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Catch Composition, Effort, and Selectivity of Fishes of recreational Fishing in Yucatán, Mexico

By Gaspar Poot-Lopez, Sharix Rubio-Bueno, Harold Villegas-Hernandez, Carlos Gonzalez-Salas, Sergio Guillen-Hernandez & Raul E. Díaz-Gamboa

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Abstract- Fishing for recreational purposes is a component rarely studied. This activity represents a potential competition with artisanal fisheries, although its impact on fish stocks remains unknown in many coastal areas worldwide. Here, In this study we described the catch composition, the catch per unit effort (CPUE), size at first capture (L_{50}) and the length-weight relationship (LWR) of the fish species caught by the recreational fishing from the coastal area off Chuburna Puerto, Yucatan, Mexico. During an annual cycle a total of 1,241 specimens of 21 fish species, belonging to 13 families, were collected with hook and line, as the main fishing gear used by the recreational fishing in the region. The species *Haemulon plumieri* and *Sphoeroides nephelus* were captured all along the study period and contributed with 43.07% and 30.55% of the total biomass, respectively. Seven species are known to have a commercial interest for exploitation and 10 with minor commercial interest.

Keywords: recreational fishing, catch composition, catch per unit effort, length-weight relationship, *Haemulon plumieri*, *Sphoeroides nephelus*, yucatan.

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CATCHCOMPOSITIONEFFORTANDSELECTIVITYOFFISHESOFRECREATIONALFISHINGINYUCATANMEXICO

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Catch Composition, Effort, and Selectivity of Fishes of recreational Fishing in Yucatán, Mexico

Gaspar Poot-Lopez ^α, Sharix Rubio-Bueno ^σ, Harold Villegas-Hernandez ^ρ, Carlos Gonzalez-Salas ^ω, Sergio Guillen-Hernandez [¥] & Raul E. Díaz-Gamboa [§]

Abstract- Fishing for recreational purposes is a component rarely studied. This activity represents a potential competition with artisanal fisheries, although its impact on fish stocks remains unknown in many coastal areas worldwide. Here, In this study we described the catch composition, the catch per unit effort (CPUE), size at first capture (L_{50}) and the length-weight relationship (LWR) of the fish species caught by the recreational fishing from the coastal area off Chuburna Puerto, Yucatan, Mexico. During an annual cycle a total of 1,241 specimens of 21 fish species, belonging to 13 families, were collected with hook and line, as the main fishing gear used by the recreational fishing in the region. The species *Haemulon plumieri* and *Sphoeroides nephelus* were captured all along the study period and contributed with 43.07% and 30.55% of the total biomass, respectively. Seven species are known to have a commercial interest for exploitation and 10 with minor commercial interest. The average CPUE was 2.86 kg/fisher/day. From the LWR parameters of 12 species presented, only five species showed isometric growth. Due to the lack of information on biological-fishing issues of the species captured by recreational fishing in the northern coast of the Yucatan, this work provides useful information on the composition and abundance of fish species that can be caught, and may represent a baseline for future management strategies for these un assessed fish species which are up to date subject of unregulated exploitation.

Keywords: recreational fishing, catch composition, catch per unit effort, length-weight relationship, *Haemulon plumieri*, *Sphoeroides nephelus*, yucatan.

1. INTRODUCTION

The fishing resources are very dynamic and diverse, but the global vision of development and promotion, that once considered them as inexhaustible, has been modified by the sustainable use (Hilborn *et al.*, 2003). In recent years, a great proportion of identified species resulted as overfished. In fact, overall it is estimated that about 13.5% of marine resources are severely damaged, 26% over-exploited, 25.5% in maximum use, 5% in development and for 30% no information is available that allows a proper diagnosis (Arreguín-Sánchez & Arcos-Huitrón, 2011).

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The fishing industry includes both recreational, subsistence and commercial fishing, including the extraction and commercialization of fish (FAO, 2016). However, fishing for recreational purposes is a component rarely studied, being a key outdoor activities in the United States (Ditton *et al.*, 2002). Recreational fishing means the capture of aquatic animals (mainly fish) that do not constitute the primary resource of the individual to satisfy their basic nutritional needs and the captured organisms are not sold or commercialized in the fish markets (FAO, 2012). In addition, this activity can be considered a sports activity (sportfishing tournaments), representing an enormous economic potential in several countries, including Mexico. This generates flow of jobs, foreign exchange and its effects expands to other activities and services, becoming good for development (TRAGSATEC, 2005; Ibáñez, 2011). However, that represents a potential competition with artisanal fisheries, although its impact on fish populations remains unknown in many coastal areas worldwide (FAO, 2012; Flores-Nava *et al.*, 2016)

The overexploitation of commercial fishing resources in Yucatan, Mexico is bordering fishermen for a change in economic activity towards the tertiary sector, particularly adventure tourism, such as recreational fishing (Gutiérrez-Pérez, 2014). For example, in some ports, off shore sport fishing tournaments are usually held frequently (3-10 per year), involving 30 to 50 boats, and up to 200 fishermen (Vidal-Hernández *et al.*, 2017). However, recreational fishing increases during weekends or holiday periods (spring-summer), where users hire artisanal fishermen as guides, and the payment includes boat rentals, fishing gear (hook and line) and bait (Gutiérrez-Pérez, 2014; Mugarte-Mendoza *et al.*, 2016; Vidal-Hernández *et al.*, 2017). Although there are no well-established services for recreational fishing and there are no catch records of this activity, it is a fact that is practiced by a large number of people, either with their own or rented boats. Similarly, little is known about scuba diving, spearfishing, and underwater photography in the area, all of which are linked to the incipient or potential use of natural resources (García de Fuentes *et al.*, 2011).

In the coast of Yucatan there are several fish species currently exploited by the recreational fishing, such as white grunt (*Haemulon plumieri*), grouper (*Epinephelus morio*), snappers (*Ocyurus chrysurus* and *Lutjanus* spp), porgies (*Calamus* spp), among other species (Salas *et al.*, 2006, Mexicano-Cíntora *et al.*, 2007, Fernández *et al.*, 2011). However, in sport fishing tournaments competitors seek to capture species with high commercial value, as well as the biggest and heaviest organisms (Vidal-Hernández *et al.*, 2017).

Up to date, there is a lack of information on biological-fishing issues of these un assessed species captured by the unregulated recreational fishing in this region. In this sense, studies examining the composition of the catches in a fishery are designed to know the exploitation status (e.g., catch rates and size structures) and changes in the selectivity patterns to contribute to management and conservation measures (Quiroz *et al.*, 2008). Therefore, the present study describe the composition of the catches, the catch per unit effort (CPUE), selectivity and the length-weight relationship (LWR) of the fish species caught by the recreational fishing, for the first time in the northern coast of the Yucatan.

II. MATERIAL AND METHODS

a) Study area

Chuburna Puerto (21°15'07" N and 89°48'57" W) is on the coast of the Gulf of Mexico in the northern coastal area off the Yucatan Peninsula. Four sampling sites were chosen, with depths ranging from 4 to 5 meters (Figure 1). The average annual temperature is 25.6°C, with a maximum of 36°C. The region has a warm semi-dry climate from March to June, with intense rain from July to October, and strong northern winds and lower intensity rain the rest of the year (Ordoñez-López *et al.*, 2013). Due to its location in the tropical zone, the study area shows three climatic periods: dry (March-June), rainy (July-October) and northerly winds (November-February), which determine the environmental and ecological dynamics of the system (Vega-Cendejas, 2004).

b) Sampling

We performed twelve samplings on a monthly basis, from October 2015 to September 2016. A 23-foot long boat with a 40 HP motor was used on each fishing trip, in which four crew members used hook and lines as fishing gears and with tentacles of squid (*Dosidicus gigas*) as bait. The standardized catch effort was four hours/fisher/day. We stored the captured specimens in coolers, except for those in a temporary fishing ban or not suitable for human consumption, in which cases were identified, measured, weighed and released at the time. The following morphological data were taken from each: standard length (SL in cm) and total weight (TW in gr). The species identification was carried out following

the guidelines of Carpenter (2002) and Gallardo-Torres *et al.* (2014). As a complementary analysis, we catalogued each species according to their exploitation uses: commercial (C_o), minor commercial (C_m), aquarium (Aq), aquaculture (Aq_c), Recreational (Rec) and livelihood fishery (LFIS), based on biological-fishery related data (i.e. regulation measures or minimum sizes of sexual maturity) available in Fish Base (Froese & Pauly, 2017) or previous published studies.

With the SL data, we constructed length frequency histograms with size class intervals of 2 cm. The cumulative frequency histogram of the lengths of each species was used to adjust the parameters of the selectivity equation, described as follows:

$$r(SL) = \frac{\exp(b_0 + b_1 SL)}{1 + \exp(b_0 + b_1 SL)} \quad (\text{Eq. 1})$$

Where $r(SL)$ is the probability of capture of the organism of a given standard length, and b_0 and b_1 are constants or parameters to be estimated for the logistic model. The function was adjusted using least squares method in the Statistica 6.1 software. We obtained the selectivity parameters (b_0 and b_1) and then estimated the size at first capture (L_{50}), which is defined as the size (SL) at which the fishing gear retained 50% of the organisms as $L_{50} = - (b_0 / b_1)$. The parameters mentioned above were estimated at 95% confidence (Millar & Fryer 1999; Arellano-Torres *et al.*, 2006) only for those species that had more than ten specimens collected.

Based on the catches in number of individuals (n) and weight (kg), the catch per unit of effort (CPUE) was estimated on a monthly basis as well as for the climatic periods (dry, rainy and northerly winds season) according to the recommendations of Vega-Cendejas (2004) and compared with a one-way analysis of variance (ANOVA).

Length-Weight relationships (LWR) was estimated using the biometric information to establish the relationships between the standard length (SL) and the total weight (TW) using the potential equation:

$$TW = a(SL)^b \quad (\text{Eq. 2})$$

Where a is the ordinate to the origin (intercept) and b is the slope. Parameter a represents the condition factor or degree of individual robustness. Meanwhile, b is a relative growth coefficient by the length and its proportionality with the weight (Safran, 1992). Both LWR parameters were estimated by linear regression in Microsoft Excel based on the logarithms of SL and TW according to:

$$\text{Log } TW = \text{Log } a + b \text{log } SL \quad (\text{Eq. 3})$$

Once estimated slope (b) of LWR of the selected species was statistically compared to test if it is or not different from the isometric growth, that is to say, b value equal to 3 (Ricker, 1975), using the one-tailed

Student's t-test (Zar, 1999). In the same way, as with the L_{50} , the LWR equation was estimated only for those species that had at least ten specimens.

III. RESULTS

a) Catch Composition

A total of 1,241 specimens of 21 fish species were collected, belonging to 13 families. Haemulidae, Tetraodontidae, Serranidae, Balistidae, Lutjanidae, Carangidae and Sparidae were the families that contributed to a large proportion of biomass and individuals captured along the study period (Table 1). The families Ariidae, Batrachoididae, Echeineidae, Monacanthidae, Scombridae and Synodontidae, accounted for less than 0.9% of the catches, and some of them with a single specimen. Two species, *Haemulon plumieri* and *Sphoeroides nephelus*, were caught during the 12 months and contributed with 43.07% and 30.55% of the total biomass, respectively. In contrast, the contribution of *Caranx crysos* concerning total biomass was only 3.32% and captured all year. We cataloged seven species under exploitation of commercial interest (C_o), where only *Epinephelus morio* supports a strong fishery in the region (Table 1). Ten species have minor commercial importance, and recreational fisheries capture 12 species in other areas (Table 1). *Opsanus beta* and *Echeneis neucratoides* also present reports of incidental catches by recreational fisheries, while *Stephanolepis hispidus* and *Sphoeroides nephelus* are species captured by the livelihood fisheries (Table 1).

b) Size at first capture (L_{50})

Table 1 shows the selectivity parameters (b_0 and b_1) and the size at first capture (L_{50}) for each species, where L_{50} of species caught varied from 11.09 to 33.64 cm SL for *Diplectrum formosum* and *Echeneis neucratoides*, respectively. All values of b_0 and b_1 were significant ($p < 0.05$). However, we did not estimate the selectivity parameters due to the low number of specimens captured (Table 1).

c) Catch per unit effort (CPUE)

The average CPUE was estimated at 2.86 kg/fisher/day, equivalent to 14.7 fish, considering 4 hours per fishing day. CPUE varied between a minimum and maximum of 1.88 (April) and 3.98 (February) kg/fisher/day. The analysis of the overall CPUE did not present significant differences between climatic periods (ANOVA, $p > 0.05$) neither for weight nor the number of individuals. In terms of biomass, species of commercial interest (C_o) accounted less than 25% of the monthly catches, *E. morio* and *L. synagris* being the most important in volume, where the CPUE of commercial species presented a minimum of 0.048 (May) and a maximum of 0.895 (February) kg/fisher/day (Figure 2). We noted that *E. morio* sustains the main scale fishery in the region, due to its commercial value and volume.

Species contributing in great proportion to the catch were previously cataloged as fish with minor commercial interest (C_m) and for livelihood fisheries (LFIS), such as *Haemulon plumieri*, *Sphoeroides nephelus*, *Balistes capriscus* and *Caranx crysos*, with more than 82% of the catches in nine months along the study period (Figure 3). CPUE by weight of these species was estimated from 1.3 (April) to 3.24 (December) kg/fisher/day.

Figure 4 shows the size frequency distributions of fish species with commercial interest (C_o), with their respective sizes of first sexual maturity reported in the literature, either furcal length (FL) or standard length (SL). Size classes that comprise the size of the first catch (L_{50}) are in blank cases (Fig. 4). *Epinephelus morio*, *Ocyurus crysurus* and *Diplectrum formosum* presented an L_{50} below their respective sizes of first sexual maturity. In spite of being a species used as human food, up to date there is no record of sexual maturity for *Calamus campechanus*. Although this later fish species commonly represents a complementary bait in recreational and artisanal fishing.

Of the species that cataloged with minor commercial interest (C_m), only *H. plumieri* showed abundant catches (Figure 5), as *Sphoeroides nephelus* did, although the livelihood fisheries (LFIS) uses the latter one. 70% of the captures of *H. plumieri* were above the size of the first maturity, meanwhile, for *S. nephelus*, no reports of their sexual maturity were found. For *Balistes capriscus*, its size of the first catch (L_{50}) matched its reported size of the first sexual maturity (Figure 5), unlike *Caranx crysos*, affecting immature organisms.

d) Length-Weight Relationships

The results of regression models of the LWR of 12 fish species were highly significant ($p < 0.001$), in which in most cases the values of the coefficient of determination (r^2) were found above 0.91 indicating that data fitted to the linear model, except for *Balistes capriscus* (Table 2). The results of the t-tests (\hat{t}) applied to the slopes (b) indicate that b values of *Calamus campechanus*, *Calamus proridens*, *Caranx crysos*, *Echeneis neucratoides* and *Epinephelus morio* show edisometric growth ($b = 3$) (Table 2).

IV. DISCUSSION

During an annual cycle, we observed in this study that the hook and line recreational fishing on the coast of the Chuburna Puerto, Yucatan, includes at least 13 families and 21 fish species. Although in the region there are other species of fish such as catfish, croakers, snappers and even rays considered by this activity (DOF, 2012). The species composition in a fishery can be influenced by various factors, such as the kind of fishing gear used, e.g., size and design of the hook (Erzini et al., 1998), or characteristics of the fishing sites

(e.g., depth), among other factors. In sportfishing tournaments (all along the coast of Yucatan), at least 20 species additional where counted respect to the present study (Vidal-Hernández *et al.*, 2017).

The depth of the selected sites was approximately 4.7 m, although some recreational fishing users can fish up to 15-20 m looking for larger specimens. For example, in recreational fishing in a locality of the Mediterranean Sea, the site caused variability in abundance and species composition (Alós *et al.*, 2008). The variation in catches is probably due to spatial differences in fishing pressure, habitat characteristics, recruitment and timing (Agembe *et al.*, 2010). In the present study, only three species (*Haemulon plumieri*, *Sphoeroides nephelus*, and *Caranx crysos*) presented captures during all months. CPUE remained in a range of 1.88 and 3.98 kg/fisher/day, without significant differences between climatic periods.

Alós *et al.* (2009) found that in recreational fishing the type of bait might influence CPUE, as well as the size of the fish caught, the composition of the catch. Similar studies were conducted by Otway & Craig (1993), Erzini *et al.* (1996, 1998, 1999) and Halliday (2002). In the present study, it was decided to use squid (*Dosidicus gigas*) as bait all year round, since fishermen in the region prefer it than artificial ones. Similarly, local fishermen use other fish species such as *Opisthonema oglinum*, *Diplectrum formosum*, *Haemulon plumieri*, *Hemiramphus* spp, *Lutjanus synagris* and octopus (*Octopus* spp), among others.

The most important species of commercial interest captured in our study, according to their biomass, were *E. morio*, *L. synagris* and *O. chrysurus*, representing less than 25% of the monthly catches. However, of these, the red grouper (*E. morio*) is the most important, and also found below the size of the first reported sexual maturity (38.1 cm SL) in the region (Brulé *et al.*, 1999). Vidal-Hernandez *et al.* (2017) analyzed the sizes frequency of six species of fish caught in sportfishing tournaments of Yucatan, and they found that only 0.5% of the *E. morio* specimens met the estimated size of sexual maturity. That is of great importance because the stock of red grouper in Yucatan is currently classified as an overexploited resource (Burgos & Defeo, 2000, 2004, Giménez-Hurtado *et al.*, 2005). The coastal areas most wanted by recreational fishing users are often critical habitats for multiple life stages of many fish species, which use these for spawning, nursery, feeding, migration, etc. (Jackson *et al.*, 2001). Also recreational fishermen target immature stages of fish in those areas (McPhee *et al.*, 2002).

Several snapper species has been the main component of the small scale fishery (artisanal) of coastal areas of the Yucatan Peninsula (SAGARPA, 2005, DOF, 2012). However, due to the decrease in the catches of the red snapper *Lutjanus campechanus*, some lutjanids such as *Lutjanus synagris* and *Ocyurus*

chrysurus recently acquired greater commercial, due to international demand (DOF, 2012). In the present study, at least 80% of *O. chrysurus*'s catches were located before or until the size of the first sexual maturity of 21.3 cm (Freitas *et al.*, 2011; Trejo-Martínez *et al.*, 2011). In contrast, *L. synagris* showed that size at first catch (L_{50}) similarly matched its size of the first sexual maturity at 18.67 cm SL (Freitas *et al.*, 2011). This agrees with that reported by Vidal-Hernandez *et al.* (2017), who determined that *L. synagris* in fishing tournaments were made up of 97% of adult organisms, unlike *O. chrysurus*, with 58% of mature fish. Regarding *Calamus proridens*, the size of the first maturity of 13.2 cm of FL (Tyler-Jedlund, 2009) was inferior to that observed in our study. Although *Diplectrum formosum*, whose L_{50} matched size at the first maturity equivalent to 12.5 cm SL (Darcy, 1985), is classified in some regions of the Caribbean as a commercial fishing species, in the Gulf of Mexico it is only associated with the catfish fishery (DOF, 2012). Also, these species are complementary bait in both artisanal and recreational fishing.

Recreational fishing can directly contribute to the decline of global fisheries through catches mortality, it can also alter the function and quality of ecosystems (Cooke & Cowx, 2004, Arlinghaus & Cooke, 2009). In the present study, most of the catches were species of minor commercial interest, but that serve as food or as a source of complementary income for the fishermen's families. An example of this is the white grunt *H. plumieri*, which supports an artisanal fishery in the northern coast of the Yucatan Peninsula, being up to date a non-regulated resource without maximum catch rates and unspecified catch size limits (Villegas-Hernández *et al.*, 2014). The size of the first maturity of this species was 16.8 cm FL in Brazilian waters (Shinozaki-Mendes *et al.*, 2013). The fishery of *H. plumier* is very important because is available all year round, representing an exploitation alternative that would serve as an "opportunity for recovery" to other species that are subject to a higher level of exploitation. This resource is considered as moderately abundant and with an intermediate distribution (Courtenay, 1961, Gaut & Munro, 1974, Domínguez-Viveros & Avila-Martínez, 1996).

Another resource that presented abundant catches throughout the year is the puffer fish *Sphoeroides nephelus*. *S. nephelus* is a species discarded for fishermen and associated with artisanal multispecies fisheries in the Yucatan Peninsula (DOF, 2012). There is evidence that the ancient Mayans used individuals of *Sphoeroides* spp as food (Herrera-Flores and Markus-Götz, 2014). However, their consumption has only been documented in the United States, where their meat is appreciated, despite its toxicity (Abbott *et al.*, 2009; DSSH, 2011). Regarding *C. crysos* and *B. capriscus*, although their catches in number were not abundant, they contributed with 3.32% and 5.31% of the

total biomass, respectively. The size of first catch of *C. crysos* found below the first sexual maturity, may vary (22.5-26.7 cm) depending on the estimation measure (*FL* or *SL*) (Berry, 1959; Goodwin & Finucane, 1985), similarly for *B. capriscus* whose size at first maturity has been estimated at 16.9 cm *FL* (Bernardes & Dias, 2000).

The values of parameter *b* in the LWR of 12 fish species varied between 2.3522 and 3.1982, where *Balistescapriscus* had the lowest one and *Echeneis neucratoides* the highest. The specimens of the families Haemulidae, Lutjanidae, Tetraodontidae, Balistidae and Batrachoididae showed an allometric growth, as well as *Diplectrum formosum* of the Serranidae family. At present, there is little information on the LWR of the species captured in this study, particularly in the Gulf of Mexico and the Yucatan Peninsula. Regarding the species *Caranx crysos* and *Echeneis neucratoides*, there was no information of these parameters. LWR of *C. campechanus* was presented for the first time by Poot-López *et al.* (2017), but *S. nephelus*, *B. capriscus*, *C. proridens* and *D. formosum* have limited information. For example, *S. nephelus* has been reported for Yucatan Peninsula (Amador-del Angel *et al.*, 2012; Poot-López *et al.*, 2017). In the present study, the value of *b* (2.35) for *Balistes capriscus* was lower than that reported by Burton *et al.* (2015) in the Southeast of the United States (2.98), whose sample was 20,431 specimens. Similarly, different *b* values have been reported for other species, such as *Calamus proridens* (Tyler-Jedlund, 2015) in the eastern Gulf of Mexico and *Diplectrum formosum* in the northern Gulf of Mexico (Bortone, 1971). Variations in the LWR are mainly due to differences between sexes, size or age of the individuals, feeding history caused by food availability, gonadal developmental state, the season of the year in which were captured or to different fishing sites (Ricker, 1975; Csirke, 1980). Haimovici and Velasco (2000) also mention other factors that affect the accuracy of LWRs such as sample size and adjustment methods.

Global fisheries resources face several threats attributed to commercial exploitation (Jackson *et al.*, 2001, Hilborn *et al.*, 2003, Pauly *et al.*, 2003, Watson *et al.*, 2003). However, some authors consider that recreational fishing is also responsible, indeterminately, for the degradation of fish stocks. Cooke & Cowx (2004) highlighted the potential of this activity to contribute to the decline of fisheries so that future fisheries management approaches should distinguish between categories of fishing activity and variations in the effort, either full-time, time partial, subsistence and recreational, although this requires data availability (FAO, 2016).

It should not be forgotten that recreational fishing could offer socioeconomic benefits in coastal regions, as an option for tourism (Ditton *et al.*, 2002, TRAGSATEC, 2005, Ibáñez, 2011). However, it is necessary to evaluate the impacts of capture rates, the

extraction of specimens in times of reproduction, sub-lethal damage to fish (use of hooks and spears), and contamination, to offer more specific management measures for each region (Arlinghaus & Cooke, 2009). In this sense, it is necessary to provide baseline information such as our results of the fish species caught by the recreational fishing from the northern coast of the Yucatan. However, future research is encouraged to carry out in the same matter in other coastal locations along the Yucatan Peninsula to establish management strategies for these unassessed fish species which are up to date subject of unregulated exploitation.

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Table 1: Catch composition of the recreational fishing (hook and line) in the coastal area off the Chuburna Puerto in Yucatan (Mexico)

Family	Species	N	% (n)	Total Weight (g)	% (g)	Use	b_0	b_1	L_{50} (SL in cm)
Ariidae	<i>Ariopsisfelis</i>	1	0.08%	293.0	0.12%	C _m , Rec	ID	ID	ID
Balistidae	<i>Balistescaprisus</i>	25	2.01%	12,726.1	5.31%	C _m , Rec	-8.99	0.543	16.55
Batrachoididae	<i>Opsanus beta</i>	9	0.73%	3,776.3	1.57%	Inc	-9.87	0.367	26.89
Carangidae	<i>Caranx crysos</i>	37	2.98%	7,949.5	3.32%	C _m , Rec	-11.56	0.577	20.03
Echeneidae	<i>Echeneis neucratoides</i>	11	0.89%	2,350.3	0.98%	Inc	-12.38	0.344	33.64
Haemulidae	<i>Anisotremus virginicus</i>	2	0.16%	852.2	0.36%	C _m , Rec, Aq	ID	ID	ID
	<i>Haemulon aurolineatum</i>	42	3.38%	2,473.4	1.03%	C _m , Aq	-30.78	2.565	12.00
	<i>Haemulon plumieri</i>	544	43.84%	103,285.9	43.07%	C _m , Rec, Aq	-10.29	0.568	18.13
	<i>Orthopristichrysoptera</i>	3	0.24%	222.4	0.09%	C _m , Aq	ID	ID	ID
Lutjanidae	<i>Lutjanus synagris</i>	32	2.58%	6,155.3	2.57%	C _o , Rec, Aq	-10.08	0.563	17.90
	<i>Ocyurus chrysurus</i>	25	2.01%	3,225.5	1.35%	C _o , Rec, Aq, Aqc	-8.99	0.543	16.55
Monacanthidae	<i>Stephanolepishispidus</i>	1	0.08%	60.0	0.03%	LFIS, Aq	ID	ID	ID
Scombridae	<i>Scomberomorus regalis</i>	2	0.16%	386.5	0.16%	C _m , Rec	ID	ID	ID
Serranidae	<i>Diplectrum formosum</i>	37	2.98%	1,295.7	0.54%	C _o , Rec, Ba	-8.348	0.752	11.09
	<i>Epinephelus morio*</i>	43	3.46%	13,841.1	5.77%	C _o , Rec, Aq	-12.56	0.578	21.71
	<i>Archosargus probatocephalus</i>	1	0.08%	248.4	0.10%	C _o , Rec, Aq	ID	ID	ID
Sparidae	<i>Calamus campechanus</i>	15	1.21%	1,762.3	0.73%	C _o	-14.48	1.023	13.96
	<i>Calamus proridens</i>	20	1.61%	3,192.2	1.33%	C _o	-20.94	1.328	15.76
	<i>Lagodon rhomboides</i>	6	0.48%	518.2	0.22%	C _m , Rec, Ba	ID	ID	ID
	<i>Synodus intermedius</i>	1	0.08%	61.3	0.03%	C _m , Aq	ID	ID	ID
Tetraodontidae	<i>Sphoeroides nephelus</i>	384	30.94%	73,258.6	30.55%	LFIS	-10.41	0.624	16.69
Total		1241		237,934.3					

*Sub-family: Epinephelinae, C_o= Commercial, C_m= Minor Commercial, Rec=Recreational, Aq=Aquarium, Aqc= Aquaculture, LFIS=Livelihood fishery, Ba=bait, Inc= Incidental, ID= Insufficient Data,

Table 2: Length-weight relationship of 12 species of fish caught by recreational fishing (hook and line) in the coastal area off Chuburna Puerto, Yucatan, Mexico. The coefficient of determination (r^2) that measures the fit of the data to the regression model and the calculated statistic (\hat{t}) of the Student's t test is shown to accept that $b=3$ (isometric growth) or $b \neq 3$ (allometric growth*)

Species	N	Standard Length (SL in cm)		Total Weight (TW in g)		Parameters of the LWR Regression		Confidence Limits		r^2	\hat{t}
		Min	Max	Min	Max	a	b	95% CL of a	95% CL of b		
<i>Balistescaprisicus</i> *	24	19.0	27.5	294.6	730.0	0.2985	2.3522	0.0976-0.9123	2.00-2.71	0.891	3.781
<i>Calamuscampechanus</i>	15	9.8	17.0	37.2	198.8	0.0476	2.9035	0.0152-0.1492	2.48-3.33	0.943	0.473
<i>Calamusproridens</i>	20	12.9	18.5	63.0	202.0	0.0333	3.0086	0.0120-0.0860	2.67-3.51	0.950	0.053
<i>Caranxcrisos</i>	31	17.0	28.2	121.4	518.2	0.0398	2.7988	0.0166-0.0955	2.51-3.09	0.917	1.409
<i>Diplectrum formosum</i> *	37	7.50	15.0	10.1	76.9	0.0343	2.8333	0.0234-0.0505	2.67-2.99	0.967	2.122
<i>Echeneisneucratoides</i>	11	23.2	38.5	59.5	302.2	0.0027	3.1982	0.0006-0.0115	2.78-3.62	0.970	1.073
<i>Epinephelus morio</i>	43	15.5	29.1	115.9	753	0.0219	3.0580	0.0127-0.0379	2.88-3.23	0.967	0.665
<i>Haemulon plumieri</i> *	544	9.5	26.5	31.5	426.0	0.0978	2.5626	0.0809-0.1183	2.50-2.63	0.917	13.22
<i>H. aurolineatum</i> *	42	10.2	14.4	32.6	75.3	0.0729	2.6032	0.0401-0.1324	2.37-2.84	0.927	2.691
<i>Lutjanus synagris</i> *	32	13.3	27.0	72.1	447.8	0.0811	2.6358	0.0439-0.1496	2.43-2.85	0.956	3.450
<i>Ocyurus chrysurus</i> *	24	13.2	25.0	60.2	294.8	0.0783	2.5575	0.0311-0.1975	2.23-3.88	0.920	2.828
<i>Opsanus beta</i> *	9	13.2	36	58.5	816.4	0.0724	2.5889	0.0348-0.1507	2.37-2.81	0.991	4.356
<i>Sphoeroides nephelus</i> *	384	11.5	25.3	52.0	530.0	0.0698	2.7505	0.0592-0.0824	2.69-2.81	0.959	8.401

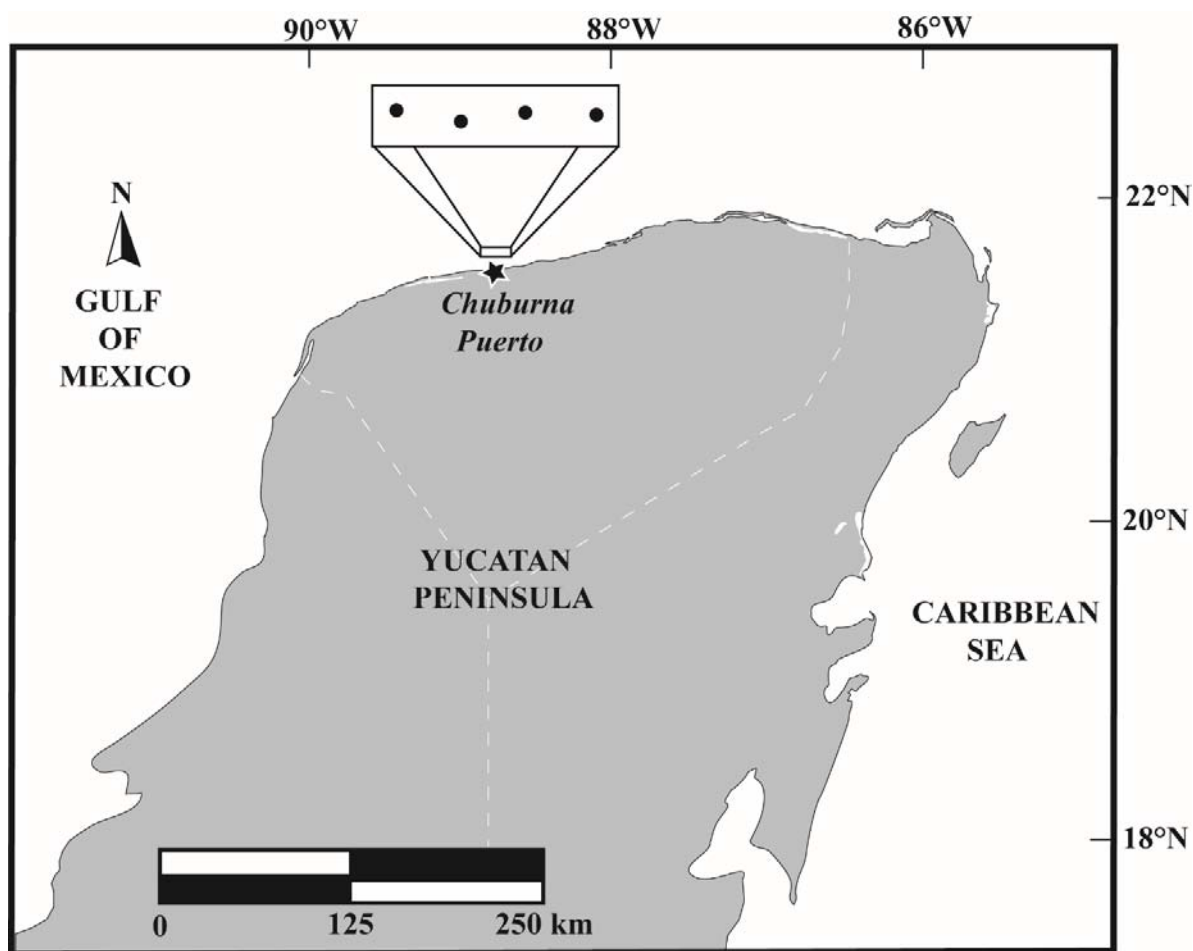


Figure 1: Location of the study area and the fishing sites along the coast off Chuburna Puerto, Yucatan, Mexico.

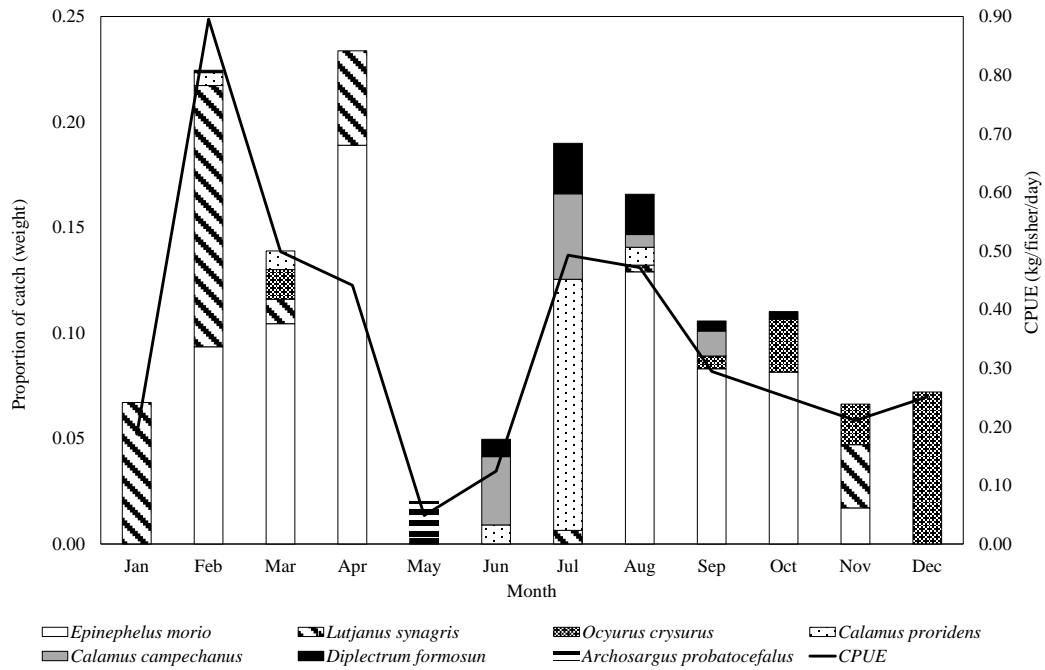


Figure 2: Monthly proportion of the catch and CPUE in weight of the species with commercial interest (C_o) obtained by the recreational fishing during an annual cycle in the coast of the Chuburna Puerto, Yucatan, Mexico.

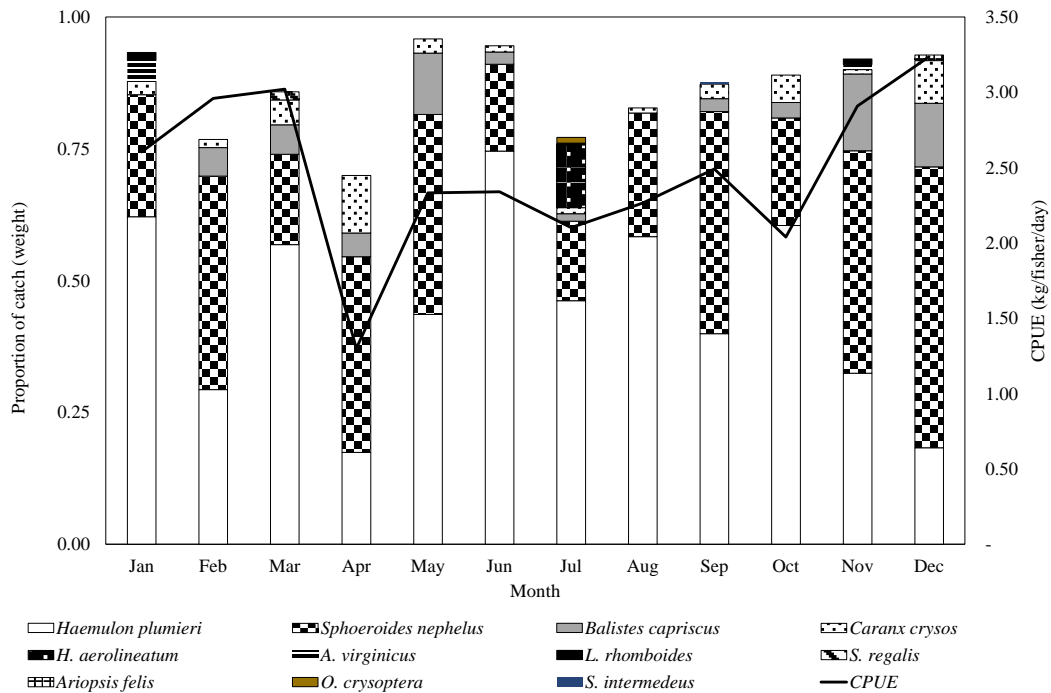


Figure 3: Monthly proportion of the catch and CPUE in weight of species with minor commercial interest (C_m) and livelihood fishery (LFIS) obtained by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan, Mexico

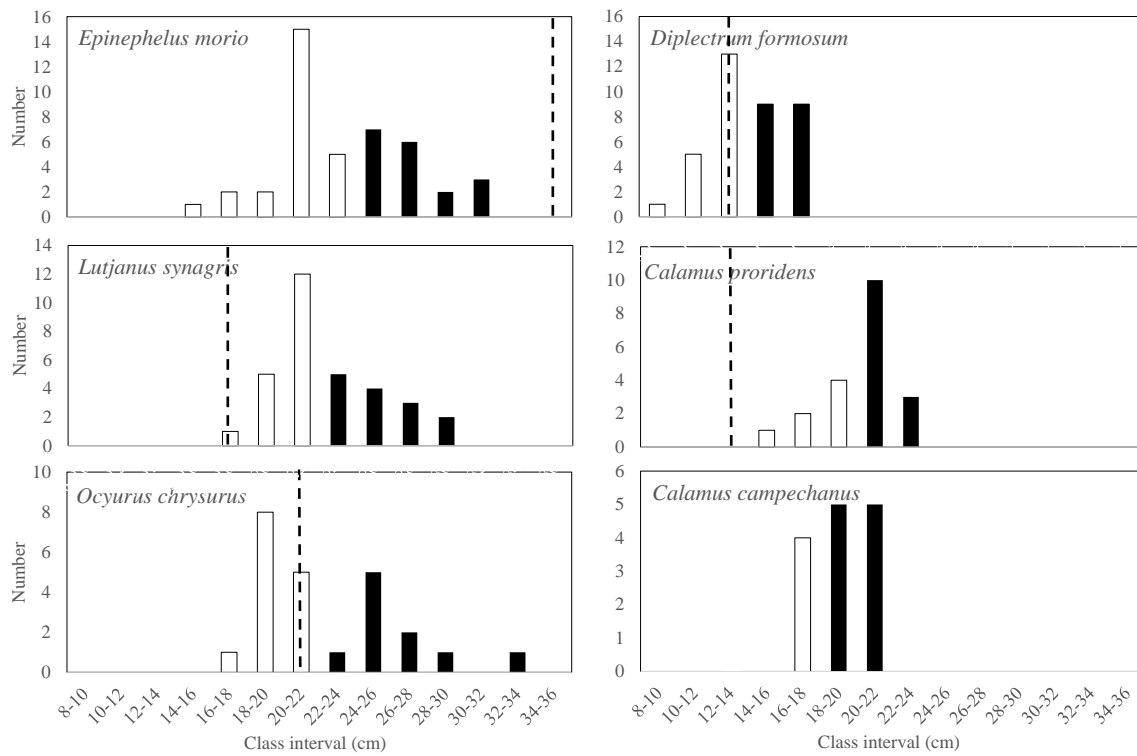


Figure 4: Size-frequency distribution in standard length (SL) of species of commercial interest (C_c) captured by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan, Mexico. The dotted vertical line indicates the size of first sexual maturity according to bibliographic references. The blank classes include the size at first capture (L_{50}).

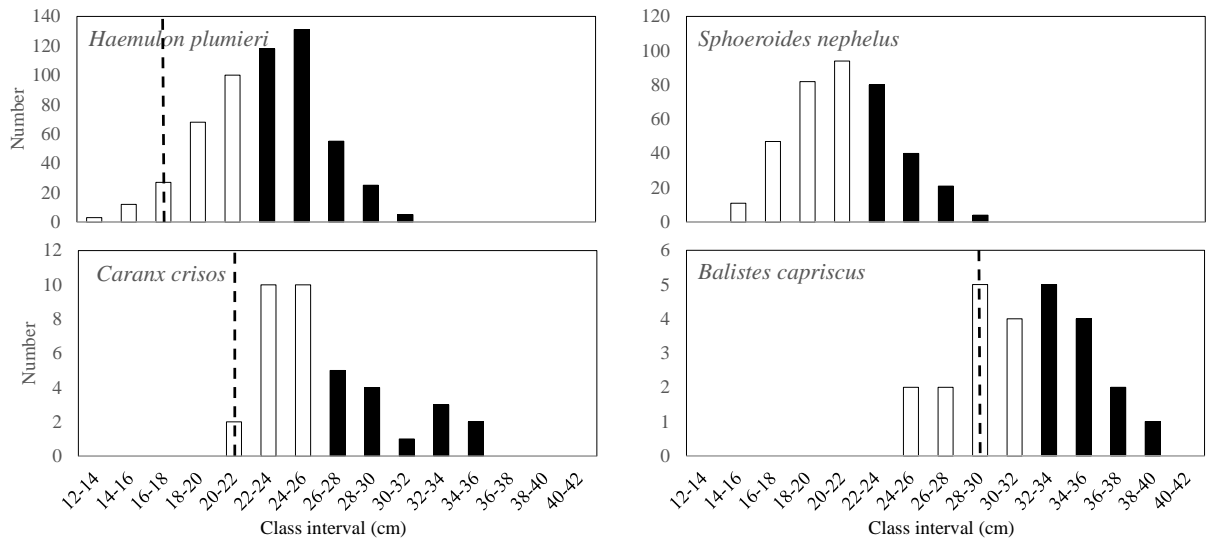


Figure 5: Size-frequency distribution in standard length (SL) of species of minor commercial interest (C_m) captured by the recreational fishing during an annual cycle in the coast of Chuburna Puerto, Yucatan, Mexico. The dotted vertical line indicates the size of first sexual maturity according to bibliographic references. The blank classes include the size at first capture (L_{50}).



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Wind-Wave Relation during Hurricane Wilma and its Applications for Marine Science and Engineering

By S. A. Hsu

Louisiana State University

Abstract- Analysis of datasets available from the literature indicates that, during tropical cyclones at sea, the barometric pressure is approximately negatively linearly related to the wind speed as well as to the wave height. During Hurricane Wilma in 2005, simultaneous meteorological-oceanographic (met-ocean) measurements were made by the National Data Buoy Center (NDBC) at the Data Buoy Station 42056 in the northwestern Caribbean Sea. Further analysis of these datasets showed that, when $U_{10} \geq 9$ m s⁻¹ during wind seas (when $H_s/L_p \geq 0.020$), $H_s = 0.43 U_{10} - 2$. Here, parameter H_s is the significant wave height (in meters), U_{10} is the wind speed (in m s⁻¹) at 10 m, $L_p (= 1.56 T_p^2)$ is the dominant wave length (in meters), and T_p is the peak wave period (in seconds). Applications of this proposed formula were successful during Hurricane Jose in 2017, Typhoon Russ in 1990 by NDBC Buoy 52009 near Guam, Typhoon Krosa in 2007 by a data buoy near Taiwan, and Typhoon Soudelor in 2015 by Jason -2 altimeter satellite. Also, its applications to rapid estimations of peak wave period, sea-surface currents and storm surge potentials were presented.

Keywords: *air-sea interaction, wind-wave relation, hurricane wilma, typhoon, storm surge, wind-induced drift currents.*

GJSFR-I Classification: FOR Code: 040305



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Abstract- Analysis of datasets available from the literature indicates that, during tropical cyclones at sea, the barometric pressure is approximately negatively linearly related to the wind speed as well as to the wave height. During Hurricane Wilma in 2005, simultaneous meteorological-oceanographic (met-ocean) measurements were made by the National Data Buoy Center (NDBC) at the Data Buoy Station 42056 in the northwestern Caribbean Sea. Further analysis of these datasets showed that, when $U_{10} \geq 9 \text{ m s}^{-1}$ during wind seas (when $H_s/L_p \geq 0.020$), $H_s = 0.43 U_{10} - 2$. Here, parameter H_s is the significant wave height (in meters), U_{10} is the wind speed (in m s^{-1}) at 10 m, $L_p (= 1.56 T_p^2)$ is the dominant wave length (in meters), and T_p is the peak wave period (in seconds). Applications of this proposed formula were successful during Hurricane Jose in 2017, Typhoon Russ in 1990 by NDBC Buoy 52009 near Guam, Typhoon Krosa in 2007 by a data buoy near Taiwan, and Typhoon Soudelor in 2015 by Jason -2 altimeter satellite. Also, its applications to rapid estimations of peak wave period, sea-surface currents and storm surge potentials were presented.

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1. INTRODUCTION

This research article is motivated by Fig. 1 as presented in Bancroft (2016 available online at <http://www.vos.noaa.gov/MWL/201604/northpacific.shtml#contents>), who states that, in August 2015 "Super-Typhoon Soudelor was a strengthening typhoon while tracking northwest and crossing near 16N 144E at 0000 UTC August 3rd with sustained winds of 115 knots (or 59 m s^{-1}). It became a super-typhoon 12 hours later and after another six hours reached maximum intensity with sustained winds of 155 knots (80 m s^{-1}). At 1200 UTC on the 4th Soudelor was a super typhoon near 19N 137E with sustained winds 140 knots (72 m s^{-1}). Fig.1 is an infrared satellite view of Soudelor, and it is just a coincidence that we have a Jason-2 altimeter pass through the eye wall of Soudelor. Note the highest significant wave height of 90.55 feet (or 27.6 m) in the northwest eye wall. This is the highest satellite detected wave height that is known of by the author. Later on the 4th Soudelor passed west of the area with a weakening trend".

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The purpose of this investigation is to validate whether these measurements are reasonable. If they are verified, then, measurements of ocean waves routinely available by satellites may be applied to air-sea interaction studies, particularly to the relation between wind and waves, see, e.g. Csanady (2001), Drennan et al. (2005), Holthuijsen et al. (2012), and Bryant and Akbar (2016).

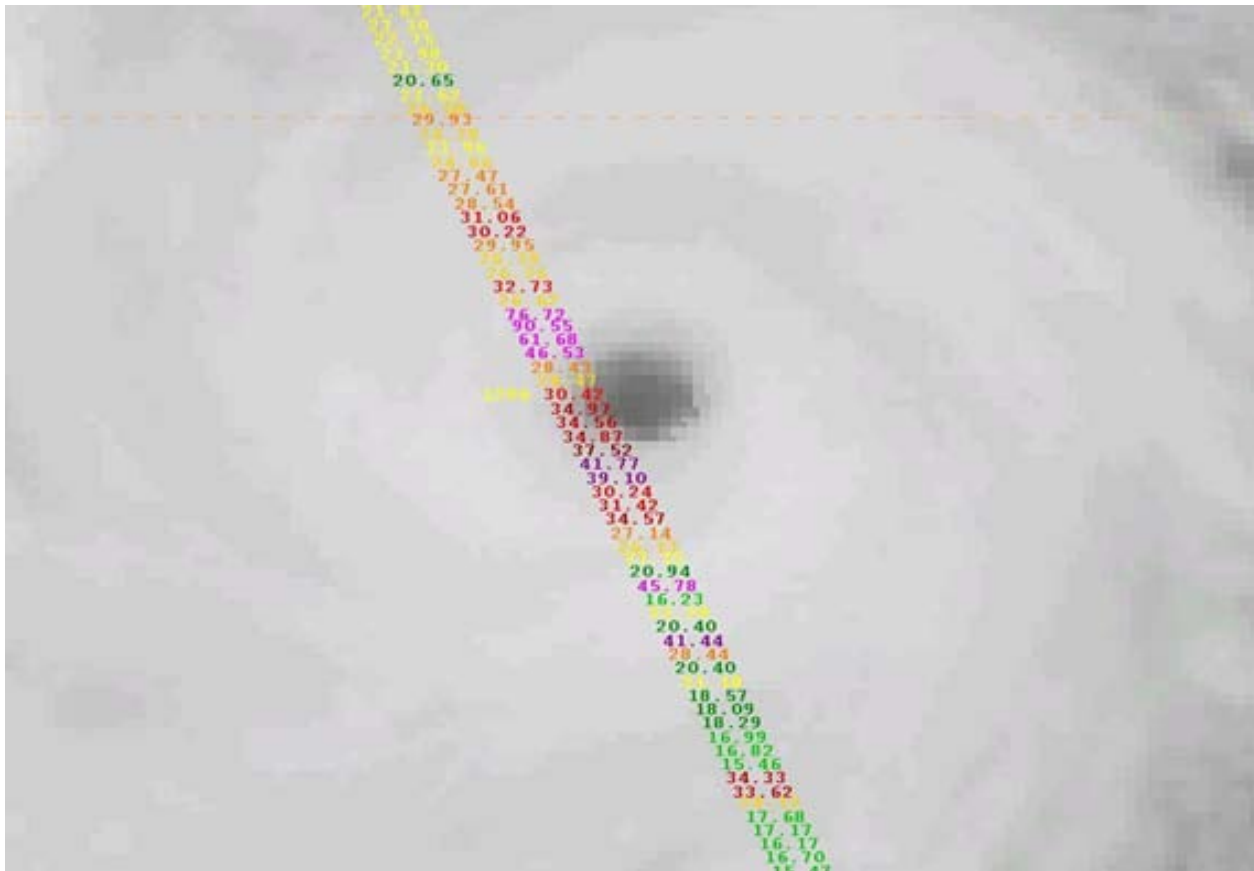


Fig. 1: A zoomed-in infrared satellite Image of Super-Typhoon Soudelor valid 1232 UTC August 4, 2015. A Jason -2 altimeter pass appears as a swath of significant wave heights given in feet to two decimal places cutting across the central core of Soudelor (for more detail, see Bancroft, 2016 at <http://www.vos.noaa.gov/MWL/201604/northpacific.shtml#contents>)

II. WIND-WAVE RELATION DURING WIND SEAS

Analytical formulas for the wind-wave relation are available in the literature. Examples are presented in Hsu et al. (2017a), who also provided following equation when the sea surface is aerodynamically rough (Hsu et al. 2017b) under the conditions of $U_{10} \geq 9 \text{ m s}^{-1}$ and $H_s/L_p \geq 0.020$, such that

$$U_{10} = 35H_s/T_p, \tag{1}$$

Here, parameter H_s is the significant wave height (in meters), U_{10} is the wind speed (in m s^{-1}) at 10 m, $L_p (= 1.56 T_p^2)$ is the dominant wave length (in meters), and T_p is the peak wave period (in seconds).

By simultaneous measurements of U_{10} , H_s and T_p at the National Data Buoy Center (NDBC) Station 42003 during Hurricane Ivan in 2004 and Katrina in 2005 and at 42056 during Wilma, Eq. (1) is further verified as shown in Fig. 2. For tracks and datasets of these three hurricanes, all located on the right side of the storm track, see www.nhc.noaa.gov and www.ndbc.noaa.gov, respectively. However, because T_p is not available from Fig. 1, one needs to correlate U_{10} and H_s directly rather

than using Eq. (1). This was accomplished in the next Section.

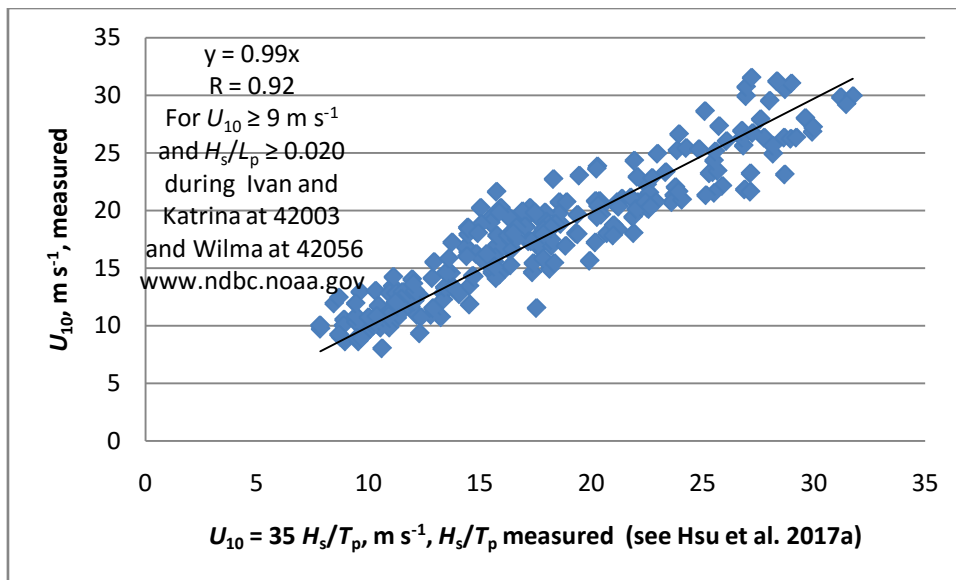


Fig. 2: Validation of Eq. (1) during Hurricanes Ivan, Katrina, and Wilma

III. RELATION BETWEEN BAROMETRIC PRESSURE AND MET-OCEAN PARAMETERS

Because the most important meteorological-oceanographic (met-ocean) parameter during a storm at sea is the barometric pressure, we first relate it to the wind speed and wave height. To validate Fig. 1, all similar circle-eye tropical cyclone datasets including barometric pressure (p_c) and the wind speed (V_{max}) available in Li et al. (2013) were incorporated in Fig. 3. It is found that they are negatively linearly related to a correlation coefficient $R = 0.89$. By Abel et al. (1989),

the wave height may also be related negatively linearly to the barometric pressure as shown in Fig. 4. Therefore, it was postulated that the wind speed and wave height are positively linearly related so that

$$H_s = aU_{10} - b, \tag{2a}$$

Here, coefficients “a” and “b” are the slope and the intercept of this proposed linear relation between H_s and U_{10} , respectively. Note that these coefficients may vary with different storms and needed to be determined from field measurements.

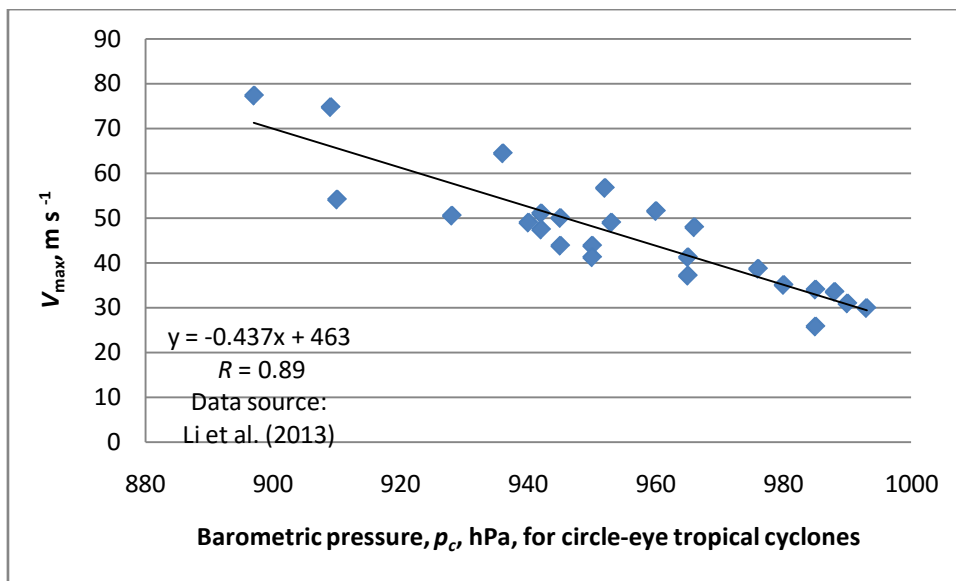


Fig. 3: Relation between barometric pressure and the maximum wind speed during circle-eye tropical cyclones

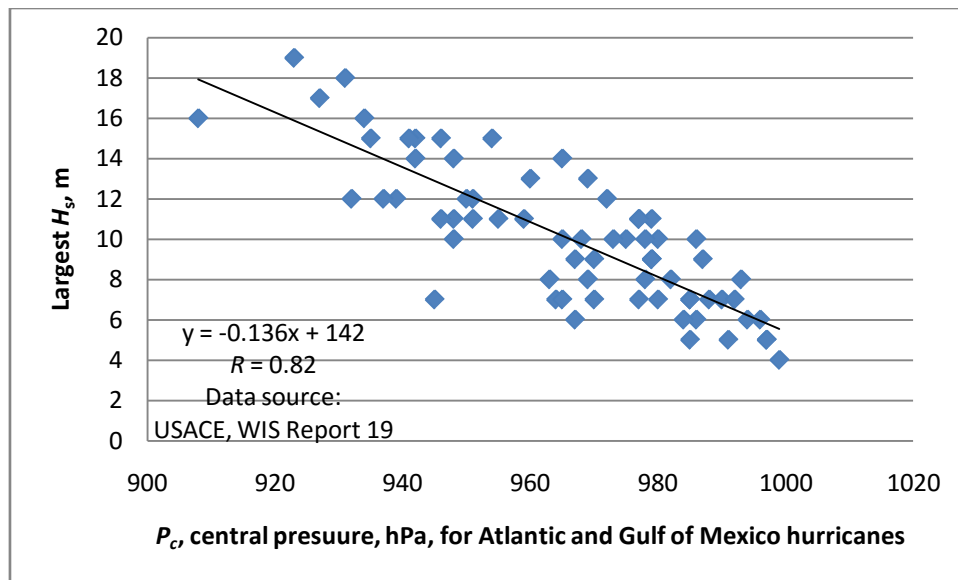


Fig. 4: Relation between barometric pressure and largest wave height during hurricanes

IV. WIND-WAVE RELATION DURING WILMA

To verify Eq. (1), pertinent data from Hurricane Wilma (see Figs. 5 thru 7) are employed. The buoy used was 42056, which was located on the right side of the storm's track as shown in Fig. 6 in the northwestern Caribbean Sea. Similar to Figs. 3 and 4, the negatively linearly relation between U_{10} and barometric pressure as well as between H_s and barometric pressure was presented in Figs. 8 and 9, respectively. According to Hasse and Weber (1985), overwater stability categories may be estimated using a graphic approach from the measurements of wind speed and air and sea temperature difference. On the basis of Fig. 10, stability "D" prevailed during the entire period (as used in this study) from 14UTC on 19 thru 23UTC on 23, 2005 at Buoy 42056, indicating that the stability is near-neutral so that the logarithmic wind profile law is valid (see, e.g., Hsu2003; Vickery et al.2009). Our results to verify Eq. (1) is presented in Fig.10that

$$H_s = 0.43U_{10} - 2, \quad (2b)$$

Since the correlation coefficient $R = 0.91$, Eq. (2b) is useful.

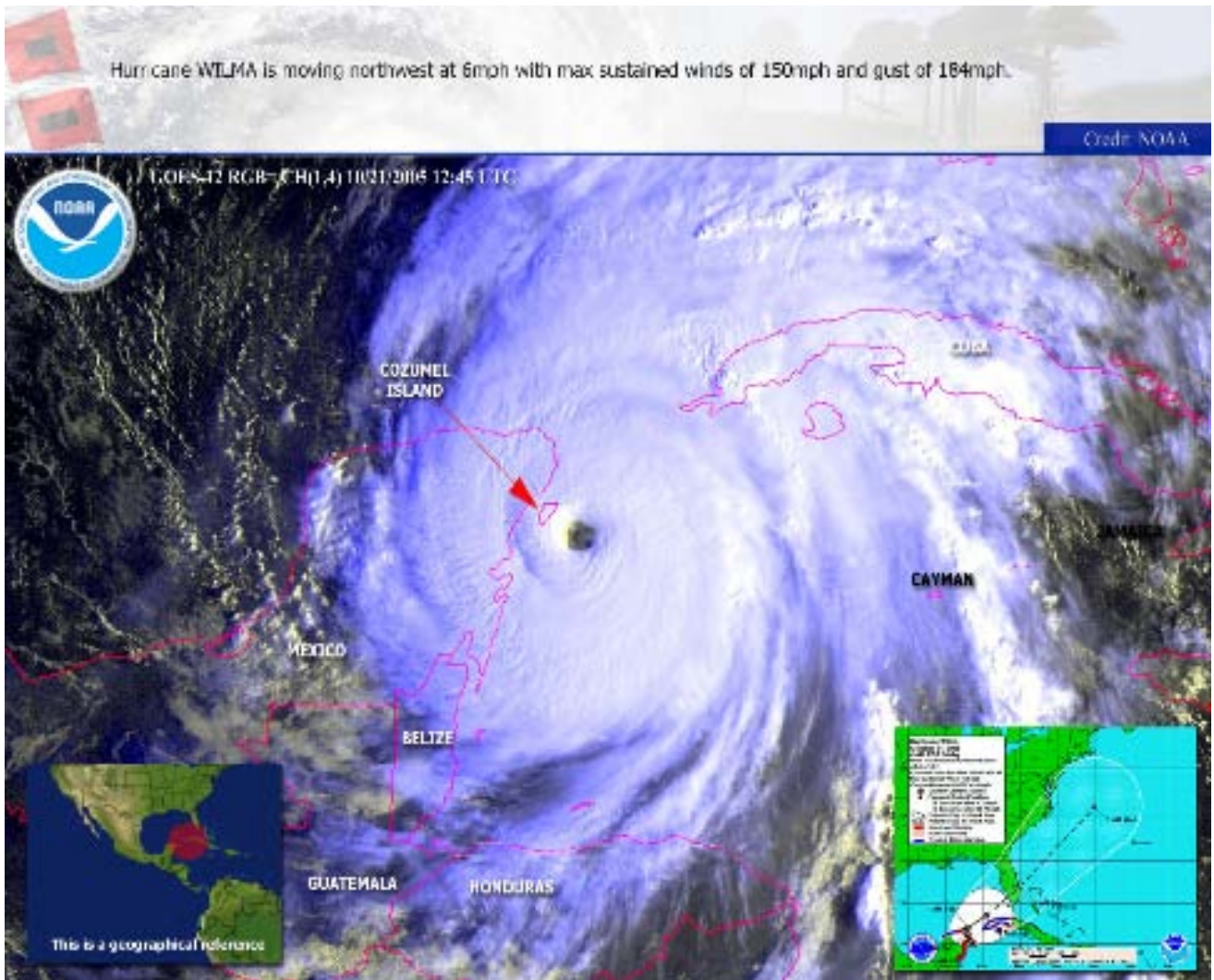


Fig. 5: Satellite view of Hurricane Wilma over the northwestern Caribbean Sea

NDBC Stations within 300 NM of Hurricane Wilma's Track 15 - 25 October 2005

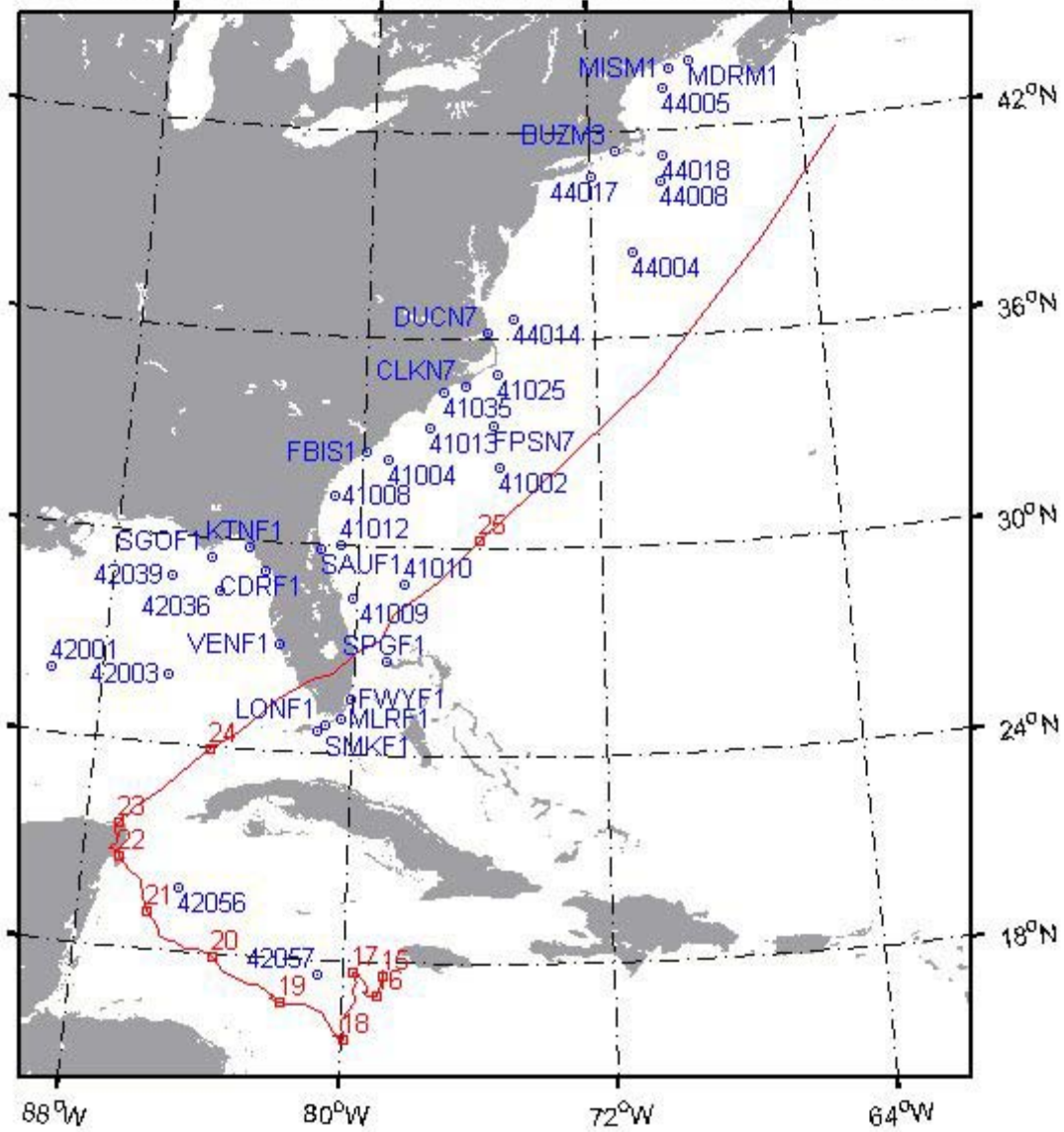


Fig. 6: Wilma's track (in red) and the location of Buoy 42056 in the northwestern Caribbean Sea (see <http://www.ndbc.noaa.gov/hurricanes/2005/wilma/>).

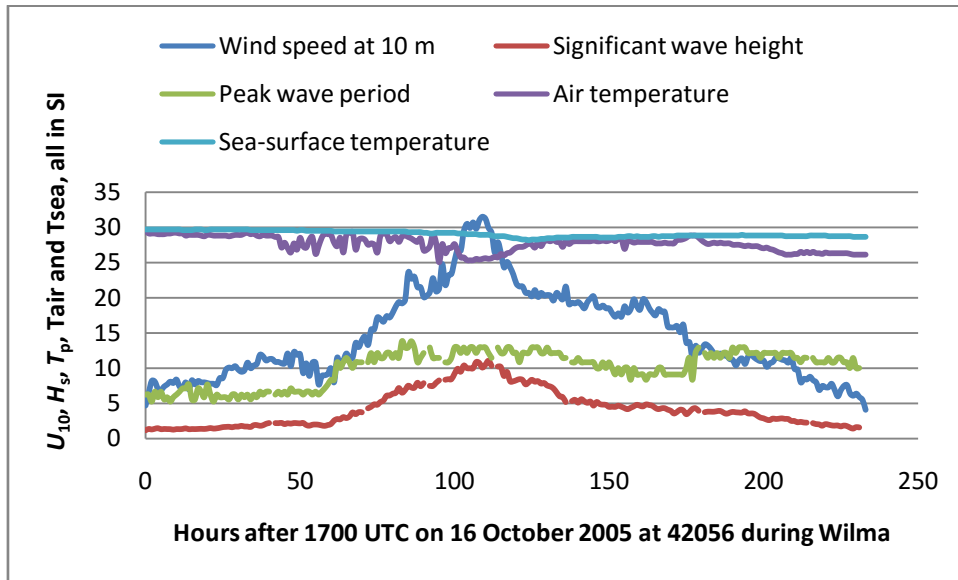


Fig. 7: Met-ocean measurements at NDBC Buoy 42056 during Hurricane Wilma

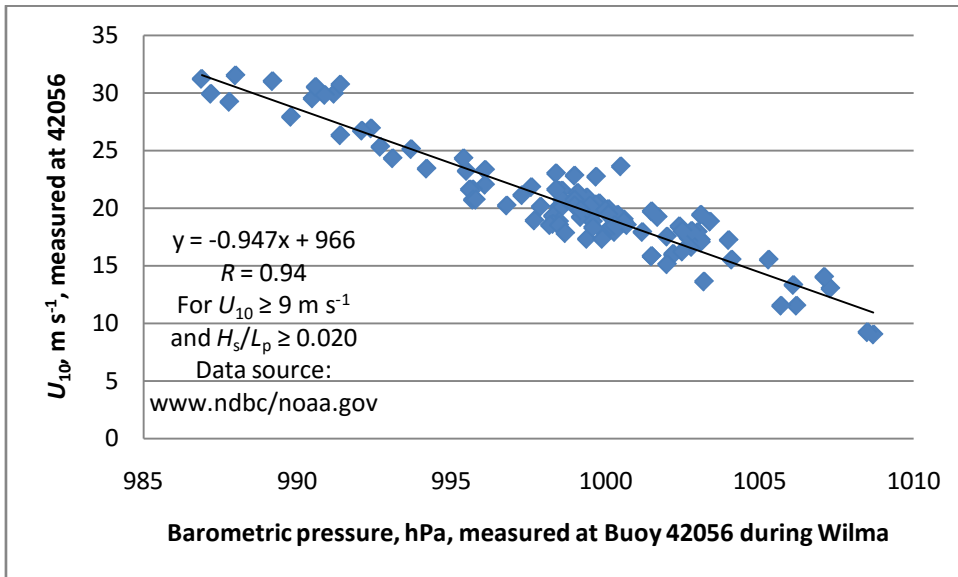


Fig. 8: Relation between wind speed and barometric pressure at 42056 during the period shown in Fig. 6



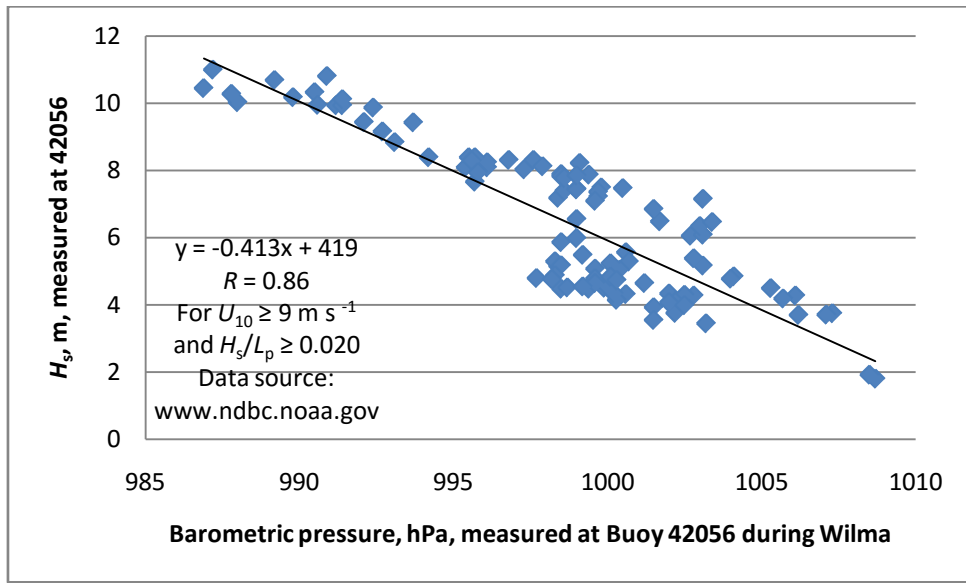


Fig. 9: Relation between H_s and barometric pressure at 42056 during the period shown in Fig. 6

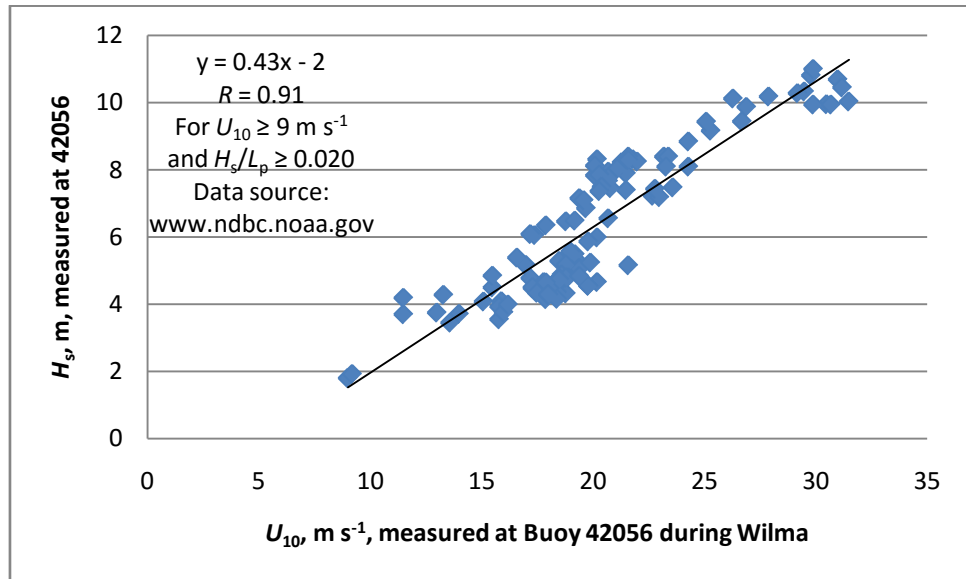


Fig. 10: Relation between H_s and U_{10} as measured at 42056 during Wilma

V. APPLICATIONS

a) Wind-wave relation during Hurricane Jose in 2017

In September 2017 Hurricane Jose, a Category 4 hurricane, passed near the data buoy 41043, located approximately 170 n.m. NNE of San Juan, Puerto Rico. Simultaneous measurements of U_4 , H_s and T_p , were available (for the track and buoy measurements, see www.nhc.noaa.gov and www.ndbc.noaa.gov, respectively). Using the method presented in Hsu et al. (2017a), Eq. (2b) is verified in Fig. 11.

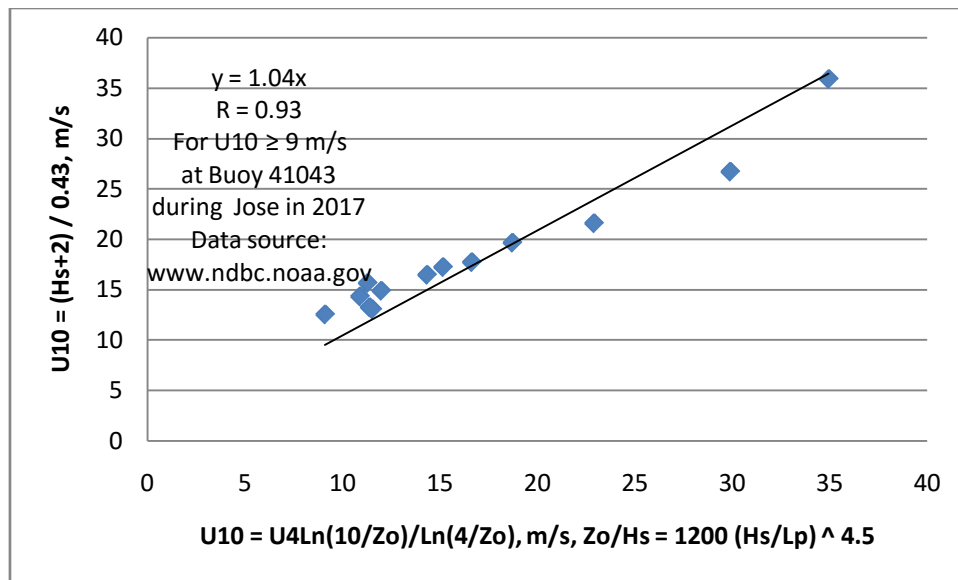


Fig. 11: Verification of Eq. (2b) at Buoy 41043 during Hurricane Jose in 2017

b) Wind-wave relation during Typhoon Russ in 1990

According to the Joint Typhoon Warning Center (<http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/atcr/1990atcr.pdf>), Typhoon Russ, the last western Pacific tropical cyclone of 1990, was the most severe to strike Guam in 14 years. Russ formed in the Marshall Islands, tracked west-northwestward and intensified to near super typhoon intensity as it approached Guam. The typhoon passed within 55 km of the southern tip of Guam and brought typhoon force winds which caused extensive damage, especially to the southern portion of the island. After leaving Guam, Russ slowly weakened, recurved and became an extratropical cyclone.

During Typhoon Russ, the National Data Buoy Center (NDBC) (see www.ndbc.noaa.gov) operated a data buoy (Station 52009) near Gaum. Before it was destroyed by Russ, met-ocean conditions were presented in Fig. 12. Using a graphic determination of overwater stability as constructed by Hasse and Weber (1985) based on the wind speed measurement at 5m, U_5 , and the difference in the air (T_{air}) and sea-surface (T_{sea}) temperatures, the stability during the period as shown was near neutral.

To reduce the effect of swell, the criterion suggested by Drennan et al. (2005) was adopted that a wind sea is defined when

$$H_s/L_p \geq 0.020, \tag{3}$$

$$L_p = (g/2\pi)T_p^2 = 1.56T_p^2, \tag{4}$$

Here, L_p is the dominant wave length, g is the gravitational acceleration, and T_p is the peak or dominant wave period. Note that the parameter H_s/L_p is called wave steepness.

According to the National Data Buoy Center (see http://www.ndbc.noaa.gov/station_page.php?

station=52009), Buoy 52009 located near Gaum was capsized during Russ. However, before its capsizing, that buoy provided some wind and wave measurements (see Fig.12) that can be employed to validate Eq. (2b). Because the wind speeds were recorded at 5m instead of 10m, one needs to adjust U_5 to U_{10} using the power-law wind profile (see, e.g., Panofsky and Dutton, 1984) and Hsu (2003) that

$$U_{10} / U_5 = (10/5)^p, \tag{5}$$

Here $p = (U_{gust}/U_5 - 1)/2$ and U_{gust} is the wind gust measured at the buoy (see, Hsu, 2003). Fig.13 shows the result that

$$U_{10} = 1.1 U_5, \tag{6}$$

Figs. 14 and 15 show that, similar to Figs.8 and 9, Eq. (1) should exist. Fig. 16 is a validation of Eq. (2b). Since the slope is unity and $R = 0.96$, Eq. (2b) can be applied to typhoon conditions.

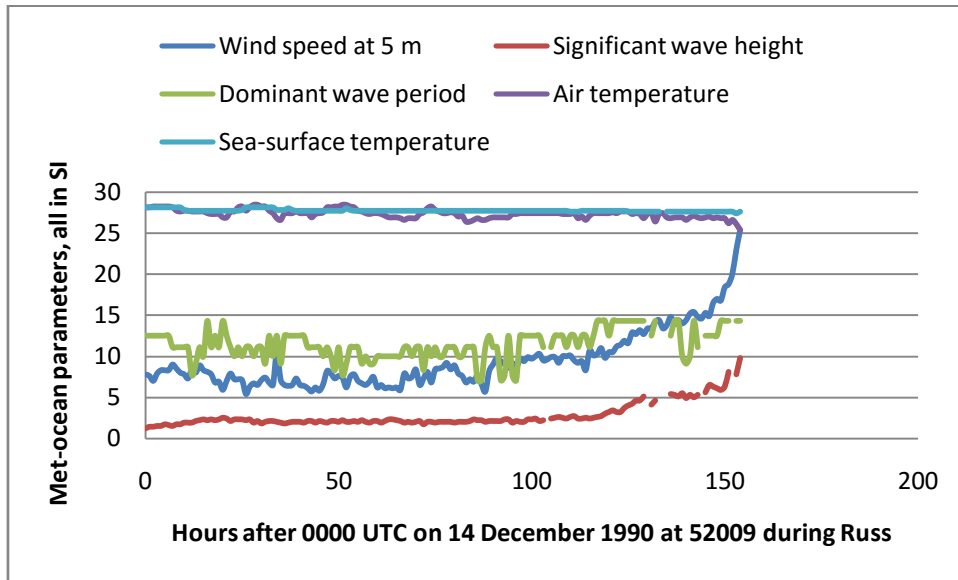


Fig. 12: Met-ocean conditions at NDBC Buoy 52009 before its capsizing by Typhoon Russ (Data source: www.ndbc.noaa.gov)

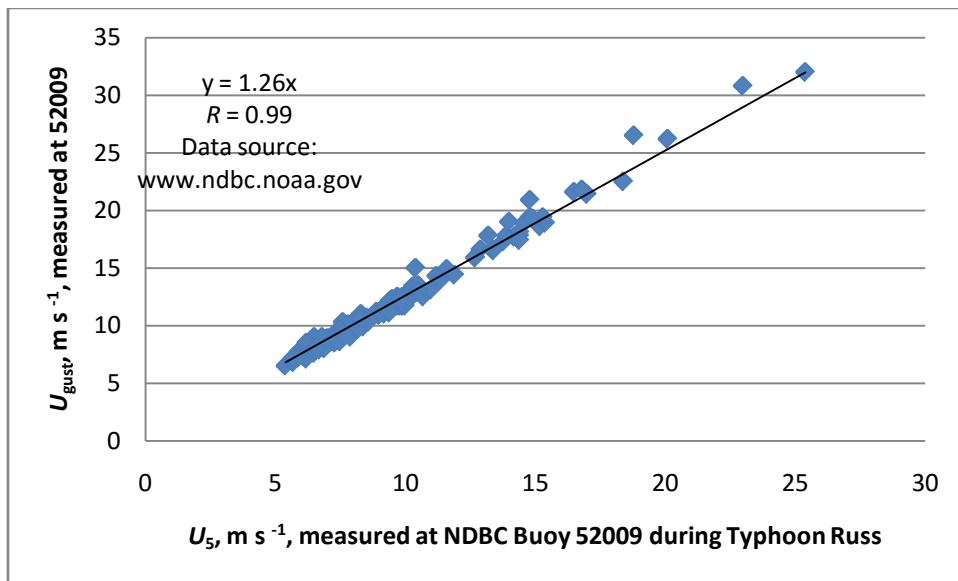


Fig. 13: The relation between the wind speed at 5 m, U_5 , and wind gust, U_{gust} , at 52009 during Russ

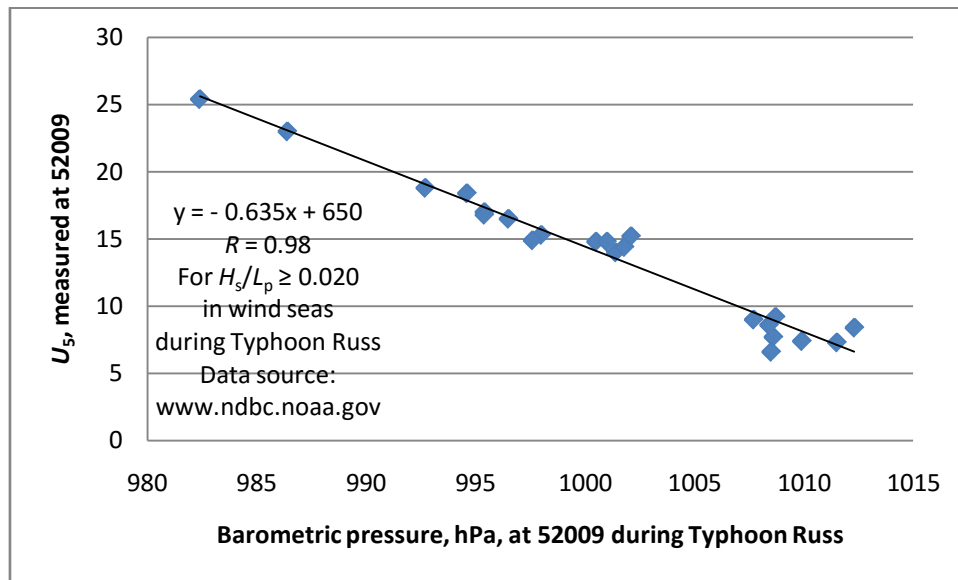


Fig. 14: Relation between U_s and barometric pressure at NDBC Buoy 52009 during Russ

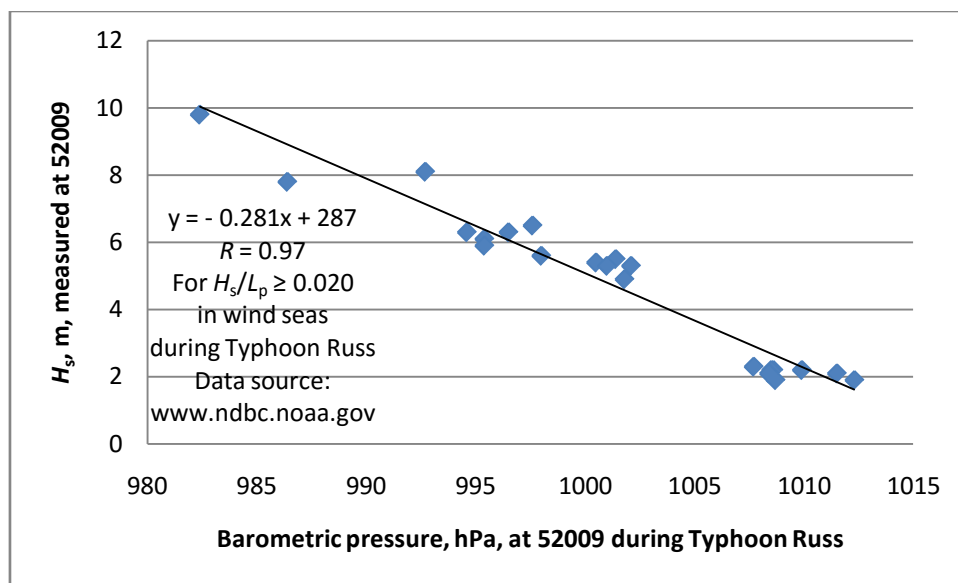


Fig. 15: The relation between H_s and barometric pressure at NDBC Buoy 52009 during Russ

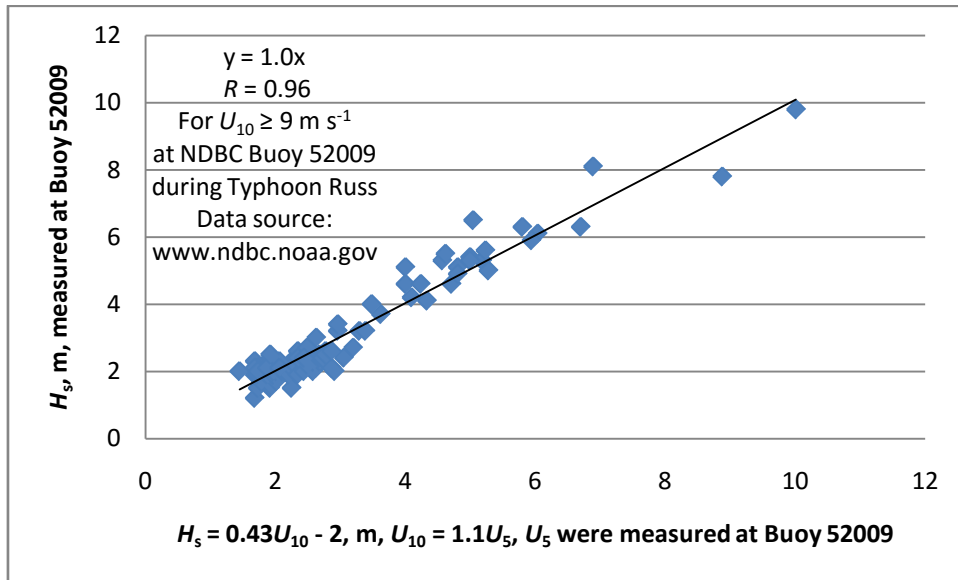


Fig.16: The relation between H_s and U_{10} at NDBC Buoy 52009 during Russ

c) Typhoon Krosa in 2007

According to Liu et al. (2008), an extreme $H_s = 23.9 \text{ m}$ was measured by a data buoy near Taiwan. The best track of Typhoon Krosa in 2007 is provided in Fig. 17 (see Joint Typhoon Warning Center available online at <http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/atcr/2007atcr.pdf>). Because the wind speed was 125

knots and 115 knots at 00 and 12 UTC on 6th, respectively, we use the average near-surface wind speed (a surrogate of U_{10}) of 120 knots (62 m s^{-1}). Now, substituting the U_{10} value into Eq. (6), $H_s = 23.8 \text{ m}$, which is in excellent agreement with that of 23.9 m as measured.

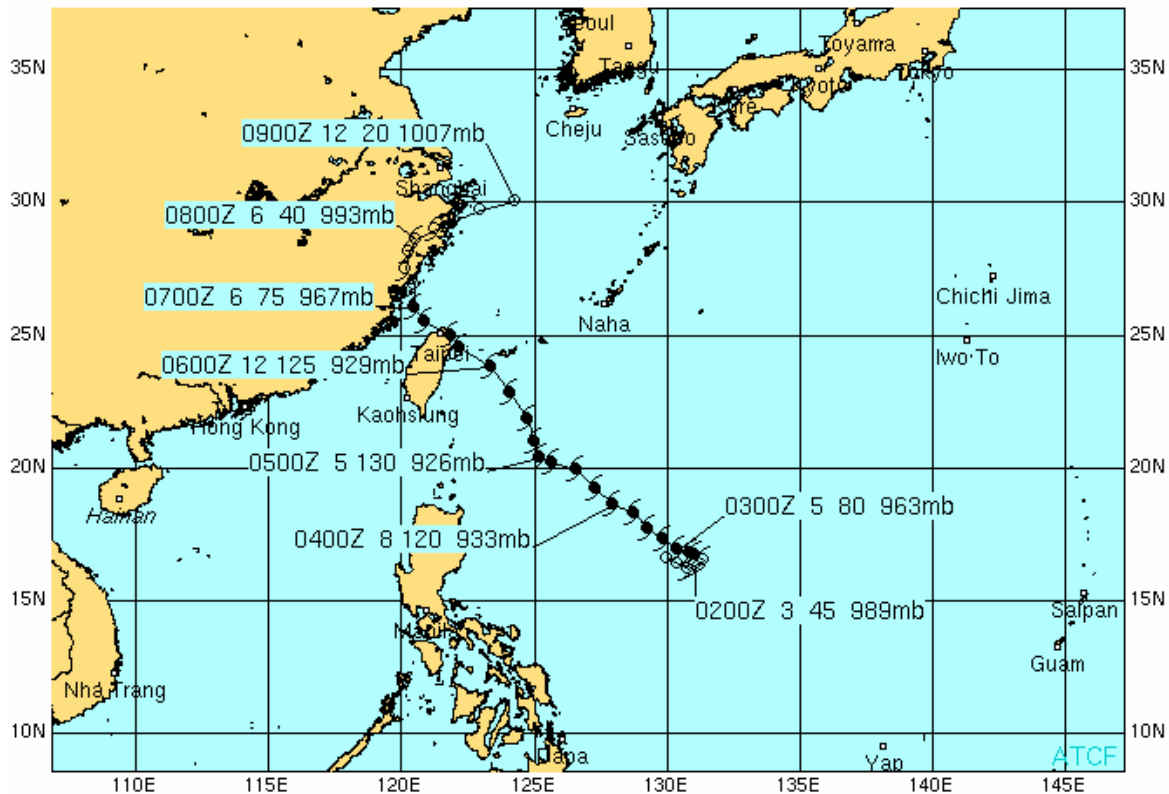


Fig. 17: Track of Typhoon Krosa in October 2007 (<http://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/atcr/2007atcr.pdf>).

d) Typhoon Soudelor in 2015

From Fig. 1, $U_{10} = 72 \text{ m s}^{-1}$. Substituting this value into Eq. (2b), $H_s = 29.0 \text{ m}$, which is also in reasonable agreement with that of 27.6 m as measured by the altimeter on Jason-2 satellite as discussed in the Introduction.

e) Relation between U_* and H_s

According to Andreas et al. (2012), overwater friction velocity (U_*) is linearly related to U_{10} such that For $U_{10} \geq 9 \text{ m s}^{-1}$,

$$U_* = 0.0583 U_{10} - 0.243,$$

According to Edson et al. (2013, Eq. 22),

$$U_* = 0.062 U_{10} - 0.28,$$

And under hurricane conditions, Hsu et al. (2017b) suggest that,

$$U_* = 0.062 U_{10} - 0.29,$$

By of simultaneous measurements of U_* , U_{10} and H_s by Geernaert et al. (1987), linear relations amongst all three met-ocean parameters (see Figs. 18 thru 20) are

For $U_{10} \geq 9 \text{ m s}^{-1}$,

$$U_* = 0.062 U_{10} - 0.26, \tag{7}$$

$$U_* = 0.12H_s + 0.34, \tag{8}$$

$$H_s = 0.45U_{10} - 4, \tag{9}$$

It is interesting to note that Equations (2b) and (9) are in good agreement numerically, although the former is based on Hurricane Wilma in the Caribbean Sea whereas the latter was based on extra-tropical cyclones over the North Sea.

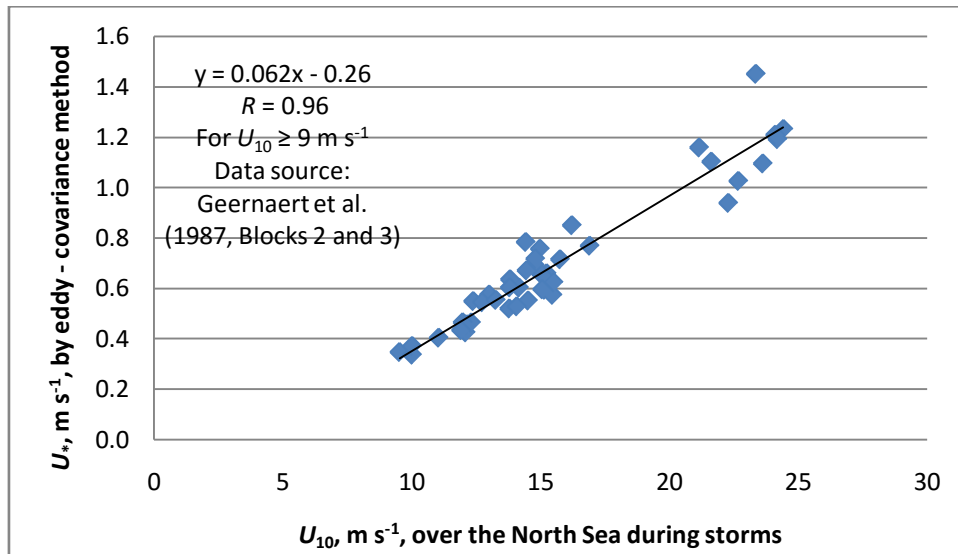


Fig. 18: Relation between U_* and U_{10} in the North Sea during storms

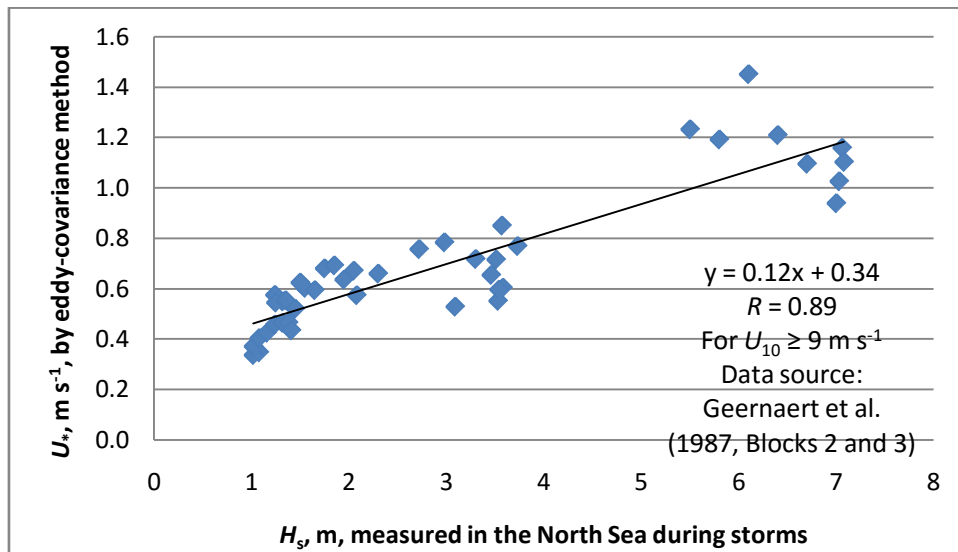


Fig. 19: Relation between U_* and H_s in the North Sea during storms

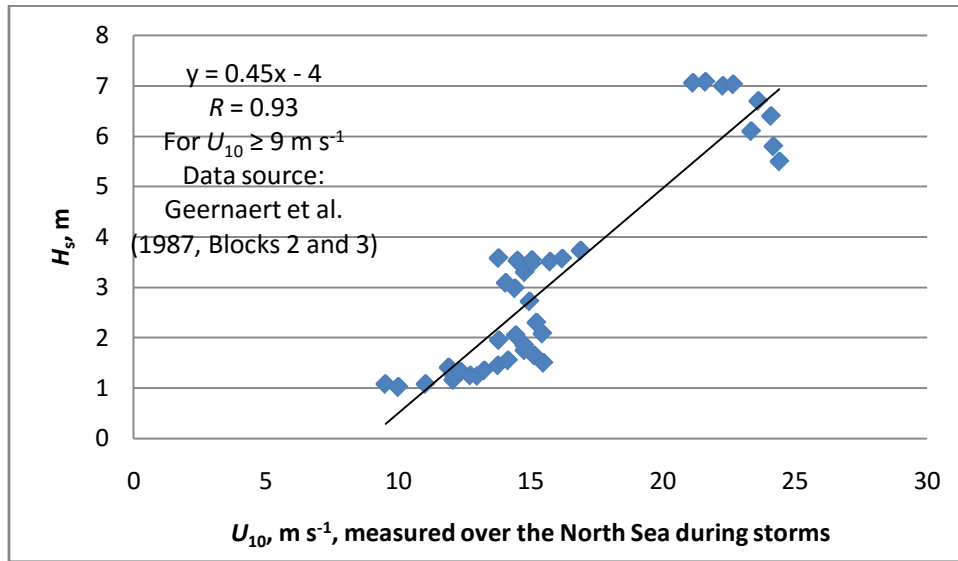


Fig. 20: Relation between H_s and U_{10} in the North Sea during storms

f) Estimating wind-driven surface currents

According to Wu (1975), the sea-surface drift velocity, U_{sea} , may be estimated from U^* that

$$U_{sea} = 0.55U_{*}, \tag{10}$$

Now, substituting Equations (7) into (10), we have

$$U_{sea} = 0.034 U_{10} - 0.14, \tag{11}$$

Similarly, substituting Equations (8) into (10), one gets

$$U_{sea} = 0.066H_s + 0.19, \tag{12}$$

An evaluation of Eq. (11) is presented in Fig.21, indicating that Eq. (11) may be useful to estimate the wind-induced surface velocity. Note that the estimates of sea-surface drift velocity using Eq. (11) are in reasonable agreement with those when a typhoon's forward moving speed is slow moving ($< 4 \text{ m s}^{-1}$). For more details about drifter measurements, see Chang et al. (2014).

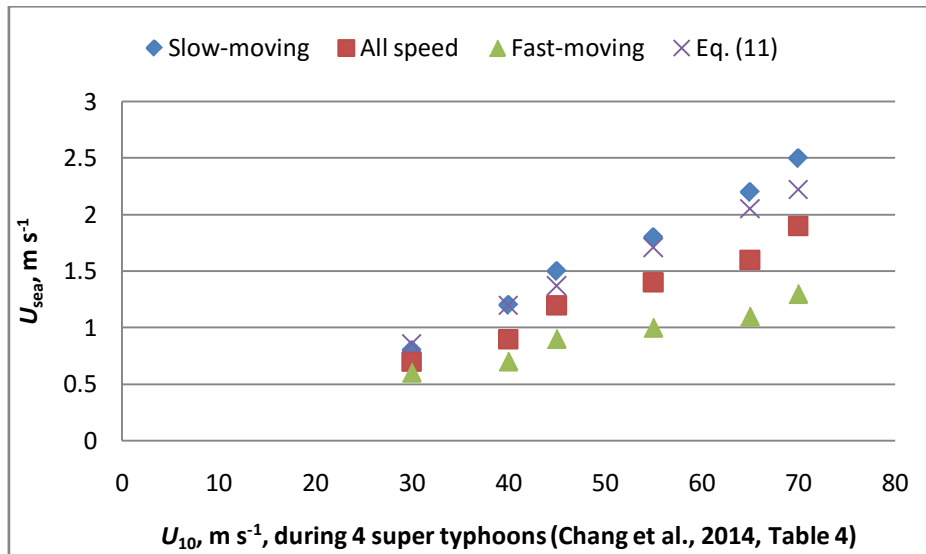


Fig. 21: An evaluation of Eq. (11) during typhoons (Data source: Chang et al., 2014)

g) Rapid estimation of storm surge potential

According to Hsu (2013), the storm surge, S , in meters, may be estimated rapidly using following formula that,

$$S = KV^2, \tag{13}$$

Here K is a proportional constant for a given location (e.g., $K = 0.0051$ for the New York region) and V is the wind speed in m s^{-1} .

During Hurricane Katrina in 2005 (see Knabb et al., 2005 or http://www.nhc.noaa.gov/data/tcr/AL122005_Katrina.pdf, pages 10 and 28), an extreme

storm surge value of 27.8 feet or approximate 8.5 m was observed at Pass Christian, Mississippi. In the deep-water region south of this max storm surge, an extreme significant wave height of 55 feet or approximately 17m was measured by NDBC Buoy 42040 (see <http://www.ndbc.noaa.gov/hurricanes/2005/katrina/>). Substituting the max H_s value into Eq. (2), $U_{10} = 44 \text{ ms}^{-1}$, respectively. Now, substituting both values of $S = 8.5 \text{ m}$ and $U_{10} = 44 \text{ m s}^{-1}$ into Eq. (13), we get $K = 0.0044$ so that Eq. (12) becomes

$$S = 0.0044V^2. \quad (14)$$

Eq. (14) is further verified during Hurricane Isaac in 2012 as follows: According to Berg (2013, see http://www.nhc.noaa.gov/data/tcr/AL092012_Isaac.pdf, pages 71 and 73), max S was 11 feet (3.4 m) located east of New Orleans, Louisiana and max V (surrogate of U_{10}) was 54 knots or 28 m s^{-1} , which is located south of that storm surge measurement place in the Gulf of Mexico. Substituting $U_{10} = 28 \text{ m s}^{-1}$ into Eq. (13), $S = 3.4\text{m}$, which is identical to the measurement of 3.4 m. Therefore, it is recommended that for a coastal region, the variation of coefficient K for Eq. (12) may be determined using historical datasets of simultaneous

observations of both S (from water level measurements) and V or H_s [using Eq.(2a) for the offshore regions such as best storm track data by National Hurricane Center or Joint Typhoon Warning Center].

h) Comparison between Equations (1) and (2b)

Because both Equations (1) and (2b) have been verified, it is prudent to compare these two formulas. Fig. 22 shows the result. Since the slope is nearly unity and the correlation coefficient $R = 0.98$, one can say that Eq. (2b) is very useful operationally because the significant wave height is available routinely from a satellite as illustrated in Fig.1. Note that the reason to employ this dataset is that, during Katrina, maximum H_s of 16.91 m was recorded at NDBC Buoy 42040 (<http://www.ndbc.noaa.gov/hurricanes/2005/katrina/>). Now, by substituting U_{10} from Equations (1) into (2b) and rearranging, we have

$$T_p = 15H_s / (H_s + 2). \quad (15)$$

Therefore, for rapid estimation of the peak wave period, Eq. (15) may be employed as a first approximation.

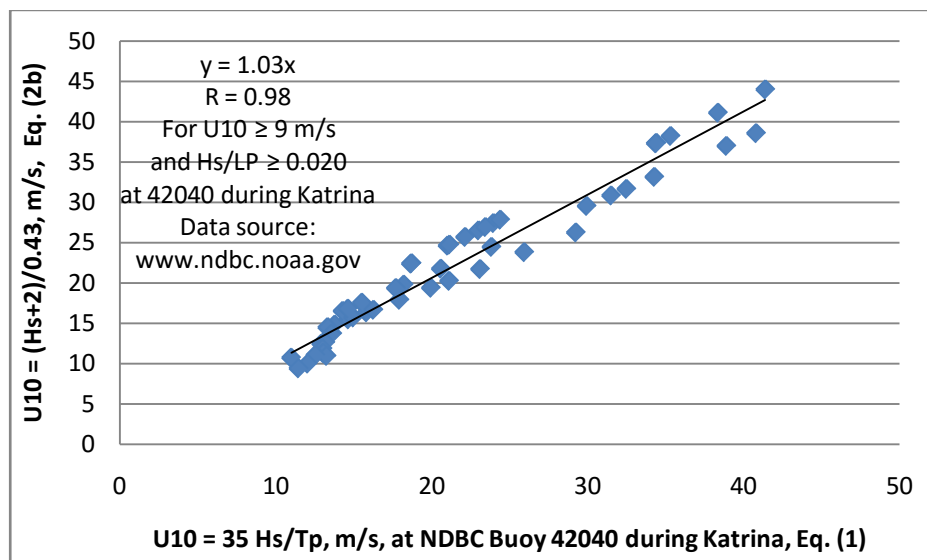


Fig. 22: Comparison between Equations (1) and (2b) at NDBC Buoy 42040 during Katrina

VI. CONCLUSIONS

By aforementioned analyses and discussions, it was concluded that, during wind seas when the wind speed at 10m exceeds 9 m s^{-1} , Eq. (2b) as deduced from the met-ocean measurements during Hurricane Wilma can explain the wind-wave relation to other tropical cyclones. Also, applications of this formula for rapid estimations of overwater friction velocity, sea-surface drift velocity, storm surges, and peak wave period were provided. These topics are needed in marine science and engineering.

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1. INTRODUCTION

Creativity and innovation are the key components of any modern knowledge society. Never before in the history of mankind, so much energy, time and resources have been channelized in giving expression to this creative impulse. Universities/Public Research Institutions (PRIs) all over the world have become a powerhouse of innovations. In India, Council of Scientific and Industrial Research (CSIR), an autonomous organisation under Ministry of Science and Technology (S&T), Government of India (GOI) leads the innovations space and IP filings¹ in the areas as varied as genetic inventions to software. But do these universities/PRI's have proper Intellectual Property (IP) policies to provide guidelines for IP ownership, collaborations and benefit sharing etc. to facilitate licensing and commercialisation of these IPs leading to Return on Investment and socio-economic growth?

An IP policy is the cornerstone of innovation and creativity for universities and the way it is crafted has a direct and deep impact on the sustainability of innovation ecosystem. It creates an environment that encourages and expedites the dissemination of new

knowledge for the greatest public benefit, while protecting the traditional rights of scholars to control the products of their scholarly work². It also ensures that the financial or other benefits of commercialization are distributed in a fair and equitable manner as it lays guidelines to recognise the contributions of the inventors, institutions as well as other stake holders^{2,3}.

A well-defined revenue sharing model as a part of the IP policy of the university motivates the students/researchers to innovate and commercialise their technologies⁴. A student or a university employee is the first owner of any invention made by him. However, there are other stakeholders such as employers, sponsors and departments who can make a claim that such patent rights should be assigned to them. IP policies of the universities/ PRI, among others, deal with issues of IP ownership, revenue sharing etc., of the IP generated through universities thus facilitating commercialisation of technologies, which if not addressed, are impendent to technology-transfer and commercialisation³. Although, numerous attempts have been made and surveys conducted to study IP policies and revenue sharing models of universities in the west including universities in USA, Canada, UK etc³⁻⁶, no detailed study has been done to understand the IP policy framework and revenue sharing models being followed by autonomous PRIs and universities in India⁷⁻⁸. The existing literature has also not comprehensively catalogued the policies typology and diversity in India⁷⁻⁸.

In the present study, IP policies for benefit sharing being adopted by key autonomous PRIs/Departments of S&T and top institutes/universities of India were studied to understand and throw light on the IP ownership and revenue sharing models being adopted by them. These policies were also studied to understand the pertinent issues/policies regarding revenue sharing models being followed in India and its bench marking with successful models being followed in the west with additional focus on the following aspects:

- What is the policy on the ownership of Intellectual Property?
- What is university/institute policy regarding commercial revenue split?
- How are the royalties split between the Inventors and the university?

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- Are there other parties involved, and if so, what portion do they receive?
- What is the payout frequency of the revenues to the inventor(s)?
- Does the IP policy specify start-up policy for its faculty/student?

II. METHODOLOGY

For brevity, the term “university” is employed and refers to both university and research institute and may be used interchangeably as the context demands. Likewise, autonomous public research institutes or departments under the Government of India, have been hereinafter referred to as ‘PRIs’ or ‘PRI’.

In the present study, IP policies/revenue sharing policies being followed by top hundred Universities/Institutes listed by Ministry of Human Resource Development (MHRD), Government of India as per the National Institutional Ranking Framework (NIRF) released in April 2017⁹ were studied to evaluate the IP ownership and revenue sharing policies followed by these universities.

The IP policies/guidelines issued by the key autonomous PRIs/Departments under the Ministry of S&T, Ministry of Defence and Ministry of Agriculture and Farmers Welfare, Government of India (GOI) including policies laid down by Indian Council of Medical Research (ICMR)¹⁰, Department of Biotechnology (DBT)¹¹, Indian Council of Agricultural Research (ICAR)¹², Council of Scientific and Industrial Research (CSIR)¹³, Indian Agriculture Research Institute (IARI)¹², Defence Research Development Organisation (DRDO)¹⁴ were also studied to evaluate the IP guidelines/benefit sharing policies being followed by them. Only data available in the public domain with open access was used and relied upon for the present study.

The autonomous PRIs/departments in India have universities supported by them through intramural funding and therefore, the policies/guidelines laid down by them are generally applicable to all universities supported by them. In case, the universities under these PRIs/Govt. departments develop their own IP policies, being fully supported, it is assumed that their IP policies will be based on the IP Policy/guidelines followed by their parent institute.

CSIR has a dynamic network of 38 national laboratories, 39 outreach centres, 3 innovation complexes and 5 units¹. CSIR’s R&D expertise and experience is embodied in about 4600 active scientists supported by about 8000 scientific and technical personnel¹. ICMR has 26 national laboratories/Institutes under its umbrella¹⁷, DBT has 14 autonomous institutes and centres under its purview¹⁵. ICAR has 99 ICAR institutes and 53 agricultural universities spread across the country and it is one of the largest national agricultural systems in the world¹⁶. There are 60

Laboratories/units functioning under Defence Research and Development Organisation (DRDO) under Ministry of Defence, GOI¹⁸. IP policies/guidelines being followed/adopted by these scientific departments were studied to understand the IP policy guidelines being given by these organisations and adopted by their universities and research centres.

As the western world has achieved excellence in science, technology, innovation and commercialisation, the IP ownership and revenue sharing policies being followed by leading universities in USA, UK and Canada were also studied and compared with Indian models to benchmark and draw inferences. This will be of relevance to policy makers and practitioners for drafting and adopting suitable policies for their institutions.

III. RESULTS AND DISCUSSIONS

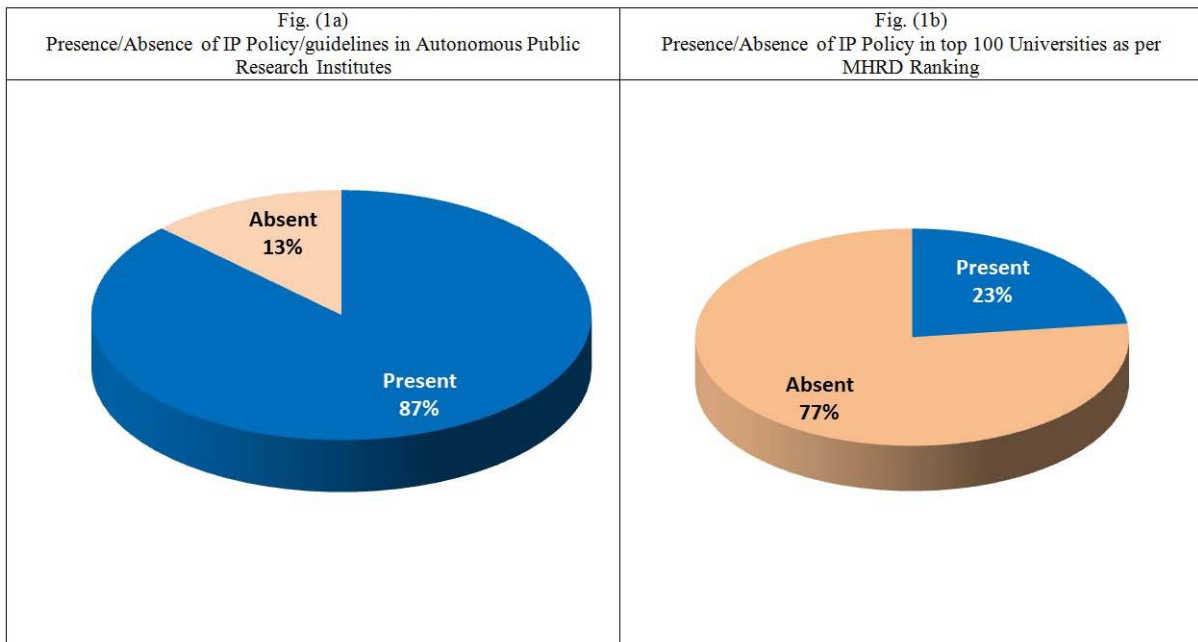


Figure 1: Status of presence of intellectual property policies in universities in India

The autonomous PRIs in India have been promoting new areas of S&T and playing key role as nodal organisation for organising, coordinating and promoting S&T activities in the country¹⁹. They have PAN India presence and have a dynamic network of national laboratories, innovation complexes and units covering a wide spectrum of science and technology sectors including from environment, health, drinking water, food, housing, energy, farm, non-farm, defence and agriculture sectors¹⁹. When the IP policies/guidelines being adopted by these PRIs were studied, it was found that CSIR as a pioneer of India’s intellectual property movement has laid down clear IP policy with revenue sharing mechanism to incentivise its institute (s), inventor (s) and departments¹³.

With the responsibility of steering R&D in the country, majority of the autonomous PRIs in India have laid down clear IP policies with revenue distribution mechanisms to incentivise and promote their institutes and inventors to pursue scientific pursuits. Such IP policies with clear revenue sharing mechanism were present in 87% of such central bodies (Fig. 1a). Ministry of Finance, Department of Expenditure, GOI in the year 2000 issued guidelines/ instructions for technology transfer and intellectual property rights¹¹. DBT is following these guidelines for defining revenue sharing policy for its institutes. While ICAR¹², CSIR¹³ and DRDO¹⁴ have clear IP policies on benefit sharing, such policies need to be more clearly defined by ICMR¹⁰ and DBT¹¹.

When presence of IP policy in top 100 Indian Universities as per MHRD ranking was studied⁹, it was observed that in 77% of these universities, no formal IP policy was present (Fig. 1b). Only 23 out of 100 such

universities had formal IP policies indicating that majority of the universities in India have strategic focus on basic R&D and publications (Fig.1b). They don’t have a formal document such as an IP policy document which sets out rules of the universities on how to accurately identify, evaluate, protect and manage its IP for development and commercialisation. It shows that these universities don’t have an IP perspective and the lack of IP vision is taking its direct toll on the structure and quality of education imparted and research done therein.

Table 1: Table showing policies regarding ownership of IP adopted by Universities and Autonomous PRIs in India

Sr. No.	University/PRI	IP generated by Intramural funding	Extramural or Grant-in-aid funding	Collaborative Research	Sponsored Research	Work-for-Hire/ Consultancy to outside Institute	Any other
1.	ICMR ¹⁰	ICMR	Generally owned by ICMR (Negotiable)	Joint IP ⁱ	N/A	N/A	N/A
2.	ICAR ¹²	ICAR	ICAR ⁱⁱ	Joint IP	Joint IP ⁱ	N/A	N/A
3.	CSIR ¹³	CSIR ⁱⁱ	CSIR	Joint IP ^{iv}	Joint IP ^{iv}	N/A	N/A
4.	DBT ¹¹	Institute ^v	Joint IP	Joint IP	N/A	N/A	N/A
5.	DRDO ¹⁴	DRDO	N/A	N/A	N/A	N/A	N/A
6.	IISc, Bangalore ²⁰	Institute	N/A	Joint IP ^{vi} Or Institute IP ^{vii}	Joint IP ^{vi} Or Institute IP ^{vii}	N/A	N/A
7.	AIIMS Delhi ²¹	Institute	N/A	Joint IP ^{viii} or As per MoU	Joint IP ^{viii} or As per MoU	N/A	N/A
8.	IIT Delhi ²²	Institute	Institute ^{ix} or Joint IP ^x	Institute ^{ix} or Joint IP ^x	Institute ^{ix} or Joint IP ^x	Institute ^{ix} or Joint IP ^{x,i}	Inventor ^{xi}
9.	IIT Kharagpur ²³	Institute	N/A	N/A	Institute ^{xii}	Institute ^{xiii}	
10.	Bharathiar University, Coimbatore ²⁴	University	N/A	N/A	N/A	N/A	Inventor ^{xiv}
11.	Pondicherry University, Puducherry ²⁵	University	N/A	N/A	Joint IP	N/A	Negotiated with external agency ^{xv}
12.	SRM University, Chennai ²⁶	Joint IP ^{xvi}	N/A	N/A	Joint IP ^{xvii}	N/A	Inventor ^{xviii}
13.	JamiaHamdard University, Delhi ²⁷	University	University ^{xix}		University ^{xix}	N/A	N/A
14.	Panjab University, Chandigarh ²⁸	University	N/A	Joint IP ^{xx}	University ^{xx} Or Joint IP ^{xx}	N/A	University ^{xxi}
15.	NIPER University, Mohali ²⁹	University Or Mutually decided	University ^{xxii} Or Joint IP ^{xxiii}	Joint IP	Joint IP	N/A	N/A
16.	IIT Kanpur ³⁰	Institute	N/A	As per MoU	As per MoU	N/A	Institute ^{xxiv} (fully or partially, on a case-to-case basis)
17.	IIT Roorkee ³¹	Institute	N/A	N/A	Institute ^{xix}	N/A	N/A
18.	Guru Jambheshwar University, Hisar ³²	University	N/A	Joint IP ^{xxv}	Joint IP ^{xxv}	N/A	N/A
19.	Goa University, Goa ³³	Joint IP ^{xvi}	N/A	As per MoU	As per MoU	As per MoU	Inventor ^{xxvi}
20.	Amrita VishwaVidyapeetha, Coimbatore ³⁴	University	N/A	N/A	N/A	N/A	N/A
21.	IIT Indore ³⁵	Institute	As per MoU	As per MoU	As per MoU	Institute	Inventor ^{xxviii}
22.	Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru ³⁶	Intellectual Property Management Committee decides on a case to case basis	N/A	N/A	N/A	N/A	N/A

23.	Vellore Institute of Technology, Tamil Nadu ³⁷	Institute	N/A	Joint IP ^{xxvii} or Institute ^{xxviii} Or as per MoU ^{xxix}	Joint IP ^{xxvii} or Institute ^{xxviii} Or as per MoU ^{xxix}	N/A	N/A
24.	IIT, Madras ³⁸	Institute	N/A	As per MoU	As per MoU	N/A	N/A
25.	National Institute of Technology Surathkal ³⁹	Institute	N/A	Joint IP ^{xxvii} Or Institute ^{xxviii}	Joint IP ^{xxvii} Or Institute	N/A	As per MoU ^{xxiv} or Joint IP ^{xxvii} or Institute ^{xxviii}
26.	Kerala University, Kerala ⁴⁰	Institute or Inventor ^{xviii}	N/A	N/A	N/A	N/A	N/A
27.	National Institute of Technology, Tiruchirappalli ⁴¹	Institute or Inventor ^{xviii}	N/A	As per MoU	As per MoU	N/A	N/A

- i. Joint IP in Collaborative Research or Sponsored research or Work-for-hire shall mean IP jointly owned by host Institute/University and the Sponsor/Collaborator/Employer in case of work-for-hire.
- ii. Using External Funds but IP assigned to ICAR.
- iii. IP created by CSIR Institutes including all.
- iv. Collaboration, sponsored work with MoU/Contract/Agreement with agreed Joint IP.
- v. IP generated by all DBT supported Institutes.
- vi. If sponsoring agency is forthcoming in filing IP and bears the cost of filing and maintaining IPR equally.
- vii. If sponsoring agency is not forthcoming and does not bear the cost of filing and maintaining IPR equally.
- viii. Joint IP or as per terms of the MoU/Agreement executed between the Parties.
- ix. IP generated by /through joint funding/ facilities of IIT Delhi and external agency or consultancy or sponsored research or work-for-hire without any Agreement.
- x. IP generated by /through joint funding/ facilities of IIT Delhi and external agency or consultancy or sponsored research or work-for-hire with formal associated Agreement.
- xi. None of the situations as defined in IP policy of IIT, Delhi or Third party ownership applies, and the IP is unrelated to the inventor's engagement with IITD, OR is generated outside the normal working hours of IIT Delhi.
- xii. IP is owned by the Institute where the sponsor does not claim intellectual property rights.
- xiii. IP rights to be assigned to the Institute in a written contract to be executed between the parties.
- xiv. The Creator/Inventor at his option may retain ownership when the IP is developed without use of University resources.
- xv. IP created without using PU resources by PU personnel, on sabbatical or long leave, or who is permitted by the PU to be engaged in an outside organization to be negotiated by PU Personnel with external organisation.
- xvi. IP generated through Intramural Funding is jointly owned by University and Inventor.
- xvii. In case of External Funding amounting to Rupees Ten Lakhs or more, IP is jointly owned by Inventor, University and External agency.
- xviii. IP developed without substantial use of University resources/facilities.
- xix. IP created through sponsored research where the sponsoring agency does not claim IP rights.
- xx. IP shall be jointly owned between University and sponsor/collaborator, if the later claims IP rights.
- xxi. In case of Work-for-hire, IP shall be owned by the University.
- xxii. University IP: Fully Govt. Funded Research.
- xxiii. Joint IP: Fully or Partially Non-Govt. Funded Research.
- xxiv. IP created during deputation, official leave, or sabbatical
- xxv. If Collaborator/Sponsor has provided Funding of Rs. 10/- lakhs or more.
- xxvi. IP created without the use of any University/College resources after due approval of University/College.
- xxvii. If the sponsoring agency bears the cost of securing and maintaining the IPR registration equally.
- xxviii. If the sponsoring agency is not forthcoming in filing a joint IPR application.
- xxix. In case of multiple sponsors

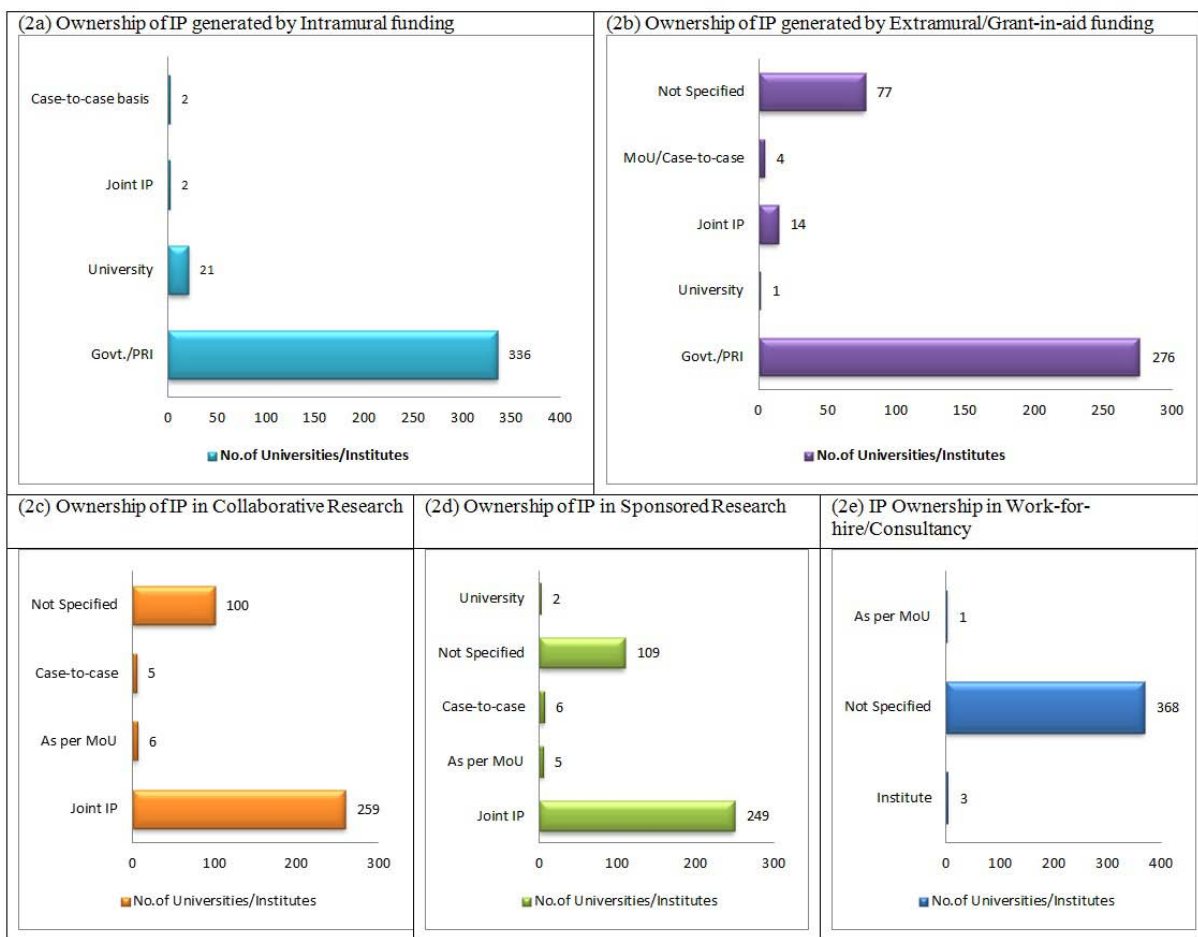


Figure 2: Ownership of Intellectual Property in different cases

In the absence of a law similar to Bayh Dole Act in India, the ownership of IP arising from research through intramural funding is owned by the Government/autonomous PRIs. The universities pursuing research and generating IP through intramural funding don't own the IP. In the present study, in 93% of universities, IP is owned by the PRI under the GOI (Fig.2a, Table-1). Only 21 out of 361 universities own the IP, which is only 6% of the total such universities included in the study. This is unlike IP ownership policies of universities in developed countries such as USA, UK, Singapore, China, Germany, Denmark, Malaysia etc. wherein IP generated through public funding is owned by the university⁴¹. IP is jointly owned by university and the inventor as per IP policy of two universities viz. SRM University and Goa University. Ownership in IP is decided on a case-to-case basis in only two universities viz. Jawaharlal Nehru Centre for Advanced Scientific Research and NIPER University. Similarly, in 74% of the cases i.e. in 276 universities, IP generated through extramural or grant-in-aid funding is owned by the Government/autonomous PRI (Fig.2b, Table-1). The IP is jointly owned by DBT and the university in case of extramural funding support provided by DBT. In 77 universities i.e. in about 20% cases, the ownership of IP generated through extramural funding has not been

specified. As per the IP policies of the Universities in Canada and Sweden, in majority of the cases, inventor owns the IP rights to their invention, fully or at least in part. These countries have developed such policies to motivate inventors to invent and commercialise the IP, thereby leading to the overall economic growth of their country⁴³. The ownership of IP in US universities is governed by the provisions of the Bayh Dole Act 1980. The Act allows transfer of exclusive control and ownership over government funded inventions to universities and businesses operating with federal contracts for commercialisation. The federally funded universities are permitted to exclusively license the inventions to other parties⁴⁴.

However, in India, in absence of an Act similar to Bayh Dole, ownership in IP vests with Government/autonomous PRIs. The universities are also mandated to license the IP arising from public funding on non-exclusive basis, thus impeding high-value strategic technology-transfers. Inspired by the Bayh Dole Act, GOI in 2008 had introduced 'The Protection and Utilisation of Public Funded Intellectual Property Bill', which is still under discussion and has not been enacted so far in the country⁴⁵.

The IP policy of about 70% of the universities in India included in the present study indicate that the IP

generated through collaborative or sponsored research shall be jointly owned by the university and the collaborator/sponsor (Fig.2c,2d, Table-1). Universities in developed countries such as USA, Europe have huge experience of academia-industry partnerships and have clear IP ownership policies in collaborative research^{6,7}. Thus, universities in the west often have more experience in interacting with industries. They also have policies and legal frameworks to manage consultancy, contract research or sponsored research as an integral component of their IP policies. However, such interactions in India have not been very prominent. India is recently witnessing industry-academia partnerships for availing funding support through public-private-

partnership (PPP) schemes of the GOI. Although majority of the leading universities in India have realised the need and have addressed the IP ownership matters in their policies, however, such matters have not been clearly specified in about 27% of the universities included in this study (Fig.2b, Table-1).

About 99% of the universities in the present study did not specify about the ownership of IP arising out from work-for-hire or consultancy assignments (Fig.2e, Table-1). In a few universities, IP ownership rights with third parties in case of collaborative/sponsored research is negotiated on a case-to-case-basis and is agreed upon as a part of the MoU between the parties (Fig.2c,2d, Table-1)

Table 2: IP Ownership policies in Copyrights followed by Universities/Institutes in India

Sr. No.	Name of the University /Institute	Thesis, Books Publications, Presentations, Speeches	Software	Teaching Material- Lectures, Laboratory records and other documents	Produced by Staff using Institute Resources	Copyrights in All Forms of Copyrightable Material	Sponsored Research	Work-for-hire or by outside professionals
1.	ICAR ¹²	Creator ⁱ	N/A	Institute	Institute	Institute	Institute Or Joint IP ^{vi}	N/A
2.	DRDO ¹⁴	N/A	N/A	N/A	N/A	Institute	N/A	N/A
3.	IIT, Kharagpur ²³	Creator	Institute	Creator	Institute	N/A	N/A	Institute
4.	IIT Delhi ²²	Creator	Creator ⁱⁱ Or Institute ³ Or Joint IP ⁴ Or Third Party ⁴	Creator	Institute	N/A	Institute ⁱⁱⁱ Or Joint IP ^{iv} Or Third Party ^v	N/A
5.	SRM University, Chennai ²⁶	N/A	N/A	N/A	N/A	Creator	N/A	N/A
6.	Panjab University, Chandigarh ²⁸	Creator	Institute	Institute	N/A	N/A	Institute ^{vi} Or Joint IP ^{vi}	N/A
7.	NIPER University, Mohali ²⁹	Institute	Creator ^{vii} Or Institute ^{viii}	Institute Or Creator ^{ix}	Institute Or Creator ^{ix}	N/A	N/A	Institute
8.	IIT, Kanpur ³⁰	Creator Or Institute ^x	Institute ^{xi}	Creator	Institute ^{xi}	N/A	N/A	N/A
9.	IIT, Roorkee ³¹	Creator	Institute ^{xii} Or Author ^{xiii}	Author	Institute	N/A	Author, Institute or Joint IP ^{vi}	N/A
10.	Goa University, Goa ³³	Creator	Institute ^{xii}	Author	Institute	N/A	Author, Institute or Joint IP ^{vi}	N/A
11.	IIT, Indore ³⁵	N/A	N/A	N/A	N/A	Author	N/A	N/A
12.	Vellore Institute of Technology, Tamil Nadu ³⁷	Creator	Institute ^{xii} Or Joint IP ^{xii}	Institute	Institute Or Joint IP	N/A	N/A	Institute
13.	IIT, Madras ³⁸	Creator	Creator Or Institute ^{xii}	Institute	N/A	N/A	N/A	N/A
14.	Pondicherry University,	Creator	Creator Or Institute ^{xii}	N/A	Institute	N/A	Author ^{vi} Or Institute ^{vi} Or	Institute

15.	Puducherry ²⁵ (Draft policy)						Joint IP ^{vi}	
16.	Guru Jambheshwar University, Hisar ³²	Creator	Institute	Creator	N/A	Institute	Author ^{vi} OrInstitute ^{vi} Or Joint IP ^{vi}	N/A
17.	National Institute of Technology Surathkal ³⁹	Creator	Institute	Institute	N/A	N/A	As per MoU	N/A
18.	National Institute of Technology, Tiruchirappalli ⁴¹	Creator	Institute	N/A	Institute	N/A	N/A	N/A
19.	Ownership matter in Copyrights not specified	ICMR, CSIR, DBT, Ministry of Aayush, AIIMS, University of Delhi, Delhi, Bharathiar University, Coimbatore, Jamia Handard University, Delhi, JNU, Amrita Vishwa Vidyapeetha, Coimbatore, Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, Kerala University, Kerala						

- i. Creator can claim their individual copyright, whether registered or not, over their creations/work published by them as per ICAR rules
- ii. IP is unrelated to the inventor's engagement with IITD or is created outside the normal working hours of IITD.
- iii. Institute owns the IP in copyrights, if it is developed using funds / facilities provided by IITD or by sponsored research and consultancy projects without any associated agreement or work-for-hire.
- iv. If material is developed through external funding and agreed as per MoU executed between the parties or has been created by IITD faculty/student/project staff/supporting staff during their visit to a Third party Institution/organization.
- v. As per terms of the MoU/Contract
- vi. Provided the Institute gets a due portion of the benefit form Copyright commercialization.
- vii. Copyrightable works created with the use of Institute-supported resources which Institute feels is commercialisable, author assigns such IP to the Institute.
- viii. IP owned by Institute can be assigned to Creator in whole or in part based on depending on the degree of institute-supported resources used in producing the copyrightable work.
- ix. Books and reports created using funds specifically provided for this purpose by IITK.
- x. All copyrights, including copyrighted software will be owned by IITK when it is created as a part of any of the academic programs of IITK
- xi. If created by significant use of Institute Resources
- xii. Software created without significant use of the Institute resources and not connected with the profession for which he/she is employed at the Institute.

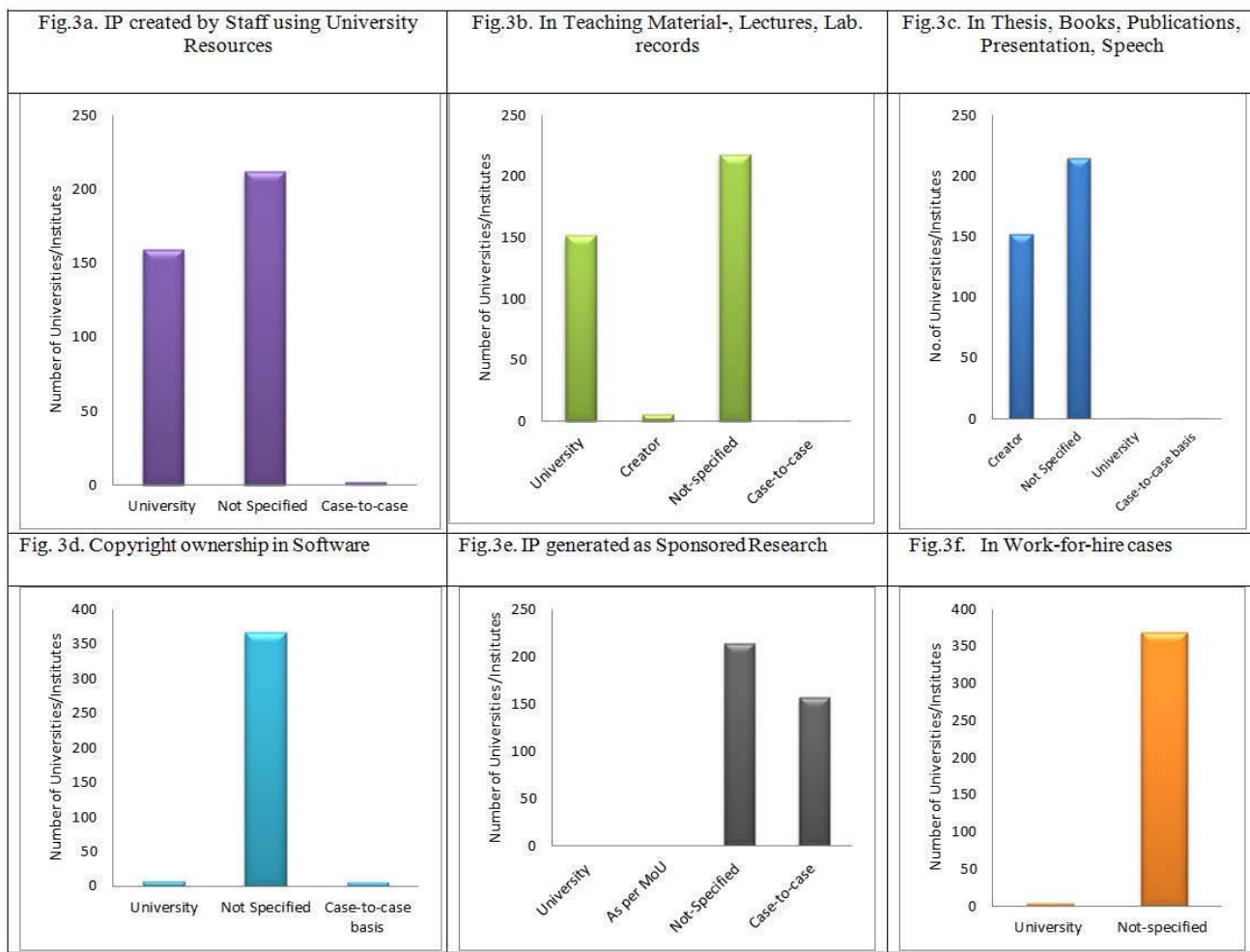


Figure 3: IP Ownership policies in copyrights

When the policies regarding ownership of IP in copyrights were studied, it was observed that most of the universities in India have broadly laid down policies for IP ownership for all forms of IP. They have not specifically defined IP ownership in copyrights and its clarity in different forms of copyright assets.

Most of the universities and central autonomous PRIs such as ICMR, CSIR, DBT and other universities including University of Delhi, JNU, Jamia Hamdard University to name a few, have not specified IP ownership in copyrights created by their faculty or students during the course of their engagement with the universities.

Universities wherein the ownership of copyrights in the IP policy has been addressed, generally implement the principle that university shall own the IP rights in the copyrighted material which its faculty/student creates at the University by using substantial aid of its facilities or financial support. Such principles are globally accepted and are also being followed by leading universities of the west such as Stanford University, Harvard, Duke University, Columbia

University etc.⁶This principle also holds true for the IP ownership in copyrights in Indian universities included in the present study (Fig.3a, Table-2).

Similarly, the copyright ownership in teaching material, lectures, lab records, thesis etc. which are created by faculty/student as a part of their responsibilities within the university is also owned by the university (Fig.3b, Table-2).

The Indian universities, in line with the global policies, reaffirm and recognise that the copyright ownership in literary and artistic works such as books, publications, presentations, speeches shall be owned by the creator (Fig.3c, Table-2).

IP ownership matters in case of software programs, work-for-hire and sponsored research have not been specified in majority of the IP policies in India (Table-2, Fig.3d,3e,3f). Some of the universities have kept the matter regarding IP ownership of copyrights created as a part of the sponsored research and software programs open ended, with a provision to decide such matters on a case-to-case basis (Fig.3d,3e, Table-2).

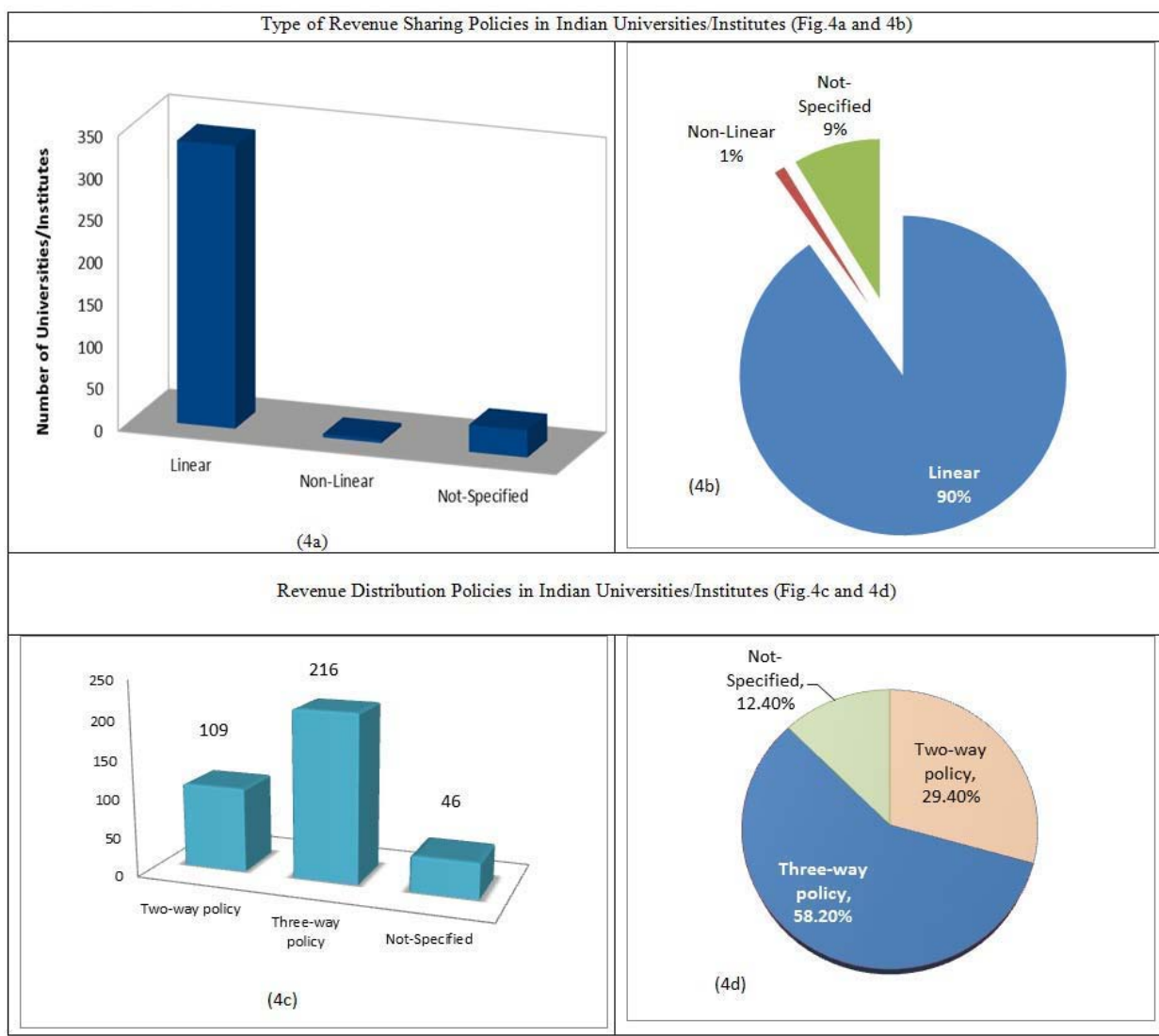


Figure 4: Type of Revenue Sharing Policies adopted by Universities/Institutes in India

The revenue sharing policies could be based on linear model when the share of revenue for inventors, institutes and other parties is set as a fixed percentage of revenue generated by an invention. It is referred to as the non-linear model when the revenue share to the

stake-holders (inventors, institute, department etc.) varies with the level of licensing income. The non-linear model is generally a regressive scheme from inventors perspective as the higher the revenue generated, this model imparts lesser revenue share to the inventors.

Table 3: Revenue Sharing Policies of Key Autonomous Public Research Institutes in S&T in India

Revenue Sharing Policies of Key Government Organisations in S&T and Defence in India					
Name of PRIs	Number of Institutes supported through Intramural Funding	Headquarter share (%)	Institute share (%)	Inventor share (%)	Any other party share (%)
ICMR ¹⁰	31	Not specified	Not specified	Negotiable	
ICAR ¹²	99 Institutes, 53 Universities	15	25	60	
CSIR ¹³	17 Research Institutes and Centres, 37 Laboratories, 39 Field Stations or Extension Centres	No	60	40	
CSIR ¹³ (Through NRDC)		No	30	40	30 by NRDC

DBT ¹¹	14 Autonomous Institutes and centres	No	As per the Institutes Policy	1/3rd	
DRDO ¹⁴ (Though NRDC)	60 Laboratories / units	Yes 35 (ARMREB) Armament Research Board.	35		30 by NRDC
DRDO ¹⁴ (Independently by Institute)		50	50		

Table 4: Universities/Institutes following Linear Model with Fixed Revenue Sharing Mechanism

Universities/Institutes following Linear Model with Fixed Revenue Sharing Mechanism				
Organisation	Institute's share (%)	Inventor share (%)	Department share (%)	Any other party share (%)
IISc, Bangalore ²⁰	40	60	N/A	N/A
AIIMS, New Delhi ²¹	60	40	N/A	N/A
IIT Delhi ²²	20	60	N/A	10-FITT, 10-IRD
IIT, Kharagpur ²³	50	50	N/A	N/A
University of Delhi, Delhi ⁵³	20	60	20	N/A
Bharathiar University, Coimbatore ²⁴	40	60	N/A	N/A
Pondicherry University, Puducherry (Draft policy) ²⁵	40	60	N/A	N/A
Banaras Hindu University, Varanasi ⁵⁴	60	35	N/A	5- Support staff
Panjab University, Chandigarh ²⁸	30	70	40% of University's share	N/A
Anna University, Chennai ⁵⁵	40	60	N/A	N/A
	25	75	N/A	N/A
NIPER University, Mohali ²⁹	60	40	N/A	N/A
National Institute of Technology Surathkal ³⁹	30	70	N/A	N/A
National Institute of Technology, Tiruchirappalli ⁴¹	30	70	N/A	N/A
Vellore Institute of Technology, Tamil Nadu ³⁷	40	60	N/A	N/A

Table 5: Universities/Institutes following Linear Model with Variable Revenue Sharing Mechanism

Universities/Institutes following Linear Model with Variable Revenue Distribution Mechanism					
Organisation	Condition	Institute share (%)	Inventor share (%)	Department share (%)	Any other party share (%)
IIIT, Hyderabad ⁵⁶	Indian Patent where cost of filing < 1Lakh (First three years of commercialisation)	50	50	N/A	N/A
	Indian Patent where cost of filing < 1Lakh (After three years of commercialisation)	70	30	N/A	N/A
	International patent / US patent where cost of filing > 1 lakh (Till cost of filing is recovered)	80	20	N/A	N/A
	International patent / US patent where cost of filing > 1 lakh (After cost of filing is recovered)	70	30	N/A	N/A
	International patent / US patent where cost of filing > 1 lakh Indian/International patent	10	90	N/A	N/A
Guru Jambheshwar University, Hisar ³²	When University is the Creator of IP	60	35	N/A	5 Support Staff
	When the individual researcher/ team of researchers is the Creator and has used substantial University resources	60	35	N/A	5 Support staff
	Funded/Sponsored research, distribution among University and inventors as per terms of the MoU	60	35	N/A	5 Support staff
	Company, Industry or Commercial Undertaking is economic user	24	14	N/A	2 Support Staff, 60 Commercial Entity
Goa University, Goa ³³	In-House Research Funded by University /College	50	50	10*	The Department gets 10% share from University's share
	Collaborative /Sponsored Research	30	70	N/A	
	University /College Consultancy	30	70	N/A	
	Individual Research	10	90	N/A	
	Patent obtained under SA -39.6	10	90	N/A	

Amrita VishwaVidyapeethamCo imbatore ⁵⁷	Student, Faculty	Approved Royalty Rate decided on a case-to-case basis, based on approval of the Vice Chancellor
Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru ³⁶	Intellectual Property Management Committee addresses all issues concerned with securing, maintaining, protecting and valorizing the Intellectual Property Rights.	
IITMadras ⁵⁸	Decided as per the prevailing IPR Revenue Sharing norms of the Institute	

The present study observed that 90% of the universities in India follow linear revenue sharing model with fixed revenue share allocated for the inventors. Linear policies are also adopted by leading universities of the west such as Stanford University and Harvard University, USA. Although, linear model of revenue sharing is a preferred model followed in US universities, UK universities preferably follow non-linear revenue sharing model⁴⁶.

As per study by Lach and Schankerman, 57% of the US universities follow linear model of revenue sharing while in UK, linear model is less prevalent with only 20% of such UK Universities following linear model⁴⁷. In the present study, it was observed that Linear

revenue sharing policies adopted by majority of Indian universities/PRIs defined fixed revenue sharing policy for different stakeholders (Table-4), while few universities had linear revenue sharing policy wherein the revenue share defined for different stakeholders varied based on different conditions/cases (Table-5). The conditions based on which the revenue sharing in such linear policies varied included amount of patent expenses, source of funding for IP generation, type of association for R&D with university etc.

Non-Linear model of revenue sharing is followed in India by some leading institutes, primarily IIT's such as IIT, Kanpur, IIT Roorkee, IIT Mumbai, IIT Indore, JNU, Delhi etc.

Table 6: Universities/Institutes following Non-Linear Revenue Sharing Model

Universities/Institutes with Non- Linear Revenue Sharing Policies					
Organisation		Institute (%)	Inventor (%)	Department (%)	Any other party (%)
IIT Kanpur ³⁰	For the First amount Q*	25	65	N/A	Service Account(10)
	For the next amount Q	45	45	N/A	10
	For amounts more than 2Q	65	25	N/A	10
IIT Roorkee ³¹	For the first slab of amount "X"	20	60	20	N/A
	For the slab of next amount "X"	25	50	25	N/A
	For amounts more than "2X"	30	40	30	N/A
	Up to twice the costs incurred by Institute for protection, marketing and other associated costs (A)	50	50	N/A	N/A
	Beyond A	0	100	N/A	N/A
JNU Delhi ⁵⁹	Money received upto 30% of the gross salary (Basic+DA+CCA)	100	0	N/A	N/A
	Money received beyond 30% and upto the gross salary	30	70	N/A	N/A
	Money received beyond gross salary	50	50	N/A	N/A
IITBombay ⁶¹	For the first amount Q*	30	70	N/A	N/A
	For the next amount Q*	50	50	N/A	N/A
	For amounts more than 2Q	70	30	N/A	N/A
IIT Indore ³⁵	For cases, where IP Rights are re-assigned to the Inventor			N/A	N/A

	For the first amount Q (Q=INR 100 Lakhs)	30	70	N/A	N/A
	For the next amount Q	50	50	N/A	N/A
	For amounts more than 2Q	70	30	N/A	N/A
	If IITI re-assigns IP Rights to Inventor			N/A	N/A
	A. Upto twice the costs incurred by IITI for protection, marketing and other associated costs.	50	50	N/A	N/A
	B. Beyond A	0	100	N/A	N/A
JamiaHamdard University Delhi²⁷	if Proceeds received > 30% of basic pay of inventor	70%	Retain upto 30% of their basic pay per year	10	10- Welfare Fund 2-IP Management Cell
	if Proceeds received < 30% of basic pay of inventor	75%,	25%		

*Q/X/A = INR 100 Lakhs

The most generous non-linear revenue sharing policies in India provide 70% revenue to the inventors, while the least generous provide 25% share from net proceeds to inventors. The non-linear revenue sharing models in India are also regressive models wherein revenue share of the inventor decreases with increase in receipt of commercialisation proceeds/revenues.

The revenue intervals for non-linear policies followed in India is nearly uniform with revenue intervals of INR 100 Lakhs in most of the non-linear policies. This is unlike the revenue intervals of non-linear revenue sharing policies being followed in US and UK Universities, wherein the revenue intervals varies widely eg. in some UK University policies, the first interval ranged from £ 1 to £5000 of the net revenues whereas others ranged from £ 1 to £50,000. In general, the non-linear schemes being adopted in UK are also regressive from inventors' perspective in line with European Union Directive EC/4798a⁴⁶. This is similar to non-linear policies being regressive in their approach in Indian universities also.

Three-way revenue sharing policies are more widely followed in Indian universities with revenue distribution among three parties viz. university, department and inventor. About 58% of the universities in India follow three-way revenue sharing policy and around 29% two-way revenue sharing policy with revenue share allocated for institute and inventor only (Fig.4c,4d; Table 4,5,6). The three-way revenue sharing model is also more popular in UK.⁴⁶

This type of two-way sharing mechanism, despite being less popular than the three-way mechanism, would better reflect the observation of Friedman and Silberman (2003) who suggested that sharing revenue with the inventor's department does not increase the overall level of licensing income at an institution⁴⁸. It is suggestive that inventors at universities with two-way policies generally receive a higher share of revenue than those at universities with three-way policies, although when studied, the values were not

significantly different in a study for UK University policies⁴⁶. Such analysis with possible correlation between type of revenue sharing model and licensing revenue can be evaluated for Indian universities to draw inferences and arrive at similar conclusions.

Entrepreneurship and spin-off company creation from universities is very common in US and UK, with Silicon Valley providing all the key ingredients for nurturing entrepreneurs⁴⁹. However, IP policies of universities in India have not laid down clear policies for their scientists to pursue entrepreneurial pursuits.

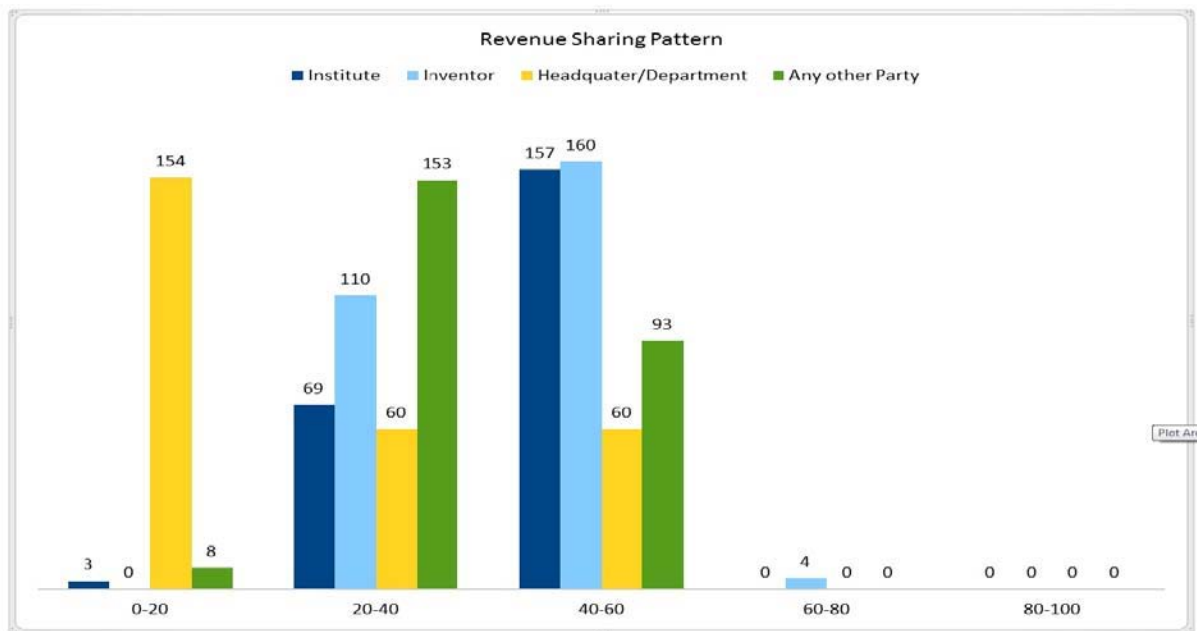


Figure 5: Revenue Sharing pattern among Indian Universities/Institutes

The analysis of the revenue sharing policies being adopted by Indian universities indicated that majority of the universities have very favourable revenue sharing policies with 160 Institutes providing 40-60% of the revenue from the commercialisation proceeds to the inventors (Fig.5). Similar number of universities retain 40-60% of the revenue from commercialisation proceeds as a part of the universities share. The most generous revenue sharing linear policies provide Indian inventors 80% of the share in revenues and the least generous provide 25% share (Table 4,5). The average inventor's share for India's linear revenue sharing policies was 54%. This is much higher than the 45% average inventor's share followed in UK linear policies and 41% in US university policies⁴⁶.

Four universities in India have very friendly inventor favouring policies with revenue share in the range of 60-80% arising from commercialisation of each IP allocated as inventor's share namely Panjab University, Chandigarh, Anna University, Chennai, National Institute of Technology, Surathkal and National Institute of Technology, Tiruchirapalli (Table 4,5).

About 154 universities in the present study, set aside a minor revenue share ranging from 0-20% for headquarter/department wherein the IP was created within the university (Fig.5).

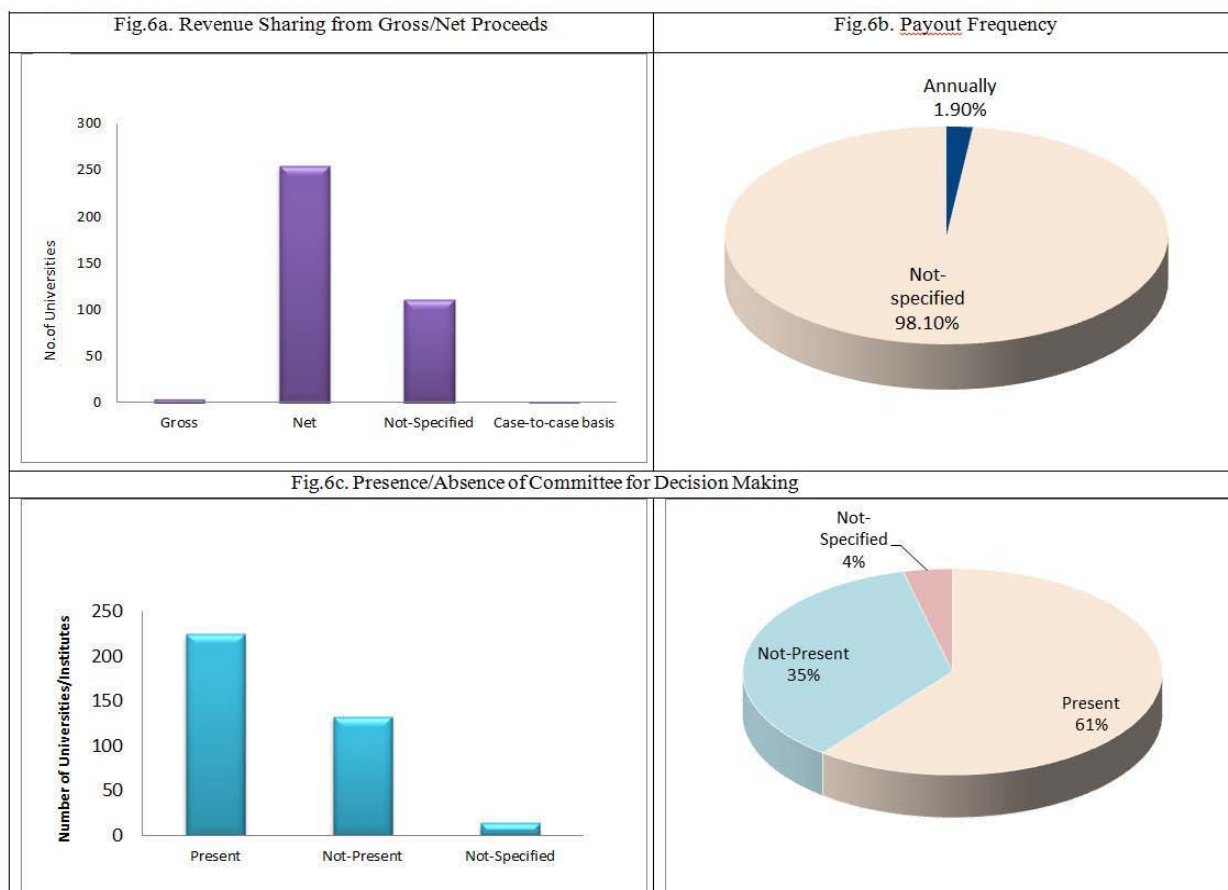


Figure 6: Revenue Sharing policies regarding Disbursement Mechanism, Payout Frequency and Decision making in Indian Universities/Institutes

Table-7: Table showing revenue sharing policy typology of Indian Universities

Organisation	Linear/Non-Linear policy	Two Way/Three Way policy	Gross/Net	Payout Frequency
ICMR ¹⁰	Linear	Two-way	Not specified	Not specified
ICAR ¹²	Linear	Not specified	Net	Not specified
CSIR ¹³	Linear	Two-way	Net	Not specified
DBT ¹¹	Linear	Not specified	Not specified	Not specified
IISc Bangalore ²⁰	Linear	Two-way	Not specified	Not specified
AIIMS New Delhi ²¹	Linear	Two-way	NET	Not specified
IIT Delhi ²²	Linear	Three-way	Not specified	Not specified
IITKharagpur ²³	Linear	Two-way	Gross, if no Third party involved	Not specified
			Third Party share deducted, prior to Inventor/Institute distribution	Not specified
University of Delhi, Delhi ⁵³	Linear	Three-way	Gross	Not specified
Bharathiar University, Coimbatore ²⁴	Linear	Two-way	Gross	Not specified
Pondicherry University, Puducherry (Draft policy) ²⁵	Linear	Two-way	Net	Not specified

Banaras Hindu University, Varanasi ⁵⁴	Linear	Two-way	Net	Annually
Jamia Hamdard University, Delhi ²⁷	Linear	Three-way	Net	Not specified
Panjab University, Chandigarh ²⁸	Linear	Two-way	Net	Annually
Anna University, Chennai ⁵⁵	Linear	Two-way	Gross	Not specified
NIPER University Mohali ²⁹	Linear	Two-way	Not specified	Annually
IIT Kanpur ³⁰	Non-Linear	Two-way	Net	Annually
IIT Roorkee ³¹	Non-Linear	Three-way	Net	Annually
	Non-Linear	Two-way	Not mentioned	Not specified
JNU Delhi ⁵⁹	Non-Linear	Two-way	Not mentioned	Not specified
IIT Bombay ⁶¹	Non-Linear	Two-way	Net	Annually
Guru Jambheshwar University, Hisar ³²	Linear	Two-way	Net	Annually
Goa University, Goa ³³	Linear	Three-way	Net	Not specified
Amrita Vishwa Vidyapeetham, Coimbatore ³⁴	Not specified	Not specified	Net	Not specified
IIT Indore ³⁵	Non Linear	Two-Way	Net	Annually
Vellore Institute of Technology, Tamil Nadu ³⁷	Linear	Two-way	Not specified	Not specified
IIT Madras ⁵⁸	Not specified	Not specified	Not specified	Not specified
National Institute of Technology, Surathkal ³⁹	Linear	Two-Way	Not specified	Not specified
National Institute of Technology, Tiruchirappalli ⁴¹	Linear	Two-way	Net	Annually

255 out of 371 universities i.e. 68% universities in India have IP policies for revenue disbursement from net proceeds (Fig.6a, Table-7). The expenses under various heads such as patent expenses, advertising, marketing etc. to be included for deduction as out-of-pocket expenses varies among different universities. As IP policies and revenue sharing mechanisms are sensitive matters which need to be updated from time-to-time and sometimes need decisions on a case-to-case basis, IP policies of majority of universities (60%) in India have provision of internal committees for decision making with mandate for decision making on different aspects of IP including IP filing, maintenance, licensing, revenue disbursement etc. (Fig.6c)

Although Indian universities have defined revenue sharing models but most of these Universities have not laid emphasis on the pay-out frequency of the revenues received from licensing/commercialisation of the IP. This is a critical issue which needs to be addressed in a revenue sharing policy to provide certainty and motivation to the inventor. There are many

ways of dealing with the issue of when to pay the inventor his/her share of the revenues i.e. paying the revenues annually, biannually or quarterly etc. Only 7 Universities in India, included in the present study specified pay-out frequency of revenue disbursement as annually. 98% of the universities did not specify the pay-out frequency in their IP policies (Fig.6b, Table-7). Paying the revenues annually to inventors is also a common practice being adopted by universities in the west including in Canada⁴. The issue of defining a clear payout frequency needs to be addressed in IP policies of Indian universities for imbuing more confidence in the inventors for a predictable royalty receipt.

IV. CONCLUSIONS

In 1999, *The New York Times* described IP as having “transformed from a sleepy area of law and business to one of the driving engines of a high-technology economy⁵⁰.” Realising the importance of innovation and IP, Government of India in 2013 launched Science, Technology and Innovation policy

with innovation as an integral component of its policy⁵¹. Although the autonomous PRIs in India with the responsibility of steering S&T innovations in the country have laid down IP policies/guidelines, however, majority of the universities in India with basic R&D focus don't have a well defined IP policy. To keep pace with the global economy, the universities in India need to shift their strategic focus from basic R&D to translational research and develop IP policies to effectively identify, evaluate, protect and manage IP for facilitating its commercialisation.

India had released its National Intellectual Property Rights Policy in May 2016 as a giant leap to spur creativity and stimulate innovation in the country⁵². National IP policy of India expresses its intent to use the IP system in a defined manner to achieve innovation driven economy. Considering the launch of National IP Policy by the government to spur innovation and creativity in the country, it is imperative for the universities to develop a high quality institutional policy to motivate the inventors and ensure that knowledge transfer takes place effectively. The university IP policy so drafted should comply with the national IP policy and strategy requirements.

As an act similar to Bayh Dole Act adopted by USA does not exist in India which emphasizes ownership of IP by the University, Government bodies in India still have a big role to play regarding policies on IP ownership, revenue sharing etc. India needs to adopt an Act similar to Bayh Dole Act to implement Institutional IP ownership or imbibe more radical IP ownership policies like the Sweden policies wherein the IP is owned by the Inventor. The adoption of Bayh Dole act in USA radically changed the innovation and commercialisation landscape of USA with tenfold increase in patents, increased annual Universities IP filings to 4000 patent applications, and about 3500 licenses & options annually. Implementation of similar Act in India could also boost the innovation profile of the country.

Majority of universities in India do not have a well-defined IP policy which leads to conflict of interest among various stakeholders on matters such as IP ownership etc. The Universities and PRIs need to develop well defined IP ownership and revenue sharing models to harmonize conflicting interests of the various stakeholders and motivate inventors for innovation. 90% of the universities in India follow linear revenue sharing model with fixed revenue share allocated for the inventors and university, unlike UK universities with dominant non-linear model which implies that universities/scientists in India are not risk averse and are inclined to have a predictable and fixed revenue sharing policy.

The most generous non-linear revenue sharing policies in India provide 70% revenue to the inventors while the least generous provide 25% share from net proceeds to inventors. Likewise, linear policies provide

maximum 80% of the share in revenues to Inventors and the least generous provide 25% share which is much higher than the maximum revenue share allocated to inventors in USA and UK. The generous revenue sharing models for incentivising inventors in India have been developed to spur indigenous innovation and commercialisation leading to economic development in the country. These have also been developed to encourage the inventors to disclose, protect and exploit their invention. The mechanism of invention disclosure, protection and commercialisation are established paths in developed countries such as US, UK, Canada. However, in India, such systematic mechanisms still need to be established. It may be noted that the average inventor's share for India's linear revenue sharing policies is 54% which is much higher than the 45% average inventor's share followed in UK linear policies and 41% in US University policies. Most Indian universities have generous, inventor friendly benefit sharing policy. However, such policies have not defined pay-out frequency of the revenues received from licensing/commercialisation, leading to uncertainty in royalty receipts. Although the universities in India have developed policies with generous revenue share allocated for inventors, there seems to be lack of awareness of such policies at the inventor level. Further, scientists have inclination towards basic R&D and publications with not much knowledge of IP. Extensive capacity building, training programs and boot camps are required to educate and motivate the scientists in Indian universities to innovate and protect their IP. This will also help them to develop skills and institutional capacity to administer, manage and use IP for their own benefit and benefit of the society at large. Such policies will also encourage the scientists to shift focus from frugal or incremental innovation to path breaking disruptive innovations. The issue of defining the payout frequency also needs to be addressed in such policies.

The IP policy/guidelines adopted by universities/PRIs should ensure that both institutions and individual researchers are incentivized to disclose, protect and exploit their inventions. Incentives can include "sticks" such as legal or administrative requirements for researchers to disclose inventions to the university or PRIs that employs them, but also "carrots" such as royalty-sharing agreements or equity participation in academic start-ups. Recognition of patent activity in the evaluation and recruitment of faculty can also be included as an Institutional policy to provide incentives to young researchers for motivating them to innovate and commercialise their IP. An IP policy document with revenue sharing model which incentivises innovators is a key to drive disruptive innovations and facilitating technology-transfers. Clarity of such policies in universities in India will go a long way in developing sustainable innovation ecosystem in the country.

Disclaimer: This document has been prepared on the basis of publicly available information and other sources believed to be reliable including the information available on universities/PRI's websites. The information contained herein is for information purposes only. The opinion provided herein presents author's view-point on the issue and does not have any legal binding attached to it. The IP policy typology included in this study may vary with time as the policies adopted by universities are generally updated periodically. The IP policy and revenue sharing data included in this paper is based on policies available in public domain only up to July 1, 2017.

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Human Chronology in the Periods of Variations of Environmental Processes

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Abstract- The chronological system based on the periods of variations of water runoff of the Neva and Dnieper Rivers with the length of 28 and 29 years is composed. It starts from the Creation of the World by the Hebrew Calendar and divides the human past for two eras: consisting from the 7 ages the Era of Separated World and the Era of United Humanity, which boundary is the 1924. The world history is presented as the successive complication of human communities which new forms originated during the completion of the ages as the results of grandiose events which could be interpreted as the Great Revolutions opening for humans the new directions of the social development.

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Human Chronology in the Periods of Variations of Environmental Processes

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Abstract- The chronological system based on the periods of variations of water runoff of the Neva and Dnieper Rivers with the length of 28 and 29 years is composed. It starts from the Creation of the World by the Hebrew Calendar and divides the human past for two eras: consisting from the 7 ages the Era of Separated World and the Era of United Humanity, which boundary is the 1924. The world history is presented as the successive complication of human communities which new forms originated during the completion of the ages as the results of grandiose events which could be interpreted as the Great Revolutions opening for humans the new directions of the social development.

The most full and complete human community – the United Humanity was appeared due to the Last Great Revolution – the Great October Socialist Revolution. In spite of the modern social regress the communistic relations initiated during this revolution are developed in the structure of bourgeois society. Most successfully they should be developed in Russia which over the time could unite round itself the Whole World in the political form of the World Socialist Soviet Republic as it was proclaimed by the Declaration of the Creation of the USSR at the year of the boundaries of eras.

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I. INTRODUCTION

The analysis of climatic time series reveals their hidden periodicities. But, if these harmonics are reliable, they, as their environmental causes, should impact to other Earth systems including human society and should be traced in history. Some hypothesis of appearance of environmental cycles in history were formulated, including the conceptions of A.L. Chizhevsky [4] concluded that 11 year cycle of solar activity impacts to the mankind development, M.A. Bogolepov [3] explained some historical events by the reaction of communities of people for the unfavorable for them changes of environment related with combinations of harmonics revealed in the hydrometeorological time series, and many other researchers.

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This research is aimed not only to formulate, present and discuss the problems of analysis, modeling and prediction of hydrometeorological and climatic time series and relate their hidden periodicities with any human activity or social process, but also to show the way of development of the combination of revealed periods into the chronological system embracing and structuring all human past. This chronological system is alike on some extent to the time scale of Joseph Justus Scaliger [11]. But this chronology is aimed to be a tool for revealing, description and analysis of some regularities of development of mankind rather than for systematization of dates of events in the past of different human communities for composing of their succession.

The chronological system should be as some analog of the Geologic time scale. As the Geologic time scale is an effective tool to describe the evolution of the life and to explain its aim – formation of humans, the presented chronological system could be applied as the instrument to describe the development of human society and to make more clear the aim and sense of history.

The chronological system could be interpreted from the points of view of different conceptions. It was combined with the doctrine of Karl Marx [7], explained the sense of history as the successive alteration of social formations from primitive communism to future communism and with conception of N.F. Fedorov – founder of philosophical direction of Russian Cosmism. According to N.F. Fedorov [5] which made the same conclusion that H.G. Wells [8] from the analysis of the world social tendencies, the sense of history is the uniting of all nations, tribes and people into the whole and universal community (modern science of western countries interprets it as globalization).

This chronological system structures the past from the moment of Creation of the World (expelling the Adam and Eve from Paradise) by the Hebrew Calendar and subdivide it for two basic eras: Era of Separated World and Era of United Humanity. The Era of Separated World consists from the seven ages which boundaries are the greatest historical and religious events caused the origination of more complicated and developed human communities that is was earlier.

The boundary of the eras, calculated by the combination of environmental cycles of 28 and 29 years, is 1924, when Vladimir Ilich Lenin and Thomas Woodrow Wilson died with two weeks distance. V.I. Lenin – the

leader of the Great October Socialist Revolution and the founder of the USSR (World Republic of Labor People) and Woodrow Wilson – the founder of the League of Nations (the first political organ of United Humanity) united the mankind on the basis of communism and capitalism respectively. The human chronology is divided for the time before V.I. Lenin or Woodrow Wilson and after them, and these persons could be considered as the men initiating the beginning of the new era.

Person, initiating the new era, should be estimated as the greatest from the humanity from all its generations. V.I. Lenin and Woodrow Wilson were the opponents during their lifetime and posthumous ideological rivals architected the different ways for mankind development, which still is the basis of modern confrontation of the Russia and United States. They are also the rivals in my chronological system. The discussion concerning their contribution to the development of humanity should be especially actual taking into the consideration the Century Anniversary of the Great October Socialist Revolution and Historical Fourteen Points of Wilson (8 of January, 1918), the base of League of Nations creation.

II. THE AVAILABILITY OF THE SAME PERIODS IN HYDROMETEOROLOGICAL TIME SERIES AND HUMAN PAST

Figure 1 illustrates the time series of water runoff of the Neva (*a*) and Dnieper (*b*) Rivers. These time series were analyzed by the method of "Periodicities" [1, 2] from their beginning to 2000. The last five years of 2001 – 2005 were applied for the computation of the training forecasts of river runoff and estimation its results by the new independent data.

The time series are added by the revealed sinusoids with the periods of 29 and 28 years respectively. There is the high correlation of the time series and the sinusoids (η). The results of training forecasts by these sinusoids are better than the predictions by the mean values of time series. These periods were revealed also in large number of different hydrometeorological time series.

The period of 29 years may be in presence in the history of the Soviet Russia and World Communist Movement. It is the cycle of the death of the most powerful and ideologically motivated communists. Friedrich Engels – co-author of conception of Marxism died at August 5, 1895. V.I. Lenin dyed at January 21, 1924, 29 years after F. Engels. I.V. Stalin – secretary-general of the communist party and prime minister of Soviet Union died at March 5, 1953. Head of the USSR L.I. Brezhnev died at November 10, 1982.

The Soviet Union collapsed at 1991. But in 2011 there were the deaths of the Heads of the States originated by the former Soviet Union copying its social organization and political system. Muammar Khadafy of

Libya died at October 20, 2011 and Kim Jong II of North Korea – at December 17, 2011.

The period of 28 years is the calendar cycle. It is the time interval for what the calendar dates stand for the same days of the week. This period was interpreted by the Velimir Khlebnikov, Russian writer of the beginning of XX century, as the cycle of alternation of generations [6]. He concluded that the leaders resolving the opposed political or ideological and world-outlook tasks are born very often through 28 years as the Peter the Great – the Emperor of Russia and the Ivan Mazepa – Hetman of Zaporizhian Host. The new generation of people confront with the older generation born 28 years before.

This period is also could be revealed in the past of Russia and former Soviet Union. The 28 year is the time interval between the Great Russian Revolution of 1917 and the victory of USSR in the Second World War. The Serfs Emancipation in Russia of 1861 and the Great Revolution are separated by two cycles of 28 years.

If the periods with the length of 28 and 29 years are available in the variations of environmental processes and human past, their combination should cause the cycle of their multiplication with the length of 812 years. This complex long cycle, if it is reliable, can be applied as the chronological unit for the systematization of the human past – its subdivision for approximately equal time intervals with the own socio-historical sense and meaning of each of them. Such systematization could be valuable because the environmental cycle of 812 years is external for society.

As on the boundaries of subdivisions of the Geologic time scale there were the outstanding environmental processes related with the mass extinctions of different groups of organisms and rapid formation and evolution of other organisms in the empty ecological niches as the important social processes should be developed near the subdivisions of chronological system of human past and great events should be occurred which cause the changes of the structure of society.

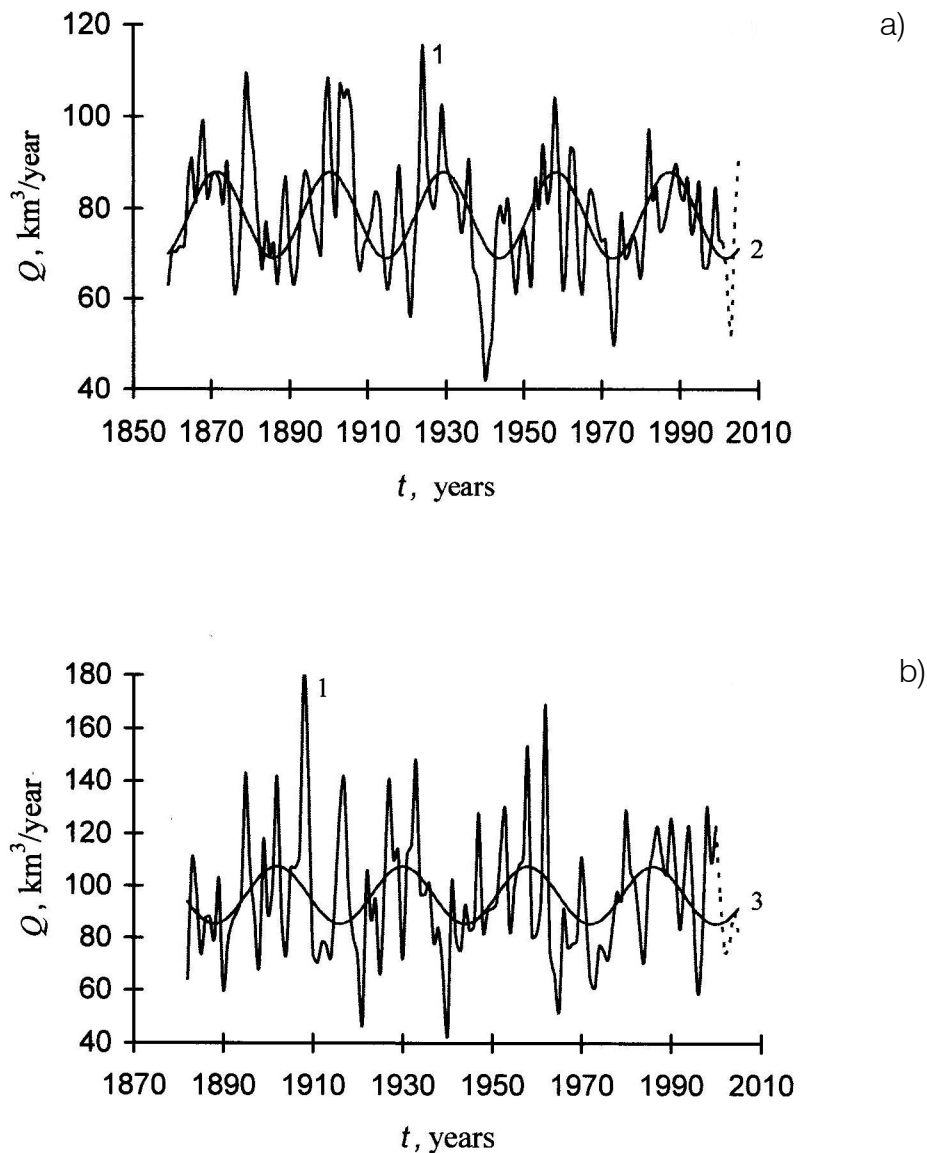


Figure 1: Variation of runoff of the Neva River, Novosaratovka (a) and Dnieper River, Smolensk (b): 1 – observation data (time series were analyzed from their beginning to 2000, dotted line shows the training forecast interval 2001 – 2005), 2 – sine with the period of 29 years ($\eta_2 = 0,516$), 3 – sine with the period of 28 years ($\eta_3 = 0,320$)

Association of the historical events into the group according to their location in the chronological system should permit to describe some of their general peculiarities, develop analogies between them and analyze and discuss the significance of their leaders in history. As these events are combined by the regularities of variations of environmental processes it should be interesting to analyze their relations, not only causality, which should be useful for formulation of general regularities of the development of the nature and society.

III. CHRONOLOGICAL SYSTEM OF HUMAN PAST AND SENSE OF HISTORY

The period of 812 years should be calculated from the important point in human past. Such important

point is the Creation of the World (expelling of the Adam and Eve from Paradise) as its beginning. There are different dates of Creation of the World of the Christian theologians and Bible researchers. Let us consider the date of October 6/7, 3761 BC, which is the beginning of the Hebrew Calendar – official calendar of the State of Israel.

Because the Creation of the World was completed near the end of 3761 BC of Gregorian calendar, let us to calculate the time from the next year – 3760 BC, which embraces the most part of the first year of human past. The chronological system, including the years of boundaries of 812 year cycles, is presented in the table 1. The years Before Christ are characterized by the minus.

The years of completing of the cycles are the 2948 BC, 2136 BC, 1324 BC, 512 BC, 300 AD, 1112 AD

and 1924 AD. The closest for us year of this dependence is 1924. From the Creation up to our time the 7 full cycles are revealed. The number 7 characterizes certain fullness and completeness, and, as a rule, namely it is used for the description and classification of various processes and states. In particular, 7 colors of visible radiation, 7 basic units of physical quantities of International System of Units (SI) are allocated.

The music scale is formed by the 7 basic notes. According to the Book of the Revelation to John of the New Testament the 7 seals are opened from the Book and 7 angels with 7 trumpets sound. The organisms of the biosphere are classified by their uniting into 7 basic taxonomical groups: species, genus, family, order, class, phylum and kingdom. There are 7 Wonders of the World – great architecture monuments of antiquity: the Great Pyramid of Khufu, the Colossus of Rhodes, the Lighthouse of Alexandria, the Mausoleum at Halicarnassus, the Temple of Artemis, the Statue of Zeus and the Hanging Gardens.

According to Russian philosopher N.F. Fedorov and British H.G. Wells the sense of the history of humans is the formation of their universal community. The most whole and universal community of people is the United Humanity. Let us to subdivide the historical time for the two eras, which boundary is the 1924. We will call time before 1924 by the Era of Separated World, and after – the Era of United Humanity. The concept of the “Era of Separated World” was applied by Russian science fiction author I.A. Yefremov [10].

Most simple human community is the family. Between family and United Humanity we could introduce five more forms of communities or levels of the organization of people – the clan, the tribe, the polis (the city-state or the principality), the nation and the union of nations. The specified forms of community are presented in table 1 in the 7th column to each of which the cycle of the chronological table corresponds at the end of which the historical events, caused its origination, occurred. Events are specified in the 4th column, their leaders – in the 5th column. In the 3th column the level of a community of people and a cycle at the end of which it was initiated, is characterized by the index.

There could be true the analogy between the events which caused origination of new forms of communities of people of higher level and Wonders of the World. Such events should to be the giant scale, involve the huge masses of people, to be characterized by uniqueness and to be on the edge or even beyond of the social and technological capabilities of people and societies of that time.

The analogy between the succession of communities of people of the presented chronology and the systematic of organisms of biosphere also could be developed. The succession of human communities may be interpreted as the social systematic of humanity. So

each person can be characterized by his belonging (or not belonging) to united humanity, large number of people – to their associations with any unions of nations, with any nation and polis.

Table 1: Eras and ages of human past

Era	Cycle (age)	Age index	Great Revolutions (events and processes of formation of human communities of next level)	Great personalities	Name of the age	Forming human community	Opening direction for social development
1	2	3	4	5	6	7	8
Era of United Humanity							
	1924 – 1112	7	Great October Socialist Revolution and formation of USSR, foundation of the League of Nations	Vladimir Ilich Lenin Thomas Woodrow Wilson	Age of unions of nations	United Humanity	Communitic
	1112 – 300	6	First Crusade and formation of Christian States in the Western Asia and Palestine	Godfrey of Bouillon Bohemond I Tancred of Galilee	Age of nations	Union of nations	Capitalistic
	300 – (-512)	5	Completing the epoch of Three Kingdoms and formation of China, War of the Eight Princes	Wu of Jin Jia Nanfeng	Age of poleis	Nation	Feudal
	-512 – (-1324)	4	Expelling the Tarquin the Proud from Rome, overthrow the monarchy and formation of the Roman republic	Lucius Junius Brutus Spurius Lucretius Tricipitinus	Age of tribes	Polis	Slaveholding
	-1324 – (-2136)	3	Development of Monotheism	Akhenaten Tutankhamun Moses	Age of clans	Tribe	Subslaveholding
	-2136 – (-2948)	2	Creation of Ark	Noah Shem Japheth	Age of families	Clan	Primitive communistic
	-2948 – (-3760)	1			Archaic age	Family	
		0	Expelling of Adam and Eve from Paradise	God		Archaic	
Era of Separated World							

In many places of the world remote from the centers of capitalistic development, people can be characterized by their belonging to a tribe and a clan, and each human person belongs to any family. In this research the history of origination of forms of communities of people according to change of their level is analyzed.

Let us the intervals of 812 years long, according to chronological terminology of I.A. Yefremov and H.G. Wells [9], to call by the ages. Era of Separated World could be subdivided for sequence of the ages named by the communities of people of that time of the highest level (table 1, a column 6).

This sequence consists from an archaic age at the time moment of Adam and Eve's expelling from Paradise (age of lack of any community among the people), age of families, age of clans, age of tribes, age of policies, age of nations, age of unions of nations which comes to the end with the Era of United Humanity.

In every age the community of people with the highest index is subject of historical process.

Such community interacts with other communities as it as lower levels, building the relations of war and peace, domination and submission, market exchange and competition and the other. So, in the age of tribes, one tribe can subdue another tribe, the relations of Spartans and Helots are an example of that, but, the tribes related by the domination and submission during its age don't become the polis.

Often poleis conquered other poleis, or entered with them into alliances or other relations. Sometimes, formations of the poleis combined with each other by various relations reached the large sizes and involved in themselves the huge mass of the population, an example of that is Rome. But the poleis related with each other in its age didn't become the nation.

The nations obeyed each other, but related with each other, in its age they didn't become the union of nations. The unions of nations were at war and traded with each other, but victories of some unions and defeats of others, as well as their peace relations, didn't lead to their association into the United Humanity.

According to Karl Marx doctrine sense of history is the consecutive alternation of socioeconomic formations which are the primitive communism, slaveholding, feudal, capitalistic and communistic. Let us apply these concepts to specify the ages on all its extent as the new direction of humanity development rather than the steady society. So, merger of unions of nations into the United Humanity opens for it the possibilities of communistic development.

Association of nations into the unions of nations opens the possibilities of development of capitalism in them. Combination of poleis into the nations gives for them the possibility of development of feudalism, and association of tribes into the poleis – developments of

the slaveholding relations, table 1, column 8. Association of families into the clans creates the prerequisites to the primitive communistic development of society. Also let us consider the subslave holding direction of development opening for the association of clans into the tribes, which was not specified by Marx.

Let us consider the processes and events of the ends of ages which caused formation of new communities of people of higher organization.

IV. PROCESSES AND EVENTS OF COMPLICATION OF COMMUNITIES OF PEOPLE

a) *Origination of United Humanity and appearance of the communistic direction of its development*

In 1924, at the moment of the end of the age of the unions of nations and the Era of Separated World V.I. Ulyanov (Lenin) and Woodrow Wilson (on February 3) died, and also the First Constitution of the USSR including the Declaration of the Creation of the USSR and the Treaty on the Creation of USSR was adopted by the Second Congress of Soviets of the Soviet Union on January 31.

V. I. Lenin – the leader of the Great October Socialist Revolution which exposed some indications of origin of United Humanity – principally new community of people. This revolution step out the solution of the political and social problems of countries and nations, and their unions, having set the aim of formation of society of a brotherhood of labor people of the whole world and their association after victory of socialist revolutions in other countries.

Almost simultaneously with origination of the united humanity on the basis of communism, the most developed capitalist countries under the leadership of the U.S. President Woodrow Wilson made an attempt of association of the world in the form of League of Nations – the first political body of United Humanity. Slightly earlier, in 1913 at Wilson's presidency the Federal Reserve System of the USA – a financial basis of association of the world was created.

The League of Nations was based on the declaration of Fourteen Points of Wilson presented to the Congress of the USA on January 8, 1918. This declaration was devoted to the principles of the world arrangement after the victory of the USA and its allies in World War I. Creation of the League of Nations was undertaken for the protection of the interests of the winners in this war – leading capitalistic powers. Nevertheless, Fourteen Points of Wilson partly repeated some of provisions of the Decree on Peace and other ideas of V.I. Lenin and slogans of the Great October Socialist Revolution, as they were the reaction to them of the capitalist world. Wilson's points formulated the need of cancellation of secret diplomacy, guarantees of the peace to the great and small nations, the rights of the

nations of the former empires of Europe and Russia for creation of their own states, and for Russia – to find its own way of development.

The human history subdivided for the two eras: the time before Lenin (or Wilson) and the time after V.I. Lenin. We can conclude that the new era after the death of V.I. Lenin begins, because the state of human society changed qualitatively. Before Lenin in all ages the mankind was divided, though the extent of this division successively reduced, the labor was an object for exploitation though its form and degree changed. After V.I. Lenin the tendency of uniting of humanity originated and the new direction of its development – communistic, liberating the labor from the exploitation, opened.

Huge significance of the Great October Socialist Revolution was realized already by its contemporaries, and, not only supporters of building of the communism. Today, when there is no more Soviet power, events of Great October and the subsequent history of the USSR seems as the real Wonder of the World doesn't have the analogs in the past.

b) *Origination of the union of nations and appearance of the capitalistic direction of development of humanity*

In December 12, 1112, after end of the age of nations, Tancred of Galilee died. He was one of heads of the First Crusade, the participant of a siege and charge of Jerusalem, the founder and the Prince of the Principality of Galilee, obeyed to the Kingdom of Jerusalem as vassal, populated by the people of the same faith as the Jesus Christ and consanguineous to him. Slightly earlier, in 1111, before the beginning of the age of the unions of nations two other heads of this campaign died: Bohemond I (on March 17) and Robert II, Count of Flanders (on October 5).

The occasion for the First Crusade was the inquiry of the Byzantine emperor Alexios I Komnenos to the Pope Urban II for assistantship in the struggle against invasion of the Turks to the Anatolian region. In November 1095 the Pope called the Council of Clermont, where he asked Western Christians for the military campaign against Muslims not only to help to the Byzantine but also to capture the Jerusalem.

The appealing of the Pope was actively supported by many European communities, people of different social groups and estates. Peter the Hermit, a priest of Amiens and the French knight Walter Sans Avoir had composed, organized and headed the poorly armed and weakly trained troops of commoners of some tens of thousands of people. In the April of 1096 this army moved to the Anatolia beginning the People's Crusade. In October it was defeated by Turks, Walter Sans Avoir and many of his soldiers were lost, Peter the Hermit retreat to the Constantinople and joined himself to the nobility and knights preparing for the First Crusade.

After the army of commoners the main troops of crusaders were formed. The prominent European feudal nobility with their detachments and vassals had arrived to the capital of the Byzantine including the Duke of Lower Lorraine Godfrey of Bouillon with brothers and nephew, Count of Flanders Robert II and the Prince of Taranto Bohemond with his nephew Tancred. Bohemond was a son of Robert Guiscard, Norman conquer of southern Italy. During the feudal wars between the heirs of his father he formed the Principality of Taranto.

The crusaders begin the military invasion into the Turkish Anatolia at the spring of 1097. The success of this campaign was caused partly by its support by the local Christians and Armenian nobility. The brother of the Godfrey of Bouillon the Baldwin of Boulogne promised the support and protection for the Armenian Prince Thoros governing by the city of Edessa, but dethroned and executed him. So, the first Crusader state – the County of Edessa was formed.

In June of 1098 the crusaders captured the submitted to Turkish Muslims the city of Antioch and formed the Principality of Antioch. The Bohemond of Taranto became Bohemond I, Prince of Antioch. In the July of the next year the troops of crusaders captured the Jerusalem which was under the authority of Fatimid Caliphate. The Kingdom of Jerusalem was established and Godfrey of Bouillon was elected to be its secular authority. Godfrey refused to be crowned and instead of accepting of the royal title he was proclaimed as the Defender of the Holy Sepulcher. After the death of Godfrey at 1100 the next ruler of the kingdom became the Baldwin of Boulogne – the king Baldwin I of Jerusalem. The Baldwin of Bourcq, nephew of Godfrey of Bouillon, changed the Baldwin of Boulogne as the Count of Edessa.

In 1099 the Godfrey of Bouillon gave to Tancred the cities of Tiberias, Haifa, and Bethsan to establish the Principality of Galilee. After the Bohemond I was captured by the Malik Ghazi Gumushtekin at 1100 Tancred replaced his uncle as Regent of Antioch. After liberation for the ransom Bohemond returned to Europe, formed the army to struggle against the Byzantine and invaded to the Balkans. But this campaign was not successful and the Peace Treaty of Devol was concluded in 1108 positioning Bohemond I as the vassal of the Byzantine. Made the peace Bohemond returned the Principality of Taranto where died.

Robert II, Count of Flanders participated in the battles for Antioch and Jerusalem. He not pursued the fiefs in the Western Asia for himself and returned to Europe. Robert II was killed in the skirmish during the war with English king Henry I. Tancred not approved the Treaty of Devol and heading the Principality of Antioch and Principality of Galilee sharply confronted with the neighbor states. He died for typhoid epidemic.

The First Crusade was as an organized campaign of the nobility as the mass movement of commoners which embraced various countries and regions of Europe. Its various nations, organizing this campaign and participating in it, for the first time felt oneself as the community based on a common goal and the general values. Thus, for the first time in the history, it was created the community of people of higher level that it was before – the union of nations, and there came the new age in the history of mankind – the age of unions of nations.

The European community known today as the European Union became the first union of nations in the history. Namely in its capital, the city of Brussels, the monument to Godfrey of Bouillon – to the Defender of the Holy Sepulcher, the founder and the first head of Kingdom of Jerusalem was built.

Also, it is possible to conclude that exactly the First Crusade opened for humans the capitalist direction of development of their society. During this campaign the methods and approaches of war by the groups of detachments on the territories very remote from their countries and formation of the authority of conquerors over the population of other belief and other culture and capturing of its lands and property which were widely used later, during an Age of Discovery and during the development of colonialism were applied for the first time. Not incidentally, in 1982, mobilizing the supporters for confrontation with the USSR and the countries of the Warsaw Pact, the fortieth U.S. President Ronald Reagan called for a crusade against communism, appealing to the origin of the capitalistic way of life.

The Great October Socialist Revolution is dated by the establishment of the Soviet power in Russia by the Second All-Russian Congress of Councils, November 7, 1917. Analogically the establishment of authority of the crusaders in Mediterranean region of Western Asia is possible to specify as the Great Capitalist Revolution, dating it on July 15, 1099 – the day of capture of Jerusalem, or by the date of election of the first head of Kingdom of Jerusalem. Bohemond I, Tancred of Galilee and Robert II, Count of Flanders, who died at the boundary of 6 and 7 ages of the presented chronology, were the leaders of Great Capitalist Revolution among others.

Establishment of the power of crusaders in East Mediterranean involved the huge mass of the population, was on the edge of capabilities of people and the European societies of that time. As well as the Great October Socialist Revolution, the event of the First Crusade should be considered as the social Wonder of the World.

c) *Origination of nation and appearance of the feudal direction of development of humanity*

In 300 the Jia Nangfeng – the superior authority of China, spouse of the emperor of Zhengdu (Sima

Zhong, Hui of Jin) – the son of the Emperor Wu of Jin, which was the first Emperor of Jin dynasty, died. She actively struggled for the power during collision of clans of the nobility which developed into the civil war known as the War of Eight Princes.

Wu of Jin (personal name Sima Yan) established his dynasty in the kingdom of Gao Wei, in 280 conquered the neighboring state – the Eastern Wu, united the China and completed the Three Kingdoms period of Chinese history. During the formation of the new state the nobility and emperor relatives structured into the clans which leaders received the possibility to have their own military detachments supported from the provinces which their governing. The base of the agriculture became the job of peasants, controlled by local authorities, on their lots of land.

The Emperor Wu of Jin died at 290. He was succeeded by his son Hui of Jin which was weak ruler or disabled person. After the death of Wu of Jin the state was governed by the regents and leaders of the nobility and their clans were in confrontation with each other for the position of the regent. The war of nobility for the regency is famous as the War of Eight Princes. During the progressing crisis Jia Nanfeng – the wife of emperor increased her authority over the court and China.

In 291 she with the emperor brother Sima Wei and several military leaders moved away from regency the Yang Jun, the father of Dowager Yang – second wife and widow of Wu of Jin and executed him with the majority of their clan. The regency was received by another clan of nobility headed by the Sima Liang, uncle of Wu of Jin, and Wei Guan. Several months later, by the edict of Hui of Jin and support of the army of Sima Wei, Jia Nanfeng moved Sima Liang and Wei Guan from the regency and killed them with their relatives. After that Sima Wei was arrested and killed accused in the unauthorized executions.

After the deaths of Sima Liang, Wei Guan and Sima Wei Jia Nanfeng have concentrated actual authority over China. But her hostility with Sima Yu, the heir of the throne was increased gradually. Prince Sima Yu was a son of Hui of Jin from the concubine Xie Jiu, while Jia Nanfeng gave a birth for four daughters. Sima Yu became the Crown Prince till by the will of Wu of Jin. Jia Nanfeng killed Sima Yu sending the assassins for him. After the death of Sima Yu, Sima Lun, another uncle of Wu of Jin, dethroned Jia Nanfeng which poisoned herself, executed members of her clan and appointed himself by the regent. At the spring of 301 he proclaimed himself by the emperor.

Jia Nanfeng in fight against clans of the nobility provided the unity of the Chinese state and formation of the Chinese nation. The large scale civil war began after her death. The coalition of the nobility defeated the army of Sima Liang which returned Hui of Jin to the throne and committed to suicide. But civil war grew gradually. It completed only after the January of 307, when Hui of Jin

died and Huai of Jin, his younger brother, succeeded him.

War of Eight Princes was the first in the history of China and the world the civil war of clans of an emperor dynasty when the leaders of confronting parties took the resources from the dependent from them regions of the state and use their own armed groups. Earlier the civil wars in China and in other countries developed as a struggle of generals supported by the government troops subordinated to them. This first war of feudal type is the evidence that the new direction of development of humanity – feudal opened in China.

Earlier the imperceptible in history and the obedient to authorities the relatives of the head of the state and other representatives of the nobility and officials realized their interests and initiated the armed struggle for them. New nature of civil war, its support by the population of the country split and stirred up against at each other by the clans of the nobility controlled different areas testifies that as a result of politics of the empress Jia Nangfeng and military and administrative efforts of the emperor Wu of Jin there were organized community of people of new, more high form – the nation. The events in China at the end of the III century could be specified as the Great Feudal Revolution and the social Wonder of the World, and its leaders are the Wu of Jin and Jia Nangfeng.

So, the first nation of humanity is the Chinese people.

d) *Origination of polis and appearance of the slaveholding direction of development of humanity*

In the 509 BC, the year close to the 512 BC, the monarchy in Rome was overthrown and the republican political system began its development. Lucius Junius Brutus – the leader of the struggle of the Rome people against the king Lucius Tarquinius Superbus, Spurius Lucretius Tricipitinus – the prefect of the Rome in the time of the Lucius Tarquinius dethrone and other politicians died.

From the Rome foundation in 753 BC the city was headed successively by the seven kings: Romulus, Numa Pompilius, Tullus Hostilius, Ancus Marcius, Tarquinius Priscus, Servius Tullius and Tarquinius Superbus. Initiating the Rome Romulus united three tribes: the Latins, Sabines and Etruscans were jointed. Each tribe subdivided for ten curiae (clans). Servius Tullius formalizing the duties of Rome people before the authority instead tribal subdivision of population classified them according the territories of their living.

Reforms of Servius Tullius cause his confrontation with the Senate, leaded by the Lucius Tarquinius Superbus – the son of the Tarquinius Priscus. Servius Tullius was dethroned and killed in 535 BC, and Lucius Tarquinius became the seventh king of the Rome.

In spite the successful conquer policy and building of the Rome (the Temple of Jupiter Capitolinus

and city sewerage, which begin to be build under his father, were completed for the time of authority of Lucius Tarquinius) the tyranny and abuses of royal family caused hostility to Lucius Tarquinius Superbus from various groups of the Roman population. The immediate occasion for the rebelling of Rome people against authority was the rape of the Lucretia, the daughter of the Spurius Lucretius Tricipitinus and the wife of the Lucius Tarquinius Collatinus – the grandson of the brother of Tarquinius Priscus, by the Sextus Tarquinius – the youngest son of the Tarquinius Superbus. Lucretius told about the incident to father and husband, and committed suicide.

Lucius Tarquinius headed the army besieging the city of Ardea. Having learned about disorders in Rome, Tarquinius moved to the capital, having appointed the Marcus Horatius Pulvillus and Titus Herminius to command the army. The insurgent people of Rome leading by the prefect of the city Spurius Lucretius Tricipitinus didn't permit him to come into the city. Then Tarquinius went back to the military camp. But Marcus Horatius and Titus Herminius received the information from the Lucius Junius Brutus – the son of sister of Lucius Tarquinius about the Tarquinius dethroning. They expelled the Tarquinius by the common resolution of the army. Marcus Horatius and Titus Herminius made the armistice with the Ardea and returned to Rome with troops.

The Rome established the authority of the two consuls elected for one year. The first consuls were the Lucius Junius Brutus and the Lucius Tarquinius Collatinus. Lucius Tarquinius Collatinus as the member of the royal family soon resigned from the consulate and this position was taken by Publius Valerius Publicola.

Lucius Tarquinius Superbus formed an army from his supporters and allies from the Etruscan cities of Veii and Tarquinii. Rome puts forward the army with infantry leaded by Valerius Publicola and cavalry – by Junius Brutus. At the beginning of their decisive battle – the Battle of Silva Arsia, Brutus and the Aruns – the son of the Lucius Tarquinius speared each other to the death. They were the friends before and traveled together to Greece to the Delphic Oracle for receiving a prediction who should be the king of the Rome.

No one party achieved the decisive success. But after the battle Etruscans refused to struggle for Lucius Tarquinius. Publius Valerius Publicola returned to Rome with the triumph. The Spurius Lucretius Tricipitinus became the consul after the Junius Brutus, but he died soon and the Marcus Horatius Pulvillus changed him. Marcus Horatius consecrated the Temple of Jupiter Capitolinus which construction was finished by the Lucius Tarquinius.

After the failure at the Battle of Silva Arsia, Tarquinius Superbus wandered the cities of Italy, agitating their authorities for war with the Rome. He finds the allies among authorities of some Latin cities. But this

coalition was finally defeated in the Battle of Lake Regillus in 496 BC. Titus Tarquinius – the last son of the Lucius Tarquinius was killed in this battle. After this defeat Lucius Tarquinius retreated to the city of Cumae, where he died in the next year.

Thus, at a boundary of 4 and 5 cycles as a result of uniting of the residents of the city combined by the tribal relations in territorial structures and formation of the republican political system more high-organized community of people – the polis was created. Rome is the first polis in history. Some later the Athens became the second polis, where in 508 BC in the course of popular uprising against tyranny and oligarchy the authority was gained by the Cleisthenes – supporter of the democratic political system. He, as Servius Tullius, replaced the tribal subdivision of population of the city to the territorial.

Overthrowing the monarchy, establishing the republic and formation of the polis – the new community of people of higher than before level opened for humanity the new direction of its development – slaveholding. Therefore, it is possible to conclude that events in Rome in 509 BC were the Great Slaveholding Revolution, which on its scale, character and consequences also has to be considered as the social Wonder of the World.

e) *Origination of tribe and appearance of the subslaveholding direction of development of humanity*

In 1323 BC, in the next year after the end of the 3 cycle, the Pharaoh Tutankhamun, the son of the Pharaoh Akhenaton or of the Pharaoh Smenkhkare died. There are various chronologies of dates of death of Pharaohs of the Amarna Period. According to one of them (W. Helc), namely Akhenaton died in a year of the end of 3 cycle [11].

The Pharaoh of the XVIII dynasty Akhenaton, Amenhotep IV, the son of the Amenhotep III, reigned by the Egypt in 1353 – 1334 BC. He developed the religious reform, trying instead of worship of population of Egypt to various gods to force to believe all of them for the monotheistic god Aton, the God of Sun.

Pharaoh founded the new capital – the city of Akhetaton on coast of Nile in 300 km to the North from Thebes. Instead of the name Amenhotep, meaning Amun is happy, he took himself the new name – Akhenaton, which could be translated as Pleasing to Aton, and gave new names to members of his family and court. From the new capital Akhenaton commanded to build the Temples of Aton and close the temples of the other gods all over the Egypt.

The modern settlement of Amarna is located near the ruins of the city of Akhetaton. The time interval of the Egyptian history, when the social processes related with the Akhenaton reforms developed, is specified as the Amarna Period. This period, in

particular, is characterized by the development of Amarna art-style with realistic pictures and sculptures of plants, animals and members of royal family, including scenes from their private life, which differ from the standard monumental arts of the Egypt of that time.

The development of the cult of Aton and struggle of the Pharaoh against other cults were followed by the economic decline, deterioration of the relations with the adjacent kingdoms, disorders in Asian possession of Egypt and loss of part of them. The reforms of Akhenaton were not supported as by nobility which income was reduced as by commoners, which life became more difficult.

After the Akhenaton death the revival of former cults began. The former cults renewed gradually for the time of supreme authority of the Smenkhkare, Tutankhamun and Ay Pharaohs, reigning 2, 9 and 4 years respectively. After the death of Ay the military leader Horemheb becomes the Pharaoh of Egypt which was the head of the state at 1319 – 1292 BC. Horemheb prohibited the cult of Aton, having restored the former religions as they were before the reforms of Akhenaton. The city of Akhetaton was destroyed.

There could be suggested different causes of the Akhenaton reforms. The development of the cult of the Aton and persecution of the other cults could be the intensification of the Pharaoh to reduce and restrict the influence of the priesthood, which was significantly enriched and increased in number as result of gifts to gods, for the state and government. It also could be the development of the tendency of the pharaoh self-idolization which already appeared during the reign of previous pharaohs. The hypothesis that Akhenaton tried to unite the population of Egypt, worshipped to different gods, by the same religious is interesting.

From the point of view of the presented conception the Akhenaton reforms are an attempt of uniting of peoples of the clans or nomes into the community of people of higher level – the tribe. There was no success to unite the Egypt population by the same religious. Nevertheless, perhaps, as a result of Akhenaton reforms the tribe of believers in the Monotheistic God was originated in the Egypt. The first tribe in the history is the Hebrew Community.

So, if the Moses, the leader of Hebrews, died before the entrance into the Promised Land at 1272 BC, and led his followers through the desert 40 years before that, the Exodus could be dated about 1312 BC – the time of the first half of Horemheb reign. This is the time of persecutions of believers for the Monotheistic God and to keep their belief and conscience, supporters of monotheism left the Egypt.

Events of reforms of Akhenaton and the Amarna Period of history of Egypt can be characterized as the Great Subslaveholding Revolution and the social Wonder of the World as a result of which the tribal social relations originated.

f) *Origination of clan and appearance of the primitive communistic direction of development of humanity*

The boundary of the second and third ages is coincides with the First Intermediate Period of Egypt – period between its the Old Kingdom and the Middle Kingdom, when important events occurred, but there is no sufficient information to classify them as the Great Revolution. The chronology of Bible events by the Hebrew Calendar points out that near the boundary of these ages the event of the Great Flood occurred in 1656 from the Creation of the World or in 2104 BC.

During the Great Flood all humans and all land animals died excepting those who were taken by the Noah into his Ark. Noah took into the Ark the pair from each species of animals and seven pairs of animals needed to be taken for purposes of sacrifice. The Noah, his wife and three his sons: Shem, Ham and Japheth with their wives went into the Ark.

These humans could be specified as the first clan of mankind. This clan – the group of humans originated from the same ancestor and united by common economy apparently originated as community for their joint labor activity – building the Ark some time before the Great Flood. Therefore the appearance of the Noah clan corresponds to the moment of the Great Revolution by the time scale of the presented chronology.

Thus, the building of the Ark and salvation of humanity and terrestrial fauna during Great Flood could be considered as the Great Primitive Communistic Revolution, the social and technological Wonder of the World which initiated the clan social relations.

g) *General peculiarities of formation of human communities of the higher level*

Years of the death of the leaders of the World communist movement – Friedrich Engels, V.I. Lenin, I.V. Stalin and in some less degree – L.I. Brezhnev and Kim Jong Il correspond to the 29 year periodic regularity, calculated directly from the time moment of the Creation of the World. The time of the death of V.I. Lenin also accords to the 28 year periodicity which is calculated from the Creation of the World. It is the evidence that V.I. Lenin is the greatest politic comparing with the other communistic leaders.

From the moment of the Creation of the World (October 6/7, 3671 BC) the full seven 812 year cycles or ages of the Era of Separated World passed. Each age was completed by the origination of the community of people of higher level than it was before and by the opening of the new direction of the social development of humanity. With the end of the seventh age edged by the death of Vladimir Ilich Lenin and Thomas Woodrow Wilson the Era of Separated World completed and the mankind entered into the new era – the Era of United Humanity.

For the completion of the ages or on their boundaries there were events initiated the origination of the human community of higher level than before. Such events could be interpreted as the Great Revolutions. The six Great Revolutions are identified from the closest to us the completing of seven ages.

The cycle of historical development of 812 years is with the same period as the period of variations of the environmental processes and could be caused by it. This environmental and social cycle could be the combination of variations with the periods of 28 and 29 years revealed in time series of the runoff of the Dnieper and Neva Rivers respectively. It could be suggested that the Great Revolutions, the formations of the human communities of the higher level and the opening of the new directions of humanity development occurs under the favorable conditions of the cyclically varied environmental parameters.

During the Great Revolutions the new forms of communities gained the outstanding results in different areas of human activity. It could be explained that uniting into the community of the new form people for the first time entered into the new social relations. These social relations were more progressive comparing with the relations between the people of the dominating forms of lower level. New social relations provided the advantages as for communities of people of the new form as for their individuals.

The peculiarity of the each age, initiated by the Great Revolution, was the obvious social regress, beginning some time after it.

The Soviet authority, aimed for the communistic development of the Russia and the World, existed 76 years and after that the bourgeois values dominates in Russia. The Principality of Galilee obeyed for the crusaders were captured and exterminated by the Muslims under the leadership of the An-Nasir Salah ad-Din in 1187. The Jerusalem was captured also. The other controlled by the crusaders territories were captured some later.

The new Crusades to the Western Asia were originated in Europe, but all of them were less successful than the First Crusade. The European people lost the understanding of their community and Europe downfall into the abyss of feudal wars.

On the last stage of the War of Eight Princes the uprising of the Five Barbarians occurred. The uprising was successful and sixteen kingdoms formed in northern China. One of these states – Northern Han (The Han Zhao) defeated the Jin army in 311 and occupied its capital – the city of Luoyang. The emperor Huai of Jin (Huái Di), one of the youngest sons of Emperor Wu of Jin, was captured. For the first time in history the China emperor was executed in captivity at 313. In 316 the Northern Han seized the city of Chang'an – next capital of Jin.

The state of Jin which became called the Eastern Jin partly kept itself in the south-eastern part of China. Its capital became the city of Jiankang. The formed China nation became separated again.

In the Rome, sometime after the dethroning of the Lucius Tarquinius Superbus the tribal aristocracy – patricians obeyed to themselves the authority of the republican form. Patricians occupied the Senate and other governmental offices. Authority of patricians supported the tribal social relations and restricted the slaveholding development of the polis.

The reforms of the Akhenaten were almost completely annulated by the Horemheb, who restored the former religious system and social relations. The monotheistic Hebrews worshiped for the Golden calf. Ham offended his farther and founder of his clan saw his nakedness.

Sometime after the Great Revolutions the new social relations between people became weaken and changed by the old relations. Great Revolutions causing the origination of the human communities of the new type are developed under the increased strain and activity of the people which could not continue infinitely.

Comprehending the history as oscillatory process we could explain that the peak of the people social activity should be alternates by its recession favorable for the reverse movement of the society from higher community to lower. Partly, the enforcement of the former social relations was encouraged by the leaders of the past-revolutionary communities due to the necessity to have the mechanisms for administrating of the society including the old, historically proved methods. The decreasing of the people activity and returning of the former social relations could be associated with the environmental changes which pass into their phase not favorable for the social relations of the new type.

But, after the completion of the Great Revolution and apparent reverse of the society to its former state, the some new algorithms of interaction of people, initiated in the course of its development, retain. These algorithms and other social peculiarities of the community of higher level are accumulated gradually in the subsoil of the past-revolutionary society. Accumulation of these peculiarities is the development of society in the new direction.

So, after the Great October Socialist Revolution, in the USSR and the leading capitalistic states the systems of pension, social health care and social education were formed. These systems work and are developed in the subsoil of the bourgeois society after the dissolution of the Soviet Union and cancellation of socialism. These systems of societal consumption of the material, cultural and spiritual values are an indication of the social development in the communistic direction.

Beginning from the epoch of the Crusades or even some earlier, in the subsoil of the feudal society of

the advanced European countries the social relations of renting of land by the small farmers and wage labor in the craft and agriculture – indications of the development of the society in the capitalistic direction developed and accumulated. Such relations of some economical freedom of small producers of the goods could be initiated for the first time or became much stronger due to the departure of the nobility with their vassals and servants from their fiefs to the military campaign to the far countries for the long years.

In the mature slaveholding society, which formation should be close in time to the War of Eight Princes, the evidences of its development in the feudal direction are appeared. The slaves, as former belonged to the slaveholders, became to have their own families, huts and labor tools. The former free peasants became dependent from the large landowners.

The origination, accumulation and the development of the new algorithms of the interaction of people make the profit for the society in general and for the overwhelming majority of its members, including the authority. Therefore the society for a long time develops in the new direction without the counteraction from the ruling class.

Already after the long time, developed in the subsoil of society, the algorithms of interaction of the people, appeared in the course of the Great Revolutions, begin the sharp political conflict with the ruling class, which aimed to keep his dominating position on the base of the former, historically rooted, principles of societal regulation. The examples of such political conflict are the bourgeois revolutions of the modern history, such as the English Revolution of 1642 or the French Revolution of 1789.

In distinction from the Great October Socialist Revolution and the other Great Revolutions from the table 1, the bourgeois revolutions of the modern time resolved only restricted tasks of the development of the political system of the society according to the needs of the algorithms of interaction of people. These revolutions not created the new communities of people of higher level and not opened the new directions for the development of humanity.

The important peculiarity of the historical process is that after the phase of the regress the communities of people formed the first due to the respective Great Revolutions develop more actively in the new opened by them directions. Very often such communities exported their algorithms of interaction of the people to other territories, becoming be the centers of development of humanity or its parts.

Bourgeois social relations most actively and successively were developed in the European community, which appeared itself for the first time for the First Crusade and the European region together with the United States of America achieved the greatest successes in the capitalistic direction of development,

especially in the sphere of the economy. European countries became the centers of huge colonial empires and exported their social relations on the controlled territories.

China nation was formed the first during the Great Feudal Revolution. Today namely this nation is the most numerous in the world. Ancient Rome stood on the slaveholding direction of development the first and namely this polis became the hugest and the only one of its kind slaveholding empire of the antiquity. As the first tribe in the human history namely the Hebrew community built the monotheistic temple and this religion became the base of the belief and moral values of the numerous Christian and Muslim communities.

The first human community, formed in the course of the Great Revolution, retains its individuality in follow history, not combining in the next ages with other communities into the social structures of higher level. So the European Union, belonging to the privileged part of humanity – the gold billion, not united and not objectively interested in the possessing integration into the United Humanity with poor nations and their unions.

China not forms any economic or military unions as it people is the first nation formed by the Great Revolution. Modern Rome is the capital of Italy. But, namely in the boundaries of the Rome the polis – independent State of Vatican City is located which is the successor of the former Rome. As the religious and spiritual center the State of Vatican City, as the Ancient Rome, retains the domination to the large number of poleis all over the world.

After completion of the building of the Holy Temple the Hebrew community split for two kingdoms – Kingdom of Israel (Samaria) and Kingdom of Judah. Kingdom of Israel was captured by the Assyrians and some later Kingdom of Judah was captured by the Babylonians. The population of the kingdoms was exiled by invaders and Holy Temple was destroyed. So the exiled and dispersed Hebrew tribe had no opportunity to associate themselves with other close to them tribes and to form their polis, and the Hebrew community is the tribe now, though increased in number according to the regularities of the demography.

V. REGULARITIES OF CHRONOLOGICAL SYSTEM OF HUMAN PAST IN THE HISTORY OF ST. PETERSBURG

The number of full ages and their length of the time of humans from Creation of the World up to now coincide with the international telephone code of St. Petersburg: 7-812. Such identity of the time and the code permits to specify the time as informational category rather than physical.

Usually the understanding of the time is related with the astronomical processes – the revolving the

Earth around its axis and around the sun. The identity of the time and the telephone code gives possibility to interpret the time as the access into the informational and communicational system, as capability to receive, to process, to analyze, to accumulate and to transfer the information.

The identity of the time of humans and the telephone code of St. Petersburg points out for the special significance namely of this city in the future. In some moment the crucially important for humanity will be the communication with its inhabitants. So, St. Petersburg should become the capital of the United Humanity. The argument that St. Petersburg should become the center of mankind is that namely in the runoff of Neva River, which flows through it, the harmonic with the period of 29 years, which is the integer of his telephone code and chronological scale of the time of humans, was revealed.

To understand the significance of the city in history it is compared with other settlements by the peculiarities of the development of its social and religious processes and by the relation of its authority to its people and people of other communities. The Philotheus of Pskov, the hegumen of the Yelizarov Monastery in the first half of the XVI century evaluating the significance of Moscow as a center of the Great State, protector of Christianity and successor of Byzantium, formulated the conception that Moscow is the Third and the Last Rome.

Comparing St. Petersburg with settlements where the great events of formation of human communities of higher level than it was before occurred, it could be concluded that his history besides the Great October Socialist Revolution which was here directly on some extent repeated these events. So St. Petersburg located in the lower river bed and mouth of Neva River is vulnerable for flooding. During the floods St. Petersburg becomes as the Ark of Noah arising over the water abyss. One of the strongest floods of the Neva River for the St. Petersburg history was at the 23 of September, 1924 – in the year of the boundary of eras. Considering the Moscow as historical continuation of Constantinople, the St. Petersburg could be identified as the Noah Ark of the contemporaneity. As an Ark, St. Petersburg should save the humanity from some global disaster in future.

As the city of Akhetaten of Amenhotep IV the St. Petersburg was not appeared spontaneously as the center of trading and crafting, but was built by the will of the Great Sovereign for the declaration of the Great Truth and the beginning the Great Changes. St. Petersburg is the Akhetaten of contemporaneity, the city – reformer and initiator of the changes in the Russia and in the World, built as the counterpoise to the conservative and inertial Moscow. The sphinxes at the Universitetskaya Embankment of the Neva River, the

monuments for Amenhotep III, the father of Akhenaten, underline the continuity of St. Petersburg to the Egypt of pharaohs of the XVIII dynasty.

Alike as in the Rome the monarch Tarquinius Superbus was overthrown, the tsar Nicholas II was dethroned namely in St. Petersburg. The technical details of pushing aside of these monarchs have large resemblance. Both the Rome and the St. Petersburg after abolition of monarchy became the centers of originations of the political systems and social formations of new type. Therefore St. Petersburg could be identified as the Rome of contemporaneity, Rome not third as Moscow, but the first, true republican Rome of Brutus and Tricipitinus.

Wu of Jin, the monarch at the Wei Kingdom, united the Chinese states, completed the Three Kingdom Epoch and formed the empire. Tsar Peter I was proclaimed as the emperor in 1721 after the victory in the Great Northern War. Due to the proclamation of empire the title of the Russian holder of supreme authority was changed. Earlier it was interpreted as "Great Sovereign and Grand Prince, the Great, Small and White Russia Autocrat". In the empire the highest title in Russia became "Emperor and Autocrat of All the Russias". So, Peter I as Wu of Jin completed the Epoch of the Three Kingdoms and formed the empire. St. Petersburg – the city of the Peter the Great is the Luoyang of contemporaneity, the cradle of the empire power.

The political leaders of modern Russia were born or rising to their offices from St. Petersburg mainly. They actively struggle against the exterminating Christians the terroristic organization "Islamic State (IS)" propagandized itself as the Caliphate. This struggle is especially intense in Syria – in the region of the Crusades and battles of Crusaders with the Byzantines, Turkish, Muslim people of the Caliphate and with each other. Therefore St. Petersburg could be identified as the Jerusalem of contemporaneity, the Christian Jerusalem of Godfrey of Bouillon and Tancred of Galilee, the city the protector of Christians of Syria and Near East.

Thus, have repeated and assimilated the greatest events of the past of humanity which caused the development of society at the boundaries of ages and being the center of the latest Great Revolution laid the beginning of the new era, namely St. Petersburg among the other cities of the world is most prepared to become the capital of the United Humanity.

VI. CONCLUSION (POSSIBLE FUTURE OF HUMANITY)

The Era of Separated World which is subdivided into the seven ages came to the end in the 1924. The Era of United Humanity began. The humanity tried to be united during the Great October Socialist Revolution and

in the form of the League of Nations on the basis of the Federal Reserve System of the USA. The Era of United Humanity opened for people the new direction of the social development – communistic.

As after all Great Revolutions from the table 1, the social regress began after the rising of the Great October Socialist Revolution. The regress is manifested by the dissolution of the Soviet Union, cancelling of the socialist social, economic and political system and dissemination of bourgeois relations in Russia and other countries.

However, some of the communistic social relations retain, and they should gradually be developed and accumulated in the subsoil of the bourgeois society, even if they are subordinated to the profit of its ruling class. After some interval of the regress the new splash of the social relations appeared during Great Revolution occurred for each age.

After the First Crusade, the new appearance of the capitalist relations falls on the Age of Discovery, 300 years later. Since the Age of Discovery the period of modern history – time of formation and development of the bourgeois relations in the society of the western countries starts.

But, it could be more correct to count the time of formation of the bourgeois relations since the First Crusade when they for the first time appeared as the factor of development of the historical process.

China, broken for the uprising of the barbarian tribes, united again into the feudal state under the authority of Sui Dynasty at the end of the VI century, practically 300 years after the War of Eight Princes. The struggle of the plebeians for their rights with the patricians – tribal aristocracy was the core of the first 300 years of the history of Rome Republic. Only after the gaining of the rights by the plebeians the rapid development of Rome as the slaveholding polis began.

Therefore the new slash of the communistic social relations even centuries after the Great October could be predicted. Because after the phase of the historical regress the new social relations developed in the communities of people formed the first in the course of the respective Great Revolutions more actively, it is possible to conclude that the communistic relations should be developed in Russia – the motherland of the Great October Socialist Revolution more successively than in any place in the world.

The development of the communistic relations in the subsoil of the bourgeois society will make an imitation of the convergence of different economic and social systems. During this convergence process the Russia will become stronger, more developed and more attractive country as social model for humanity. After the time the communistic social relations will become dominate in Russia and cause the respective changes of its political system.

Russia will become the Soviet Republic again. At the beginning Russia will restore the federative relations with its adjacent countries – the republics of the former USSR and after all other countries joint to this federative agreement. The humanity will be united into the World Socialist Soviet Republic proclaimed by the Declaration of the Creation of the USSR at the moment of the boundaries of the eras.

Because all human communities formed the first by the Great Revolutions retain in history, the united the humanity the World Socialist Soviet Republic will be until the humans will exist. The capital of the United Humanity will be the center of the Great October Socialist Revolution – the city of St. Petersburg-Petrograd-Leningrad, modern capital of the CIS, what could be predicted, in particular, apart from by other speculations, by the coincidence of the number of ages of this “Human chronology in the periods of variations of environmental processes” and their length with the international telephone code of St. Petersburg.

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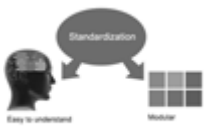
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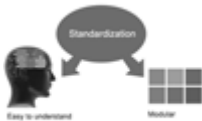
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Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

FORMAT STRUCTURE

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY SCIENCE FRONTIER RESEARCH PAPER

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.



20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.



The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."



Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

THE ADMINISTRATION RULES

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.



CRITERION FOR GRADING A RESEARCH PAPER (COMPILATION)
BY GLOBAL JOURNALS

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	C-D	E-F
<i>Abstract</i>	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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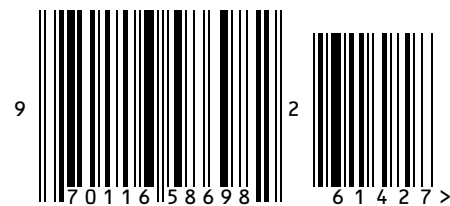
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