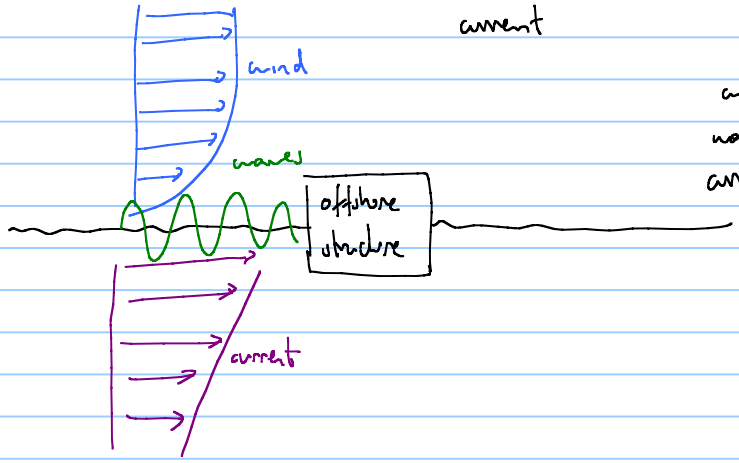
Note Title

Notes for Youtube video Marine loads and offshore structures for hydrocarbon production

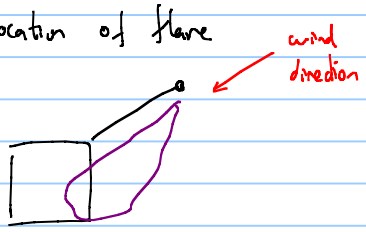
Offshore structures for oil and gas production

- effect of oceanographic environment: wind
  waves
  current

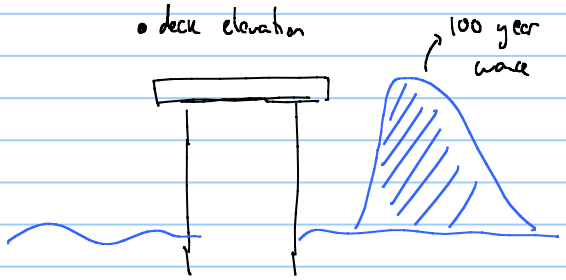


wind, waves, current must be taken into account when designing the offshore structure

- location of flare



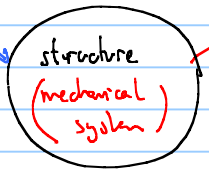
- deck elevation



- design wave, for a range of periods is most likely in the area
- storm (100 year storm)
- long term variations ~ fatigue

forces and marine loads on structure (t)

- magnitude
- frequency
- direction



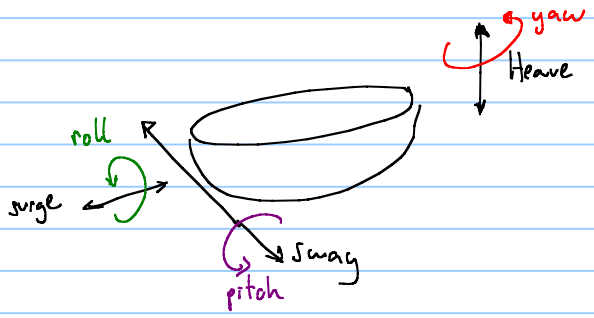
→ movement (t)
stress (t) → maximum stress
fatigue design

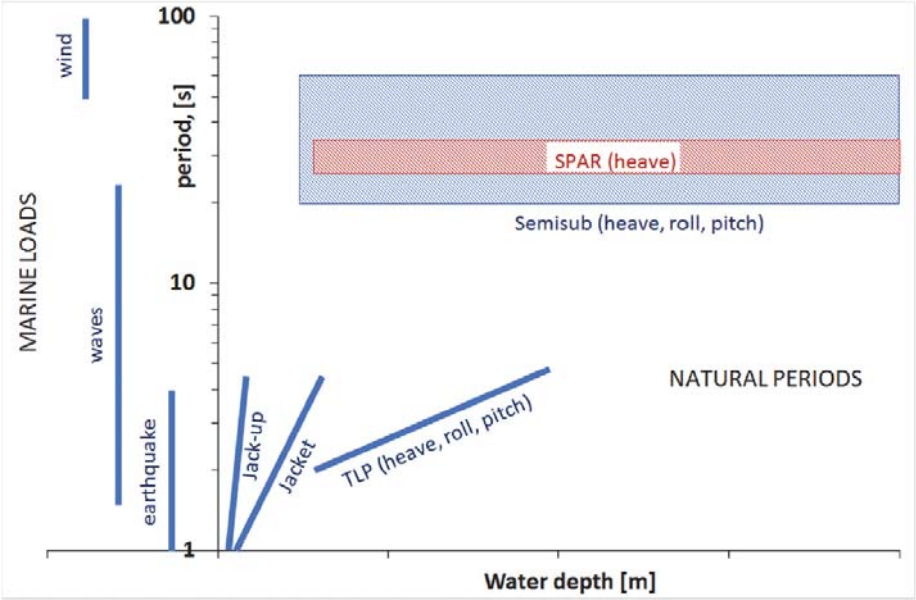
each structure, depending on it characteristics (mass, flexibility, dampening)

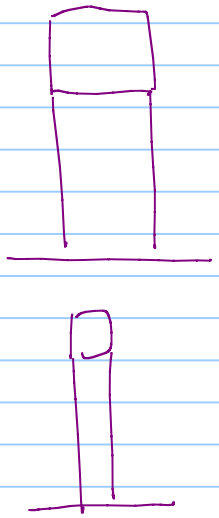
will have a natural frequency that if excited at this frequency might exhibit maximum movement and stress.

fixed structure

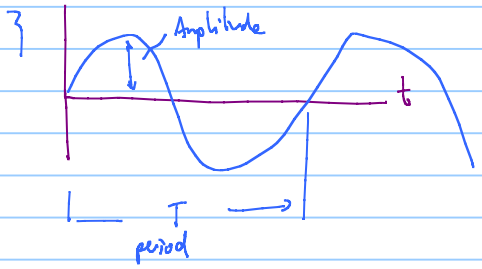
floating structure





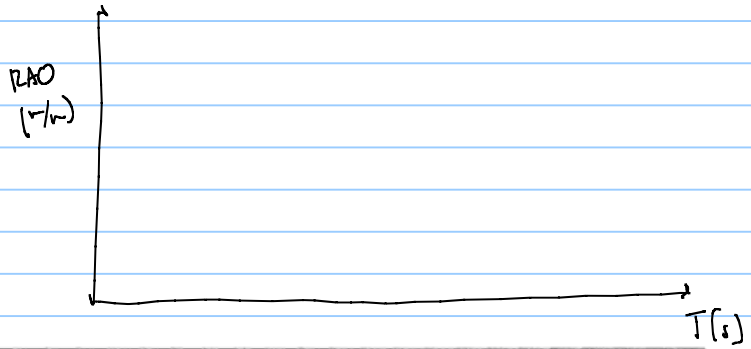


Response amplitude operator (RAO) = $\frac{\text{amplitude of response}}{\text{amplitude of excitation}} = \frac{\text{Heave [m]}}{\text{wave amplitude [m]}}$



$f = \frac{1}{T}$ $\frac{\text{cycle}}{s}$

RAO = 2



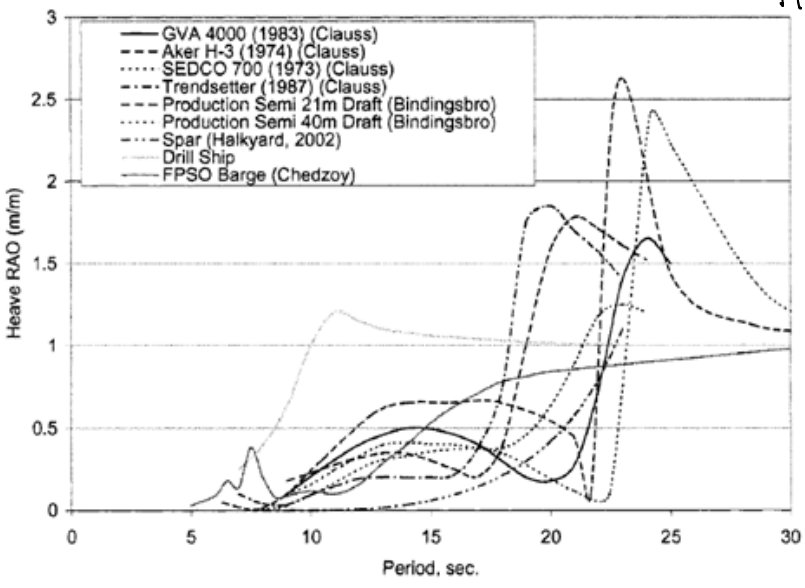


Figure 7.3 Example heave RAOs of various floaters

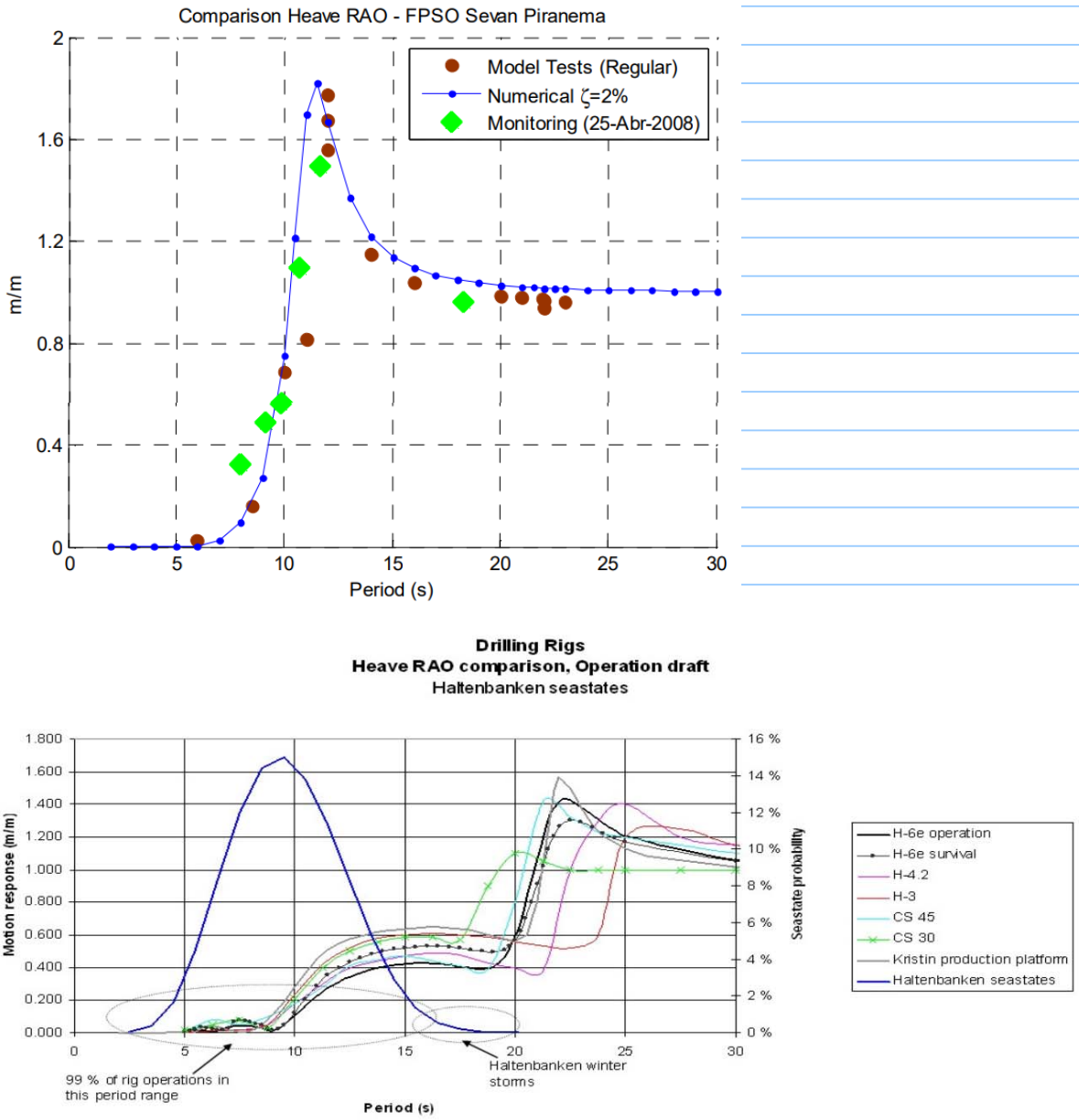


Figure 16.2: *RAO published on the AKER Drilling website.*

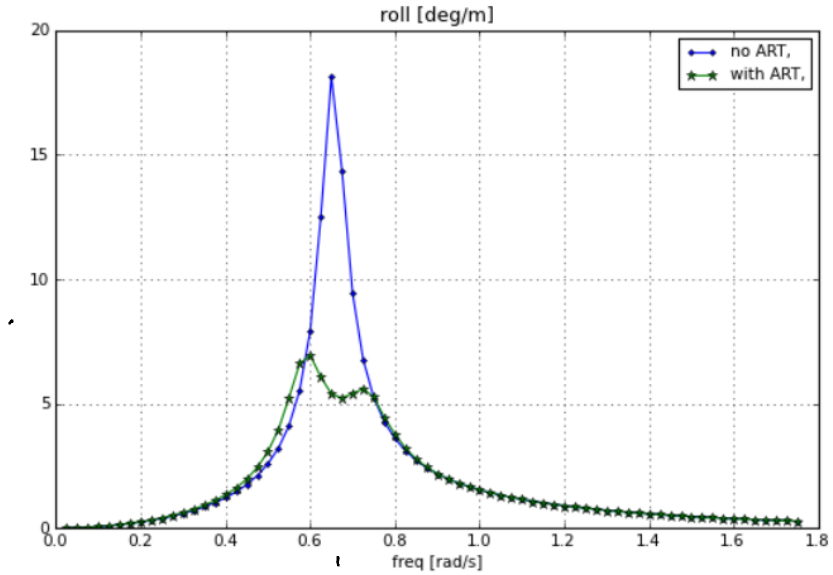
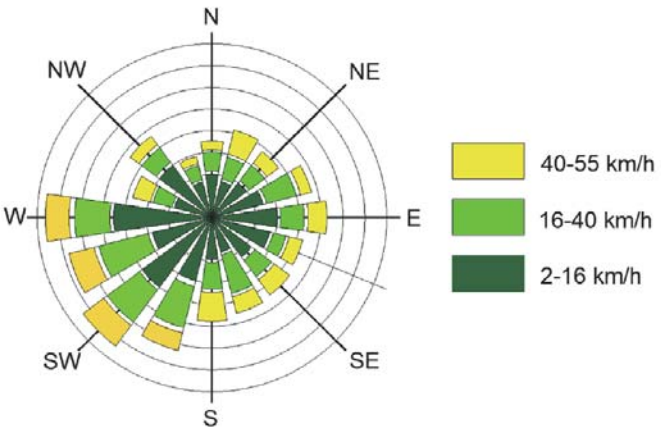


Figure 1: Typical RAO of roll of a ship with and without ART.

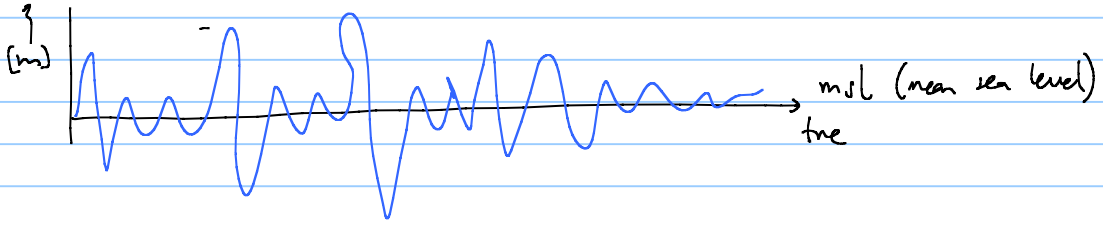
Wind



wind rose

wind and current are typically assumed constant and using the maximum value. (wind direction also must be taken into account)

Waves



Fourier

$$f(t) = \sum_{i=1}^{N} A_i \sin(\omega_i t + \phi_i)$$

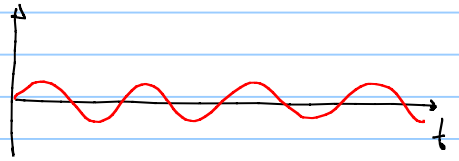
ϕ_i ~ phase shift

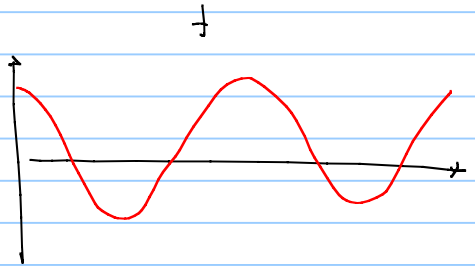
A_i ~ amplitude (m)

angular frequency $\omega_i = 2\pi f_i$

$\omega_i = \frac{rad}{s}$

$\left[\frac{cycle}{s}\right]\left[\frac{2\pi\ rad}{1\ cycle}\right]$

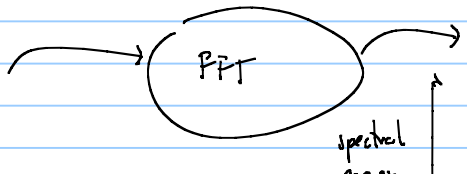




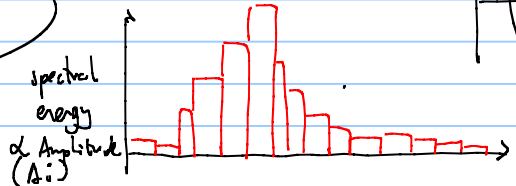
Discrete Fourier transform

FFT Fast fourier transform

t	value
0	0
1	0
2	2
3	2



spectral peak period
dominant frequency



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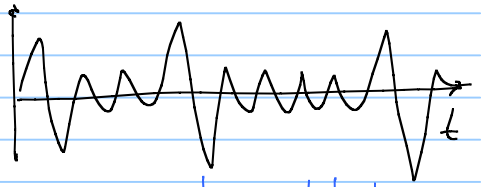
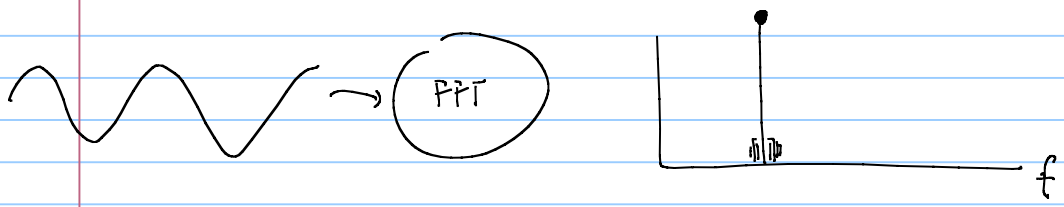


sometimes analytical equations are used

Pierson Moskowitz, JONSWAP



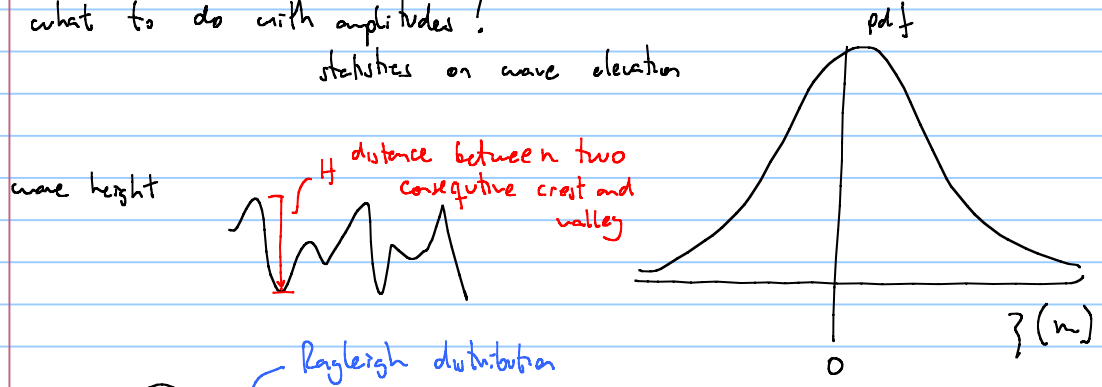
to deal with the variability of waves in time, we apply FFT on the signal and report spectral peak period

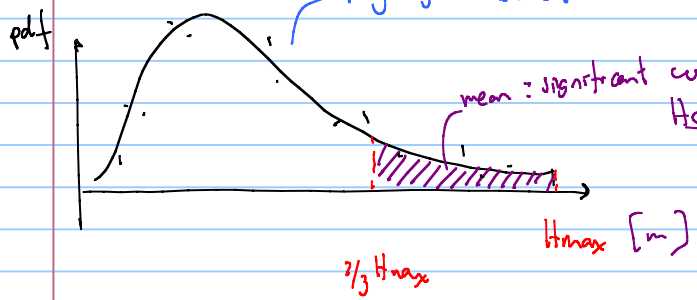
the spectral peak period does not change significantly in 3 hours

sea state

what to do with amplitudes?

statistics on wave elevation



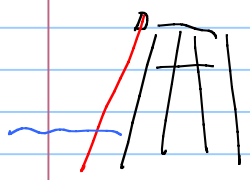


to characterize a sea state (3 hrs) Hs and Tp are used

wave Data must be gathered for at least 2 years to obtain a representative sample of wave conditions in the area

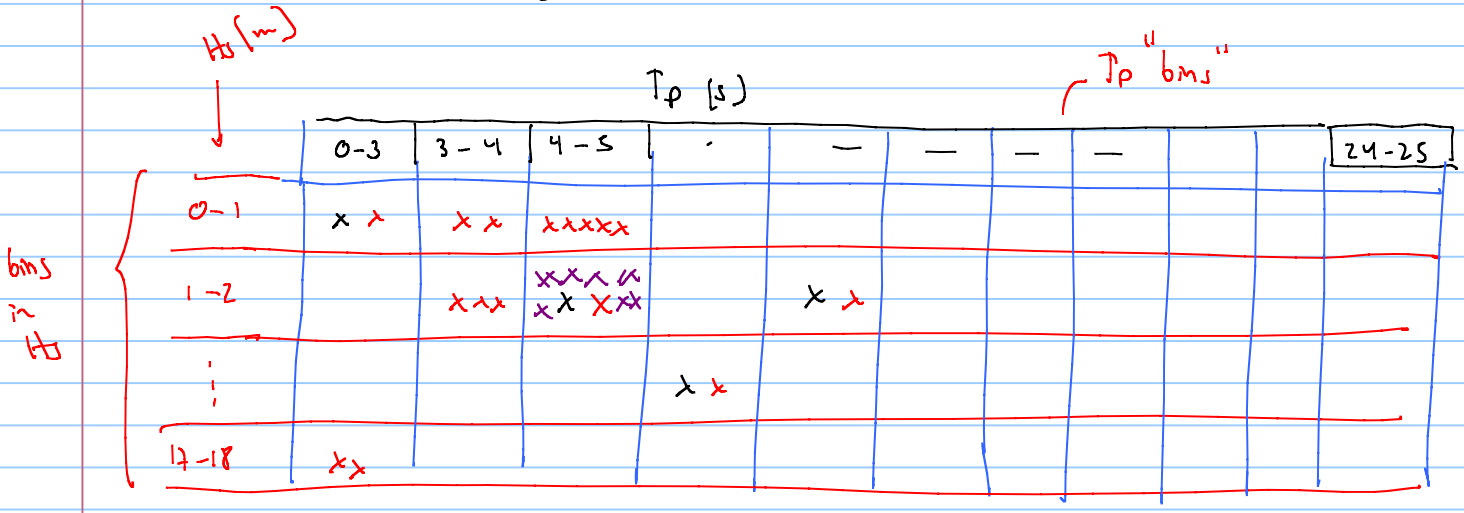
How many sea states are in 2 years

$$2\,\text{years} \cdot \frac{365\,\text{day}}{\text{year}} \cdot \frac{24\,\text{hrs}}{1\,\text{day}} \cdot \frac{1\,\text{sea state}}{3\,\text{hr}} = 5840$$



with all measured data, compute Tp, Hs for all

Scatter diagram of long term wave statistics

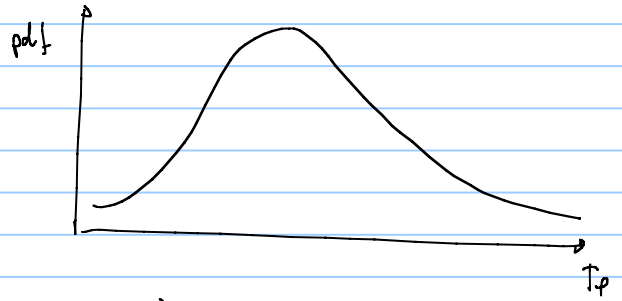


classify each data point I have in each box

	Spectral Peak period (T_p) [s]																						
Hs [m]	0-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	Sum
0-1	15	290	1367	2876	3716	3527	2734	1849	1138	656	362	192	101	52	26	13	7	3	2	1	0	0	0	18927
1-2	1	81	1153	5308	12083	17323	18143	15262	10980	7053	4169	2316	1229	631	315	155	75	36	17	8	4	5	1	96348
2-3	0	2	94	1050	4532	10304	15020	15953	13457	9752	5991	3403	1795	894	426	197	88	39	17	7	3	1	1	83026
3-4	0	0	2	72	686	2782	6171	8847	9189	7493	5082	2991	1577	762	345	148	61	24	9	4	1	0	0	46246
4-5	0	0	0	2	51	433	1645	3495	4807	4750	3638	2286	1229	584	251	100	37	13	5	1	0	0	0	23327
5-6	0	0	0	0	2	39	294	1037	2069	2664	2440	1709	968	463	193	72	25	8	2	1	0	0	0	11986
6-7	0	0	0	0	0	2	32	215	692	1264	1485	1228	767	382	159	57	18	5	1	0	0	0	0	6307
7-8	0	0	0	0	0	0	2	27	157	447	730	762	555	302	130	46	14	4	1	0	0	0	0	3177
8-9	0	0	0	0	0	0	0	2	23	112	276	392	355	223	104	38	11	3	1	0	0	0	0	1540
9-10	0	0	0	0	0	0	0	0	2	19	77	160	192	148	79	31	9	2	0	0	0	0	0	719
10-11	0	0	0	0	0	0	0	0	0	2	16	50	85	85	55	24	8	2	0	0	0	0	0	327
11-12	0	0	0	0	0	0	0	0	0	0	2	12	29	40	33	18	7	2	0	0	0	0	0	143
12-13	0	0	0	0	0	0	0	0	0	0	0	2	8	15	17	12	5	2	0	0	0	0	0	61
13-14	0	0	0	0	0	0	0	0	0	0	0	0	2	5	7	6	4	1	0	0	0	0	0	25
14-15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	2	1	0	0	0	0	0	9
15-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	4
16-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	16	373	2616	9308	21070	34410	44041	46687	42514	34212	24268	15503	8892	4587	2143	921	372	146	55	22	8	6	2	292172

FIGURE 6-18. SCATTER DIAGRAM OF LONG TERM WAVE STATISTICS

for a fixed wave Hs



$\frac{292172}{2420\left(\frac{\text{states}}{1\text{ year}}\right)} \approx 120$ years

for a fixed Tp