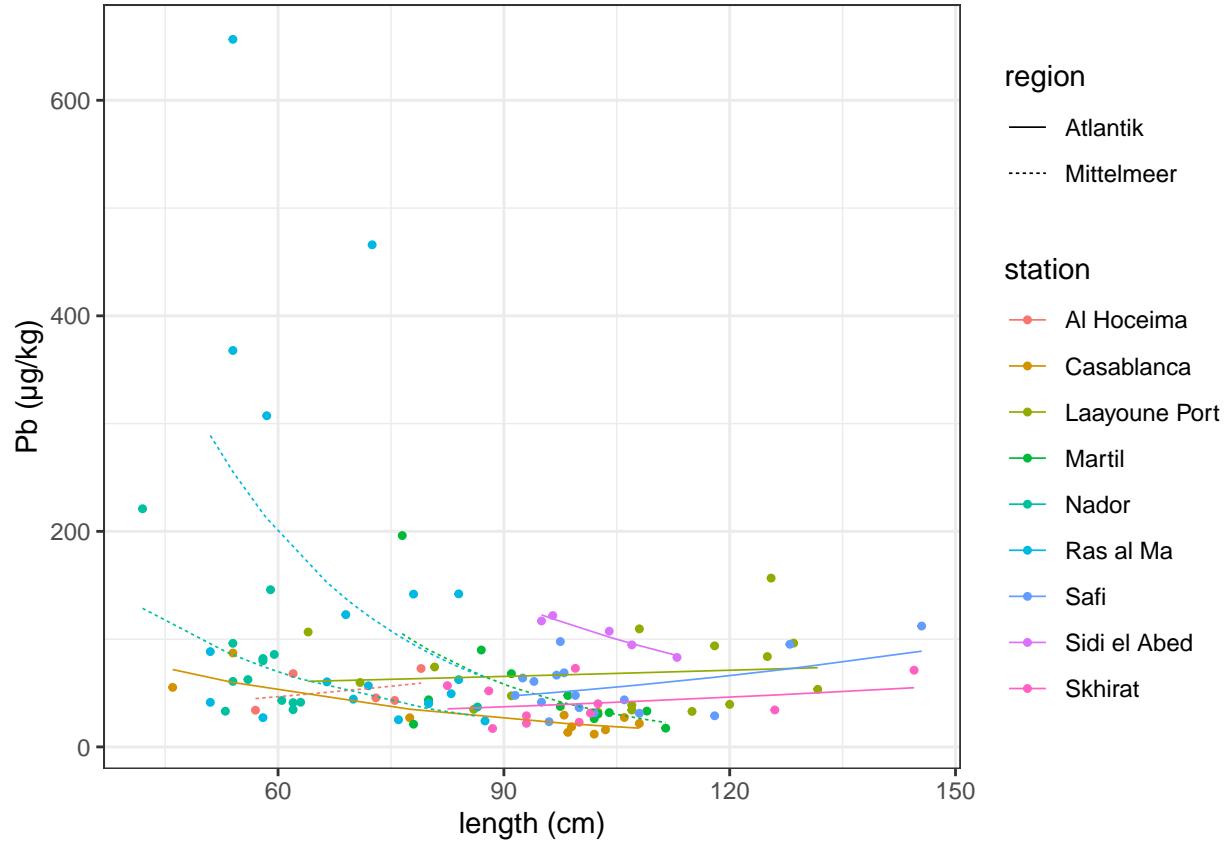
Fig 2b Raw data and GLM predictions of contaminat levels in COnger in single graph

Tab 1 Model statistics, all values are provided on the log scale. Estimate for "station" provides the y-Intercept (i.e. contaminant load for a given station when length is 0) per station; significance indicates different from 0. Estimates of "station:length" provide the effect of length for this station (i.e. the change in contaminant load for an increase of one unit in length); significance indicates whether the effect is different from 0 at this station (i.e. the slope of contamination load over length at this station is significantly different from 0).

Hg_Coefficient	Estimate	std_error	t_value	p_value
stationAl Hoceima	-4.225	1.243	-3.400	0.001
stationCasablanca	-1.508	0.456	-3.311	0.001
stationLaayoune Port	-4.253	0.439	-9.677	0.000
stationMartil	-3.434	0.794	-4.326	0.000
stationNador	-3.316	0.514	-6.453	0.000
stationRas al Ma	-4.854	0.461	-10.530	0.000
stationSafi	-2.340	0.619	-3.781	0.000
stationSidi el Abed	-4.431	2.306	-1.922	0.058
stationSkhirat	-2.658	0.598	-4.447	0.000
stationAl Hoceima:length	0.034	0.018	1.922	0.058

Hg_Coefficient	Estimate	std_error	t_value	p_value
stationCasablanca:length	-0.007	0.005	-1.440	0.153
stationLaayoune Port:length	0.022	0.004	5.357	0.000
stationMartil:length	0.030	0.008	3.622	0.000
stationNador:length	0.011	0.008	1.283	0.203
stationRas al Ma:length	0.035	0.007	5.417	0.000
stationSafi:length	0.013	0.006	2.151	0.034
stationSidi el Abed:length	0.037	0.022	1.647	0.103
stationSkhirat:length	0.015	0.006	2.535	0.013

Cd_Coefficient	Estimate	std_error	t_value	p_value
stationAl Hoceima	3.860	2.214	1.744	0.086
stationCasablanca	4.065	0.812	5.008	0.000
stationLaayoune Port	6.398	0.936	6.836	0.000
stationMartil	6.071	1.414	4.293	0.000
stationNador	2.172	0.945	2.298	0.025
stationRas al Ma	0.586	1.298	0.451	0.653
stationSafi	2.879	3.304	0.871	0.387
stationSkhirat	3.462	1.065	3.251	0.002
stationAl Hoceima:length	0.010	0.032	0.327	0.745
stationCasablanca:length	0.024	0.009	2.671	0.010
stationLaayoune Port:length	-0.002	0.009	-0.255	0.799
stationMartil:length	-0.012	0.015	-0.812	0.420
stationNador:length	-0.015	0.015	-0.986	0.328
stationRas al Ma:length	0.053	0.018	3.034	0.004
stationSafi:length	0.028	0.032	0.869	0.388
stationSkhirat:length	0.024	0.010	2.339	0.023

Pb_Coefficient	Estimate	std_error	t_value	p_value
stationAl Hoceima	3.086	2.228	1.385	0.169
stationCasablanca	5.325	0.817	6.517	0.000
stationLaayoune Port	3.929	0.788	4.986	0.000
stationMartil	8.007	1.423	5.625	0.000
stationNador	6.281	0.921	6.818	0.000

Pb_Coefficient	Estimate	std_error	t_value	p_value
stationRas al Ma	7.768	0.827	9.398	0.000
stationSafi	2.801	1.110	2.524	0.013
stationSidi el Abed	6.752	4.134	1.633	0.106
stationSkhirat	2.973	1.072	2.774	0.007
stationAl Hoceima:length	0.013	0.032	0.395	0.694
stationCasablanca:length	-0.023	0.009	-2.565	0.012
stationLaayoune Port:length	0.003	0.007	0.380	0.705
stationMartil:length	-0.044	0.015	-2.940	0.004
stationNador:length	-0.034	0.015	-2.259	0.026
stationRas al Ma:length	-0.041	0.012	-3.511	0.001
stationSafi:length	0.012	0.011	1.098	0.275
stationSidi el Abed:length	-0.020	0.040	-0.511	0.610
stationSkhirat:length	0.007	0.010	0.688	0.493

Tab 2 Pairwise comparisons between stations; significance indicates whether the effect of length differs between the two stations. Theoretically, when effect of length is stronger in one station compared to another then also the contaminant level should will be higher given that the "base" contamination load is equal between stations (i.e. all conger have the same contamination at length 0, the y-intercept). However, models perform better when "base" contamination is calculated separately per station (e.g. for Hg the calculated intercept ranges from 0.014 - 0.22 and differences are significant). Considering this value is far outside the observed range of data (starting around 60cm) they have little biological meaning; yet, especially when expressed per kg, differences in the "base" contamination are theoretically possible (particularly when expressed per kg) and thus we did not force the model thorgh the same y-Intercept to achieve the best fit to the empiric data. This does, however, require a more differentiated interpretation, since contamination is not solely explained by accumulation (i.e. as a function of length) at a given station, but also by differences in the "base" contamination.

```
## Lade nötiges Paket: emmeans

## The 'lsmeans' package is now basically a front end for 'emmeans'.
## Users are encouraged to switch the rest of the way.
## See help('transition') for more information, including how to
## convert old 'lsmeans' objects and scripts to work with 'emmeans'.
```

contrast.Hg	estimate	SE	df	t.ratio	p.value
Al Hoceima - Casablanca	0.041	0.018	90	2.238	0.391
Al Hoceima - Laayoune Port	0.012	0.018	90	0.668	0.999
Al Hoceima - Martil	0.004	0.020	90	0.209	1.000
Al Hoceima - Nador	0.023	0.020	90	1.193	0.956
Al Hoceima - Ras al Ma	-0.001	0.019	90	-0.066	1.000

contrast.Hg	estimate	SE	df	t.ratio	p.value
Al Hoceima - Safi	0.022	0.019	90	1.150	0.965
Al Hoceima - Sidi el Abed	-0.003	0.029	90	-0.089	1.000
Al Hoceima - Skhirat	0.020	0.019	90	1.043	0.980
Casablanca - Laayoune Port	-0.029	0.006	90	-4.523	0.001
Casablanca - Martil	-0.037	0.010	90	-3.848	0.007
Casablanca - Nador	-0.018	0.010	90	-1.838	0.657
Casablanca - Ras al Ma	-0.043	0.008	90	-5.186	0.000
Casablanca - Safi	-0.020	0.008	90	-2.572	0.213
Casablanca - Sidi el Abed	-0.044	0.023	90	-1.921	0.602
Casablanca - Skhirat	-0.022	0.008	90	-2.861	0.112
Laayoune Port - Martil	-0.008	0.009	90	-0.874	0.994
Laayoune Port - Nador	0.011	0.009	90	1.208	0.953
Laayoune Port - Ras al Ma	-0.013	0.008	90	-1.741	0.720
Laayoune Port - Safi	0.009	0.007	90	1.304	0.928
Laayoune Port - Sidi el Abed	-0.015	0.023	90	-0.650	0.999
Laayoune Port - Skhirat	0.007	0.007	90	1.031	0.982
Martil - Nador	0.019	0.012	90	1.642	0.779
Martil - Ras al Ma	-0.005	0.011	90	-0.506	1.000
Martil - Safi	0.017	0.010	90	1.714	0.736
Martil - Sidi el Abed	-0.007	0.024	90	-0.279	1.000
Martil - Skhirat	0.015	0.010	90	1.522	0.842
Nador - Ras al Ma	-0.025	0.011	90	-2.326	0.338
Nador - Safi	-0.002	0.010	90	-0.187	1.000
Nador - Sidi el Abed	-0.026	0.024	90	-1.092	0.974
Nador - Skhirat	-0.004	0.010	90	-0.387	1.000
Ras al Ma - Safi	0.023	0.009	90	2.592	0.205
Ras al Ma - Sidi el Abed	-0.001	0.023	90	-0.056	1.000
Ras al Ma - Skhirat	0.021	0.009	90	2.377	0.309
Safi - Sidi el Abed	-0.024	0.023	90	-1.045	0.980
Safi - Skhirat	-0.002	0.008	90	-0.246	1.000
Sidi el Abed - Skhirat	0.022	0.023	90	0.957	0.989

contrast.Cd	estimate	SE	df	t.ratio	p.value
Al Hoceima - Casablanca	-0.013	0.033	62	-0.403	1.000

contrast.Cd	estimate	SE	df	t.ratio	p.value
Al Hoceima - Laayoune Port	0.013	0.033	62	0.383	1.000
Al Hoceima - Martil	0.022	0.035	62	0.640	0.998
Al Hoceima - Nador	0.025	0.035	62	0.721	0.996
Al Hoceima - Ras al Ma	-0.043	0.036	62	-1.181	0.934
Al Hoceima - Safi	-0.018	0.045	62	-0.392	1.000
Al Hoceima - Skhirat	-0.014	0.033	62	-0.413	1.000
Casablanca - Laayoune Port	0.026	0.013	62	2.069	0.446
Casablanca - Martil	0.036	0.017	62	2.067	0.447
Casablanca - Nador	0.039	0.018	62	2.195	0.369
Casablanca - Ras al Ma	-0.030	0.020	62	-1.504	0.803
Casablanca - Safi	-0.005	0.034	62	-0.134	1.000
Casablanca - Skhirat	-0.001	0.014	62	-0.037	1.000
Laayoune Port - Martil	0.010	0.017	62	0.566	0.999
Laayoune Port - Nador	0.013	0.018	62	0.724	0.996
Laayoune Port - Ras al Ma	-0.055	0.020	62	-2.823	0.108
Laayoune Port - Safi	-0.030	0.034	62	-0.906	0.984
Laayoune Port - Skhirat	-0.026	0.014	62	-1.942	0.528
Martil - Nador	0.003	0.021	62	0.141	1.000
Martil - Ras al Ma	-0.065	0.023	62	-2.841	0.103
Martil - Safi	-0.040	0.036	62	-1.128	0.948
Martil - Skhirat	-0.036	0.018	62	-2.003	0.488
Nador - Ras al Ma	-0.068	0.023	62	-2.937	0.082
Nador - Safi	-0.043	0.036	62	-1.206	0.927
Nador - Skhirat	-0.039	0.018	62	-2.129	0.408
Ras al Ma - Safi	0.025	0.037	62	0.680	0.997
Ras al Ma - Skhirat	0.029	0.020	62	1.427	0.841
Safi - Skhirat	0.004	0.034	62	0.118	1.000

contrast.Pb	estimate	SE	df	t.ratio	p.value
Al Hoceima - Casablanca	0.035	0.033	90	1.069	0.977
Al Hoceima - Laayoune Port	0.010	0.033	90	0.299	1.000
Al Hoceima - Martil	0.056	0.035	90	1.602	0.801
Al Hoceima - Nador	0.047	0.035	90	1.319	0.923
Al Hoceima - Ras al Ma	0.054	0.034	90	1.582	0.812

contrast.Pb	estimate	SE	df	t.ratio	p.value
Al Hoceima - Safi	0.001	0.034	90	0.030	1.000
Al Hoceima - Sidi el Abed	0.033	0.051	90	0.646	0.999
Al Hoceima - Skhirat	0.005	0.034	90	0.162	1.000
Casablanca - Laayoune Port	-0.026	0.012	90	-2.219	0.403
Casablanca - Martil	0.021	0.017	90	1.208	0.953
Casablanca - Nador	0.011	0.017	90	0.634	0.999
Casablanca - Ras al Ma	0.018	0.015	90	1.247	0.944
Casablanca - Safi	-0.034	0.014	90	-2.494	0.249
Casablanca - Sidi el Abed	-0.002	0.041	90	-0.058	1.000
Casablanca - Skhirat	-0.030	0.014	90	-2.192	0.420
Laayoune Port - Martil	0.047	0.017	90	2.804	0.129
Laayoune Port - Nador	0.037	0.017	90	2.196	0.417
Laayoune Port - Ras al Ma	0.044	0.014	90	3.176	0.050
Laayoune Port - Safi	-0.009	0.013	90	-0.683	0.999
Laayoune Port - Sidi el Abed	0.023	0.041	90	0.572	1.000
Laayoune Port - Skhirat	-0.004	0.013	90	-0.342	1.000
Martil - Nador	-0.010	0.021	90	-0.468	1.000
Martil - Ras al Ma	-0.003	0.019	90	-0.138	1.000
Martil - Safi	-0.055	0.018	90	-3.035	0.073
Martil - Sidi el Abed	-0.023	0.043	90	-0.547	1.000
Martil - Skhirat	-0.051	0.018	90	-2.806	0.128
Nador - Ras al Ma	0.007	0.019	90	0.383	1.000
Nador - Safi	-0.046	0.018	90	-2.480	0.256
Nador - Sidi el Abed	-0.013	0.043	90	-0.315	1.000
Nador - Skhirat	-0.041	0.018	90	-2.249	0.384
Ras al Ma - Safi	-0.053	0.016	90	-3.346	0.031
Ras al Ma - Sidi el Abed	-0.021	0.042	90	-0.498	1.000
Ras al Ma - Skhirat	-0.048	0.016	90	-3.085	0.064
Safi - Sidi el Abed	0.032	0.041	90	0.774	0.997
Safi - Skhirat	0.004	0.015	90	0.300	1.000
Sidi el Abed - Skhirat	-0.028	0.041	90	-0.668	0.999

Comparing station averages

Tab 3 Predictions of contamination at mean length of all congers (and mean for Pb)

station	length	Hg_at_length	Cd_at_length	Pb_at_length	Pb_mean	Pb_g
Al Hoceima	88.1	0.3	118.3	66.4	52.7	
Casablanca	88.1	0.1	467.5	27.4	30.8	
Laayoune Port	88.1	0.1	492.0	65.1	68.4	
Martil	88.1	0.5	150.2	63.1	53.6	
Nador	88.1	0.1	2.3	26.9	73.7	
Ras al Ma	88.1	0.2	194.2	62.6	151.3	
Safi	88.1	0.3	212.3	45.7	56.1	
Sidi el Abed	88.1	0.3		141.0	104.7	
Skhirat	88.1	0.3	267.4	36.7	40.8	